AERONAUTICAL RESEARCH AND DEVELOPMENT

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ADVANCED RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES

NINETIETH CONGRESS

SECOND SESSION

SEPTEMBER 24, 25, 26, 30; OCTOBER 1, 2, AND 3, 1968

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U.S. GOVERNMENT PRINTING OFFICE

21–064 WASHINGTON : 1968

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AERONAUTICAL RESEARCH AND DEVELOPMENT

TUESDAY, SEPTEMBER 24, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to call, at 10 a.m., in room 2325, Rayburn House Office Building, the Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. HECHLER. The committee will be in order.

These hearings are designed to identify the priorities needed in aeronautical research and development. We are looking primarily toward the future in our emphasis on how to strengthen the entire area of aeronautics so that the Nation will be thereby strengthened in the 1970's and beyond.

In the past two decades, the emerging problems in aeronautics have been solved as much by empirical expediency as by sound planning. These problems are catching up with and overtaking us. They will get worse in the years ahead. There are enough people working on immediate crash problems, and in these hearings we are not as much concerned with present crises as we are with planning for the future.

The United States has always ranked at or near the top in nearly every phase of aeronautics because of the foresight which has enabled so much effort to be concentrated on advanced research. I deplore the efforts to squeeze, pare down, eliminate or cripple advanced research in aeronautics in the name of either economy or the stress demands of very immediate practical application. If these hearings accomplish nothing else, I hope they will focus national attention on the urgency of greater emphasis on aeronautical research. We cannot afford to slow down an effort which is so vital to all the people and to the strength of the Nation itself. Whether we are talking about civil air transport, noise, air pollution, safety, congestion, or improvements in aircraft themselves—and this list is certainly not all inclusive—we desperately need more research effort, intelligently organized and directed.

This committee has consistently and persistently advocated increased support for aeronautics. We have many times voted more funds for aeronautics than requested by the administration. We have frequently recommended that aeronautics be accorded a more important role within the administrative structure of NASA, and are pleased that NASA now has a Deputy Associate Administrator for Aeronautics—even though this committee has gone beyond that to recommend a full Associate Administrator on a par with areas like manned space flight. Despite the disparity in expenditure, I suggest that history will record that aeronautics is fully as important as manned space flight, and will become even more so.

The motives of this committee are transparently clear. All we are interested in doing is to gain public support for what we feel is vital to the Nation's future strength.

I have a letter from the Honorable Clinton P. Anderson, chairman of the Senate Committee on Aeronautical and Space Sciences, which reads as follows:

SEPTEMBER 19, 1968.

DEAR MR. CHAIRMAN: Thank you very much for your letter of September 12, letting me know that your Subcommittee will hold hearings on the adequacy of aeronautical research and development efforts.

As you know, the Senate Committee on Aeronautical and Space Sciences has been vitally interested in this matter for some years and I am glad to see that you are holding these special hearings. I have asked the staff to follow them closely and keep me advised.

Sincerely yours,

CLINTON P. ANDERSON, *Chairman.*

An excellent staff report on "Policy Planning for Aeronautical Research and Development" was prepared for use of the Senate Committee by the Legislative Reference Service of the Library of Congress and published in May, 1966. Subsequently, the Senate committee held hearings in January and February of 1967. These present hearings will, of course, build on those hearings, and I hope update and project forward the pertinent information elicited by the Senate hearings, and Senate Report No. 957, entitled "Aeronautical Research and Development Policy," published by the Senate committee in January 1968.

I would like to recognize the ranking minority member of this subcommittee who is the Honorable Thomas Pelly of Washington.

Mr. PELLY. Mr. Chairman, if I might comment at the opening of these special hearings, I think it is appropriate to associate myself with the remarks that you have just made and to point up the importance of aeronautical research. With the Russians successfully circling the Moon and returning their spacecraft to Earth and with impending further feats and achievements in space, by both the Soviets and ourselves, it is hard to retain perspective in less spectacular areas such as aeronautical research. I certainly hope these hearings will point up the importance of aeronautical research and our effort in that respect.

I might say that research a little nearer at home, for example, right now in the vicinity of my congressional district in Seattle the Boeing Co. is bringing into production the latest aircraft, the 747, and they are working in connection with the problems of the supersonic transport. These developments are only possible because of research. There is, it seems to me, great danger of our overlooking the values of aeronautical research. I don't think the payoff of Federal investment and research is generally recognized. Only the engineering and scientific fraternity fully comprehend the needs and the benefits of this research effort. So I join with you today in hoping that our hearings will contribute along this line.

Mr. HECHLER. Thank you, Mr. Pelly. Certainly what you have said has underlined the importance of aeronautical research in the national interest.

Before proceeding, I would also like to read a communication I received from E. C. Welsh, Executive Secretary, National Aeronautics and Space Council.

SEPTEMBER 23, 1968.

DEAR MR. CHAIRMAN: I respectfully express commendation to you and your colleagues for focusing thoughtful attention on the essentiality of research and development in the field of aeronautics. The outstanding witnesses you have called for this serious examination of present and future aeronautical needs should help you perform a real public service with these hearings.

As you know, while my agency is frequently referred to as the "Space Council", it is properly termed the "National Aeronautics and Space Council" and its interest has been devoted to both areas. This was and still is the intent of Congress. It is my considered opinion that both the technology and the performance in space and aeronautics are growing closer together with mutual benefit to both of these major fields. It could be said that we are in a sense approaching a technological marriage between space and aeronautics.

It should come as no surprise to any thoughtful man that we need to augment greatly both the quantity and the quality of our research, if we are going to increase our productivity faster than we increase our population. To do this we have to develop the technology rapidly and pass on the practical returns to the general public. Certainly, this is very greatly needed in aeronautics.

One of the major reasons why this country has a higher standard of living than any other nation is because we have in the past invested more per capita in research. Yet, I am now worried at the disease of shortsightedness which seems to have afflicted so many. We need and we need now an antibiotic for virus of postponing research and development. It would almost seem that some people are making a determined effort to have this country grow old, obsolete, and inefficient. The truth is that the nation needs to accelerate its investment in research and development and where should this acceleration be greater than in aeronautics—an arena in which we have the world leadership but which we could lose in a very short period of time.

I am far from satisfied with the status of our civil air transport system. In fact, it is not only becoming inadequate; it has already reached that condition. Resources and intelligence should be devoted in a growing measure to meet the need for greater air safety and better service—a need which is being accompanied by an increased demand that we eliminate or at least minimize air pollution by both materials and noise. I am impressed with those who believe that both the Government and private industry should take positive action to invest more in airports and airport facilities, in air traffic control, in improvement of aircraft, and particularly in research and development so that our technology will be in advance of our ability even to use it.

Again, Mr. Chairman, I compliment you on the decision to hold these hearings and in the thorough preparations which have been made for them.

Sincerely,

E. C. WELSH.

Our first witness this morning is Dr. Thomas O. Paine of the National Aeronautics and Space Administration. Dr. Paine will become Acting Administrator of the National Aeronautics and Space Administration on October 7, 1968.

Technically, I suppose you are still Deputy Administrator. Is that correct?

Dr. PAINE. That is correct.

Mr. HECHLER. And I understand this is your first Capitol Hill experience since being named as Acting Administrator?

Dr. PAINE. Yes, sir.

Mr. HECHLER. We appreciate your appearing before the committee, and if you have a prepared statement, you may proceed.

Dr. PAINE. Thank you.

(The biography of Dr. Paine follows:)

Dr. Thomas O. Paine, Deputy Administrator, National Aeronautics and Space Administration

Dr. Thomas O. Paine was born in Berkeley, California, Nov. 9, 1921, son of Commodore and Mrs. George T. Paine, USN (Ret.). He attended public schools in various cities and was graduated from Brown University in 1942 with a B.S. degree in Engineering.

In World War II he served in the U.S. Navy in submarines in the Pacific, and in the Japanese occupation evaluating submarine material. He qualified in submarines and as a Navy deep-sea diver.

In 1946–49 Dr. Paine attended Stanford University, receiving an M.S. degree in 1947 and Ph. D. in 1949 in Physical Metallurgy. In 1949 he married Barbara Helen Taunton Pearse of Perth, Western Australia. They have four children, Marguerite, George, Judith, and Frank.

Dr. Paine worked as a research associate at Stanford University from 1946–49, where he made basic studies of high temperature alloys in liquid metals in support of nuclear reactor programs for the Navy. He joined the General Electric Co. in 1949, as research associate in the laboratory at Schenectady, N.Y., where he initiated research programs on composite materials. The work led to basic patents on "Lodex" permanent magnets, now used in hearing aids and instruments. In 1950 he transferred to the Meter and Instrument Department, Lynn, Mass., as manager of materials development and later as laboratory manager. Major projects ranged from development of photocells and non-arc-tracking organic insulation to solid-state nuclear reactor control systems and aircraft instrumentation. For the successful fine-particle magnet development program Dr. Paine's laboratory received the Annual Award for Outstanding Contribution to Industrial Science from the American Association for the Advancement of Science.

From 1958 to 1962 Dr. Paine was research associate and manager of Engineering Applications at GE's Research and Development Center in Schenectady. He formulated and conducted basic studies in the physics of composite materials, and organized and managed a new laboratory component engaged in complex technical-economic studies and development programs.

In 1963–68 he was manager of TEMPO, the GE Center for Advanced Studies in Santa Barbara, Calif. This 400-man long-range planning and interdisciplinary study group conducted some $10 million in interdisciplinary research annually for federal, state and local governments, foreign nations, and industry. TEMPO programs ranged from criteria for selection of model cities to the logistics support system for Polaris submarines and from computerized management information systems to economic development in Africa. About 15 per cent of this work was done for the management of the parent company.

President Johnson appointed Dr. Paine Deputy Administrator of NASA Jan. 31, 1968. His appointment was confirmed by the Senate Feb. 7 and he was sworn in March 25. President Johnson named him Acting Director on Sept. 16, 1968, effective Oct. 7.

Dr. Paine's professional activities include chairmanship of the 1962 Engineering Research Foundation—E.J.C. Conference on Science and Technology for Less Developed Nations; secretary and editor of the Engineers Joint Council Engineering Research committee on the Nation's Engineering Research Needs 1965–1985; member, Advisory Committee and local chairman, Joint American Physical Society—Institute of Electrical and Electronic Engineers International Conference on Magnetism and Magnetic Materials; chairman, Special Task Force for U.S. Department of Housing and Urban Development; lecturer, U.S. Army War College and American Management Association; Advisory Board, AIME *Journal of Metals*; member, Basic Science Committee of IEEE and the Research Committee, Instrument Society of America.

Dr. Paine is a member of Institute for Strategic Studies (London); Sigma Xi; New York Academy of Sciences; American Physical Society; Institute of Electrical and Electronic Engineers; American Institute of Mining, Metallurgical and Petroleum Engineers; American Society for Metals; Institute of Metals (London); Submarine Veterans of World War II; American Society of Naval Engineers; Society for the History of Technology; Marine Historical Association; American Museum of Electricity; Newcomen Society (London); Naval Historical Foundation; American Association for the Advancement of Science; National Association for the Advancement of Colored People; U.S. Naval Institute; Navy League; Association of the U.S. Army; American Ordnance Association; and Instrument Society of America.

STATEMENT OF DR. THOMAS O. PAINE, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY JAMES M. BEGGS, ASSOCIATE ADMINISTRATOR, ADVANCED RESEARCH AND TECHNOLOGY, NASA

Dr. PAINE. Mr. Chairman and members of the subcommittee, before beginning my statement, I would like to say that it is a distinct personal pleasure for me to appear for the first time before this subcommittee which has contributed so importantly to the development and support of the Nation's and NASA's aeronautics programs. As you know, NASA's aeronautics program is a major element of its advanced research and technology program, and I have with me today Mr. James M. Beggs, Associate Administrator for Advanced Research and Technology, and Mr. Charles W. Harper, Deputy Associate Administrator for Aeronautics.

Let me say at the outset that we greatly appreciate this opportunity to appear before you in the opening session of these important hearings on the general problems and progress in this Nation's aeronautical research and development efforts. These hearings are especially timely because we have made progress not only in better identifying the nature and scope of these problems, but also in further clarifying avenues of approach to their solution.

Indeed, we are already progressing along some of these avenues. I will largely devote my statement to these aeronautics matters as we see them in general in NASA today. Mr. Harper will follow me with a statement addressed more to the particulars of attractive on-going and potential future thrusts in the Nation's aeronautics research and development efforts, both as they involve NASA specifically and in concert with other Government agencies and the industry.

A number of recent studies, including especially the one of the Library of Congress for the Senate; the one carried out by the transportation workshop under the sponsorship of MIT; and the one just completed by the aerospace engineering board of the National Academy of Engineering, have emphasized the continuing importance of military and civil aviation contributions to the Nation. The full realization of these contributions is clearly contingent, however, on our ability to plan and implement the multitude of necessary aeronautics efforts from research to development and operations in a farsighted and systematic fashion. This requirement became clear to the military almost two decades ago and led to their adoption of the weapons system concept in the development of new military aircraft. The new breed of aircraft that evolved, including the B–47, 52, and 58, and the Century series fighters were highly complex, integrated systems of airframe, engines, electronics, and armament, all carefully configured to carry out their missions in the total air-ground environmental characteristic of their operations. The role of NASA (then NACA) as a supplier of new aeronautics technology for the military evolved in accordance with this trend toward the systems approach.

Specifically, while we continued our efforts across a broad spectrum of disciplines to provide new and improved technology for aircraft in general, we also organized special efforts to focus on the development of technology particularly suited for proposed new military systems. This joint-type effort with the military found further effective application in the development of X-series of research airplanes and these are noteworthy examples of the value of "experimental hardware" work in our view. You will remember, in this connection, that these airplanes pioneered the flight regime from transsonic to hypersonic speeds.

Today we are using and enlarging on these time-proven methods for providing the most effective NASA support of the military. Thus, for example, we have for some time had a special team of OART Center experts working with the Navy and the Air Force to provide technical support in their FX and V–FX aircraft studies. More recently we created a top level technical advisory group consisting of Mr. Beggs, Mr. Harper, and the OART Center directors to work with Dr. John Foster, Director of D.D.R. & E., on the FX and the V–FX programs as they develop. By these methods and the continuing coordinating activities of the AACB and other joint groups, we believe we are maximizing NASA technical support of the DOD within the framework of their systems approach to new military aircraft.

In the case of civil aeronautics the situation is substantially more complicated for NASA and the Nation, due to major changes that have occurred over the past decade. Thus, we find that:

(1) Air transportation has grown from a highly specialized adjunct to ground and sea transportation to the principal mode of long-range passenger movement. Scheduled air carriers of the United States now account for approximately two-thirds of all the passenger-miles attributed to common carriers; and, according to some projections, total passenger traffic handled by the scheduled airlines is expected to grow at a rate of 15 percent per year to a figure of 300 billion revenue passenger-miles by 1975. Even more rapid growth is projected for airfreight. These increases will be paralleled by growth in general aviation, corporate, and private planes, which now number above 100,000, and will double by 1980.

(2) Development of military aircraft has declined markedly in recent years, and those military aircraft which are now developed or are under development are principally the highly integrated weapon systems that I noted earlier. Thus, although military aircraft do advance technology and provide a proving ground for new ideas, they are less directly applicable to civilian use, as was the case, for example, of the KC–135 and the 707. Future advances in civil aircraft may well require, therefore, the development of expensive "experimental hardware" ranging in scope from research aircraft to true prototype vehicles.

(3) Ground transportation has reached and passed a saturation point in many localities, and one answer to this transportation dilemma is the current rapid increase in local "commuter" air services using helicopters and smaller airplanes. This will undoubtedly require a wide variety of new civilian aircraft and supporting communications and ground facilities for safe, low-cost air commuting in highly populated areas. Attention must be given now to the problems of safety and reliability without imposing unacceptable burdens of noise and inconvenience on those living in these areas. For example, the rapid pro-

liferation of helicopter landing pads in the LA basin portends future aerial traffic jams.

Thus, we see that it is not enough simply to build aircraft which are bigger, fly faster, or take off vertically; rather, future advances in aeronautics must also take the form of aircraft which will complement the Nation's overall transportation systems while operating harmoniously within the constraints imposed by urban environments. VTOL and STOL developments together with effective new urban traffic control networks are of prime concern. These special purpose civilian aircraft will require major advances in the level of sophistication of aeronautics and electronic systems and substantial technical and financial risks will be involved. However, success in the air will relieve even more expensive new forms of ground transport.

The foregoing considerations are involved in a basic issue facing NASA and the country today with regard to civil aeronautics R. & D. Simply stated, the issue is: What is the proper role of the Federal Government in fostering advances in civil aeronautics? Inherent in this issue are a number of questions.

For example, should the Government assist the air transport industry in developing and implementing advanced air transportation systems through experimental hardware or proof-of-concept programs in which the Government assumes the burden and risk of developing and demonstrating the technical feasibility of new concepts? By what processes are particular aeronautical systems chosen for development and what are the most effective roles of the various Government agencies?

One example of the role of government is found in the national aircraft noise abatement program where, within a coordinated Government program involving several agencies, NASA assumed the responsibility of conducting a three-pronged experimental hardware program which we have described to you before. This includes the acoustical treatment of existing jet transports, innovations in aircraft operations such as steep descent, and the development of new quiet engines for the future.

The Department of Transportation has the prime responsibility for integration of all aspects of this aircraft noise abatement program; NASA is the chief R. & D. arm; with the FAA and Department of Housing and Urban Development responsible for regulation of operations and programs for compatible land use near airports.

Although the Government's role in attacking the aircraft noise problem is fairly well defined at this point, the extent of future participation by the Government in other civilian aeronautics programs is less clear. There is general agreement and support, in my opinion, that as a minimum the Government should continue to support its advanced research programs in the aeronautical sciences as an effective contribution to future developments in aeronautics. There is general agreement, too, that programs similar to that developed to support production of the SST represent possibly the maximum Government participation that is appropriate without seriously weakening the role of free enterprise in civilian aeronautics. We must recognize that sharply increased support for civil aircraft R. & D. is required now that military aircraft R. & D. no longer provides a free ride.

In my view, Government actions to stimulate the development of advanced aircraft transportation systems, should be such as to leave the maximum initiative and business risk in the hands of industry. A way to do this might be for the Government to carry promising new technological principles found in advanced research work into experimental hardware, but only to the point of demonstrating the soundness of the principle involved, and only when this demonstration is essential and would not be otherwise undertaken. Under this approach the Government would bear a larger share of the technical risks involved adopting new technology, while leaving industry free to choose those lines of development most economically attractive within the context of Government regulations defining acceptable limits of operation.

This approach is consistent with the general recommendations of the National Academy of Engineering report, which I referred to earlier, and provides a guideline to evaluate and formulate priorities and programs to implement specific recommendations on advancing aeronautics.

In order to develop and better understand the most effective patterns of cooperation between the Department of Transportation and NASA in advancing development and implementation of advanced aircraft transportation systems, DOT and NASA, last month, agreed to initiate a joint study to determine the appropriate role of Government support for aeronautical R. & D. Under this agreement, which resulted from an exchange of letters between Assistant Secretary Frank W. Lehan, of DOT, and myself, DOT will take the lead in directing and coordinating the study and to bring in other Government agencies as appropriate.

Initially, the study will focus on providing early assessment of the consequences of accelerating development along selected lines; for example, by incorporating all identified advances in subsonic jet transports and V/STOL aircraft. The assessment will be based on a time-value analysis approach to measuring quantitatively the potential benefits of improved systems; and on measuring and relating the development and growth of aviation to the national welfare and economy. Beyond its immediate importance, the study will assist in establishing a pattern of cooperation between DOT and NASA which I believe, in the long run, will bear marked similarities to that existing between DOD and NASA.

We welcome these hearings, which I am sure will provide us with a greater appreciation and understanding of the complex task we face in tailoring NASA's R. & D. activities in aeronautics to the needs of this country and the world in the decade ahead.

Mr. Chairman, this concludes my statement.

Mr. Hechler. Thank you, Dr. Paine.

The chairman of the full committee, Hon. George P. Miller of California, who authorized the subcommittee to hold these hearings, has long been a leader in emphasizing the national interest in aeronautics and aviation. I would like to recognize Chairman Miller at that point.

Chairman Miller. Thank you very much. I am very happy to be here. I just got in from California late last night, and I am happy to have the opportunity to see Dr. Paine and welcome him here, as well as the other members of the NASA establishment.

I have just been glancing over your statement. I think that a great deal can come of these hearings if nothing more than perhaps to spur some interagency activities, as Dr. Paine has just been pointing out. We find that sometimes we have to have a little catalyst, Doctor, to get agencies together. I am drawing on my own experience, when I was the chairman of the Subcommittee on Oceanography of another committee. It was organized right after the National Academy of Science appointed its very fine committee, made a very comprehensive report on oceanography on what should be done in that area of science. We found seven different departments of Government doing research in oceanography, while no department knew what the others were doing. Today we have a well-rounded group who are patterned after the National Aeronautics and Space Council, which is doing very constructive and fine work in oceanography. I believe that by drawing together the several elements of Government that have common capabilities in research areas, we may find solutions to very important problems.

I don't like to think there is any insurmountable problem in aeronautics today that American science and American ingenuity can't whip. My thought is, let's get on with it because it is going to be a great factor in the future of our country.

I just came from my home where the great Alameda Naval Air Station is located. An aircraft carrier is standing offshore waiting for her turn to get into the San Francisco drydock, the only one that can take carriers. Her pilots are practicing landings, and they are coming in over Alameda. We are used to Alameda being primarily an industrial complex. All of the pilot training years ago was transferred down to the San Joaquin Valley to Livermore where there would be no noise problem. But these fast jets coming in over the city today are setting us all on edge. The noise problem, even where people are used to it, becomes acute when jet aircraft disturbs the normal order of things.

I want to congratulate Mr. Hechler, his subcommittee and his staff for the assistance to you and other agencies in the Government who think that he can make a very constructive contribution in the solving of this problem.

Mr. Hechler. Thank you, Mr. Chairman.

I would like to ask one or two general questions. It is pretty obvious that the Soviet Union has concentrated a massive financial and scientific effort into manned space flight. Is it your observation that this has squeezed out the effort that the Soviet Union has made in the development of aeronautics?

Dr. Paine. Not at all. We find, in fact, to the contrary, that the Soviet Union is pressing ahead in a most determined manner in the field of aeronautics, and as we look at the organization which they have brought to bear on this, it is extremely impressive. It goes all the way back to the engineering schools and the graduate schools, the research institutes, the manner in which they keep a continuing new series of prototype aircraft apparently with design teams vying with each other much in the way that industry teams vie with each other in this country, and I think this has been done at no cost whatsoever to their space program. Similarly, in this country these two programs, space and aeronautics, support each other.

Mr. HECHLER. You mentioned on the first page of your statement that "NASA's aeronautics program is a major element of its advanced research and technology program." The item "aeronautics" may well be the major item under OART expenditure. Nevertheless, I wonder if it would be fair for you to draw the conclusion, that this is major with relation to the Nation's research needs in aeronautics?

Dr. PAINE. Well, I think that we have seen within NASA a continuing emphasis on the aeronautics area as demonstrated by the level of funding that we have had in the last few years. We have gone from a level in 1962 of $44 million to a level in our interim operating plan for 1969 of $166 million, a steady increase that reflects the diminishing relevance of military R. & D. mentioned before. We are putting in our interim operating plan for this year the full amount that has been authorized by the Congress, and I believe that this indicates the high priority which we place on aeronautics, Mr. Chairman.

At the same time, I am sure there is a good deal more that could be done and should be done. I think that in the commercial area we are, essentially, exploiting in our subsonic jet technology, a technology that is now a quarter of a century old, and we are quite concerned within NASA that we carry out effectively the R. & D. that will be required for the next several decades as we go into new areas, particularly the areas of short take-off and landing, vertical takeoff, supersonic and eventually hypersonic flight. Both commercial and the burgeoning private aircraft will benefit.

Mr. HECHLER. We want to emphasize in these hearings problems and potential developments of the future, rather than figures. Do I gather from your use of the figure of $166 million that you think that is pretty good because the rest of the program of NASA has been squeezed, and you have been able to preserve aeronautics?

Dr. PAINE. I don't think my point is so much that it is good, but it does indicate the great importance we have attached to aeronautics because in an era of declining financing we have consistently increased the funding in this area. As we come before the Congress with our 1970 budget, I hope we will be able to secure even greater funds in this area.

Mr. HECHLER. Are you limited by availability of personnel that happen to be there or just the facilities that happen to be there? I would like to see if we could open up some new areas that would enable you to concentrate on these emerging problems without reference to just what you have done in the past with the personnel and facilities available.

Dr. PAINE. Yes, I would not say that we are facility limited, although as in any on-going research some new and different facilities are required. We need to put in better noise measurement and noise research facilities, for example, for our programs in that area.

But by and large, it is pretty much a fund limitation today. Given the funding, we can get the talented people, and we have many excellent facilities which we are not now operating at peak capacity.

Mr. HECHLER. Mr. Pelly?

Mr. PELLY. Dr. Paine, I certainly want to say that I am glad you are here before our subcommittee on your first appearance on the Hill, and I certainly welcome you.

You mentioned that you wanted to install more noise measurement devices. We know from being in touch with our constituents that we will have no trouble in getting support for noise abatement problems as far as the public is concerned. We have our problems in trying to support general research and technology in the House because of the fact that certain members have international airports in their districts and they don't want any money spent for technological developments that are going to make more noise. As we all know, you have a very difficult problem. We hope there will be a breakthrough.

On page 2 of your statement you mentioned that progress is being made in the better identification of the nature and scope of the problems in our national aeronautics research and development effort. Would you give us some examples?

Dr. Paine. I think that the increasing view of aeronautics, particularly the civilian aeronautics effort of the United States in the context of a total transportation system, is very much helping us.

In fact, the aircraft noise problem is one which comes out of such a look. I think too that the increasing public concern with the Nation's air traffic control network is a key ingredient in the Nation's air systems The total transportation needs view is helping to identify this as a very critical area.

We are getting away from the aerodynamics or propulsion approaches, and doing a much better job today, with our friends in the Department of Transportation, in trying to understand the total problems of the system. This was primarily the effort that I was alluding to here. A pressing current example is the problem of inadequate terminal facilities for the jumbo jets now rolling off the production lines.

In the defense area we have had for some years the systems approach, but it is really just coming in for the first time in the civilian area.

Mr. Pelly. On page 3 you mention the systems approach used by the military and their successful resolution of many of their research problems.

To what extent has NASA used this approach in selecting which area and on what levels aeronautical research should be conducted?

Dr. Paine. This is an area which perhaps it would be well if I were to ask Mr. Beggs to handle since he is the Associate Administrator for Advanced Research and Technology. Would you like to hear his views?

Mr. Hechler. Yes, Mr. Beggs.

Mr. Beggs. As Dr. Paine mentioned earlier, we have for about 2 years now been conducting studies directed specifically to looking at the total system of aeronautics, that is not only at the airframe and propulsion end of it, but also at the interface with the ground facility, the air traffic control, the transportation to and from the ground facility, and all the associated problems.

We have just recently initiated a joint study with the Department of Transportation continuing this work on a broader scale.

We are endeavoring by these studies to isolate or pin down the critical point in the system so as to begin work on research directed to those problems.

This work is progressing well, and I think we will be able to make some preliminary recommendations in the coming year on programs which need to be started.

Mr. HECHLER. May I interrupt? You said within the coming year. Do you want to pinpoint when this study is expected to be finished and come up with some recommendations?

Mr. BEGGS. Well, it is a continuing study, Mr. Chairman. I would say that by the beginning of the hearings in the January or February period, we may have some specific recommendations to make.

Mr. HECHLER. Mr. Pelly?

Mr. PELLY. One final question, Mr. Chairman, if I might.

Dr. Paine, on page 8 of your statement you refer to an agreement between NASA and DOD for a joint study to determine the appropriate role of the Government in its research. Would this agreement in any way call for the use of NASA capabilities for research in areas other than flight vehicles?

Dr. PAINE. Yes. In fact, one of the activities which we have just started with the Department of Transportation is to make available to them the capabilities of our Jet Propulsion Laboratory in Pasadena, which is perhaps best known for its planetary exploration studies to help DOT take a look at the total air problems in the Los Angeles basin. We have the helicopter, the short takeoff and landing vehicle, the many multiplicities of air commuter services that are coming in here; so we are now using this NASA facility which has greatly distinguished itself in the development of R. & D. capability to support the new Department of Transportation. That is just one example.

I believe that when the chairman visited our Electronics Research Center in Boston this week he saw some of the other areas in which we are working with the Department of Transportation. One of these is aircraft collision avoidance systems and there are a number of others.

Mr. PELLY. Speaking of the Electronics Research Center in the Boston area, has NASA been able to overcome some of the difficulties that it encountered in connection with underestimating the costs of providing the research facilities? Is NASA proceeding to carry out the building program?

Dr. PAINE. Yes. Again, I would turn to Mr. Beggs to give you a more up-to-date statement of the status of the new construction up there.

Mr. BEGGS. We did have problems, Mr. Pelly.

Mr. PELLY. Problems with our committee as well as with Congress?

Mr. BEGGS. Yes. We do have them well in hand, I believe. I was reviewing the building program a couple of weeks ago at ERC and I think we have pinned down the costs, and we have, in fact, started construction. I don't know whether you got a chance to see it when you were up there, Mr. Hechler.

Mr. HECHLER. Yes. I was very impressed with the progress not only in construction, but the work being accomplished in avionics and aeronautics.

Mr. PELLY. Can we look forward to having actual new research facilities, rather than rented space?

Mr. BEGGS. Yes, sir. We should be in those facilities next year, and our hope is that we can continue to pick up the options that we have on additional land up there. As you know, this will require that we continue our building program.

Mr. Pelly. How are the costs today running against your estimates?

Mr. Beggs. The entire program is under contract and proceeding on schedule. Contract costs are very close to the revised estimates.

Mr. Pelly. Thank you, Mr. Chairman.

Mr. Hechler. Mr. Hunt?

Mr. Hunt. Thank you, Mr. Chairman.

Dr. Paine, I notice on page 5 of your statement that you discuss ground transportation as having reached the saturation point in many localities. Then, we come back to talking about low-cost air commuter service.

Is NASA interested as much as DOD is in the VTOL plane that Britain has developed?

Dr. Paine. I think perhaps that it would be well to indicate NASA's broad interest not only in British, but also in the commercial area the French Breguet, the German Dornier aircraft, and the Canadian Otter aircraft. There is now a great deal of interest in STOL aircraft that are suitable for commercial service. NASA is following this very closely with the Department of Transportation.

The McDonnell Douglas Co. in this country has made available the French Breguet (McDonnell Douglas model 188) experimental shuttle service between Washington National and La Guardia Airports, essentially using small pieces of taxiway for landing. A service is now being started in the Washington area to link Dulles, Washington National, and Baltimore airports together using the Dornier. We are following this very closely with the Department of Transportation people who are primarily interested in this as a system.

In our own case, we are trying to pioneer in the advanced avionics that are going to be required to satisfy these needs. We have been flying a highly instrumented light aircraft out of our Edwards Air Force Base in California to study advanced private plane avionics. We are also working to see whether or not some of the space technology that we have developed may have some avionics applications. I would imagine Mr. Hechler saw in Boston some of the applications of our Gemini control hardware being adapted to problems of helicopter vertical takeoff and landing controls. These are just a few of the areas we are working in.

Mr. Hunt. The DOD is essentially interested in the Harrier-type plane. I had the opportunity of seeing the French plane out of La Guardia. I wonder how close the coordination is between DOD, Department of Transportation, and NASA. We have tried to get the answer to these problems at the time the appropriations were considered but could not find the appropriate organization which is handling them as a unit. I am interested in finding out who will have the information so we might have it quickly in a capsule form.

Dr. Paine. When it comes to the technical status of aircraft of the Harrier type, this will primarily be between the Department of Defense and ourselves. The Department of Defense has recently turned over several aircraft of similar VTOL type to NASA, for example, the Ryan XV-5B. We are conducting flight operations with these, particularly examining their control problems. As we progress to the

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point where some potential commercial applications appear, then the Department of Transportation will be increasingly in this as well as aircraft manufacturers. At the present time this is primarily a military research type of undertaking, but I believe that through the network that we have developed between the DOD, NASA, DOT, and the manufacturers, we will move in an orderly way into the commercial arena. It is too early now for the commercial use projections. The immediate commercial prospects now are more along the lines of the light STOL aircraft and helicopters.

Mr. HUNT. Thank you, Doctor.

Mr. HECHLER. We are very pleased to have our colleague, the gentleman from Ohio, Mr. Mosher, here, and Mr. Mosher, would you care to make any observation or ask any questions?

Mr. MOSHER. I won't ask any questions at this point. I am not a member of your subcommittee; I am only here as an observer, but I appreciate your invitation to come, and salute you for holding the hearings.

I am interested especially because I live in a town where one of the FAA's major traffic control centers is located. It is a community that seems to be seriously threatened by the rumored development of a major new jet-age airport. All of these problems are of a very personal interest to me and to my constituents and I am glad to be here and have this opportunity to listen to the discussions.

Mr. HECHLER. Thank you, Mr. Mosher.

Dr. Paine, I wanted to ask you a general question about future emphasis on aeronautics within NASA.

Once the Apollo major expenditures are out of the way, will NASA place increased emphasis on aeronautics, perhaps even to the extent of elevating it to a position on a par with manned spaceflight?

Dr. PAINE. Well, this, of course, is a judgment question and as we look at our recommendations every year for the budget and see what opportunities and costs are involved in the space area, and the opportunities and costs involved in the aircraft area, we will make a series of continuing judgments. As you can see from the figures on NASA's aeronautics R. & D. in recent years, even with the tremendous expenses we have had in the space area and with Apollo in particular, and in the face of declining budgets, we have found it desirable and the Congress has agreed to increase our aeronautics R. & D. budget. I would expect to see this trend continue for some years. I think the United States is in a position today where its vital aeronautical research and aeronautic leadership is indeed being threatened. The fact is that a nation's power in the world today is strongly tied in with its position in aeronautics—not only in the military sense, but in the economic sense. As you well know, a very substantial part of our present foreign exchange earnings are coming from our advanced aeronautics industry. It is to preserve our national power that we must continue to emphasize R. & D. and all other factors of air strength.

This gets back to the first question that we addressed ourselves to: whether or not we saw in the Soviet Union a decline in their aeronautics R. & D. because of their manned and unmanned space program. To the contrary, we saw increased emphasis going into the aeronautics area. I think the primary threat we see to our air power is the Soviet

Union, but there are many other lively and very capable nations that are moving ahead in very specialized areas. We mentioned some of the STOL or VTOL developments and the fact that these are arising in many nations today. So that for us to maintain our position is going to require us not only to continue to be preeminent in subsonic jet technology, but to move on ahead into some of these other newly developing areas. This includes the capability of operating with lower noise levels and increasingly within a total air transport system environment, all of the things that go into successful commercial, passenger, and air freight operations.

The United States is in the midst of development of its supersonic air transport system. This is a program that has encountered obstacles which are being systematically evaluated, but I think this also indicates the great importance of more civil aircraft R. & D. America will not fly the first supersonic transport. We will fly the third. The British French combine and the Soviet Union will have supersonic aircraft flying before us. However, we should eventually come out with one that will be an aircraft that has the performance characteristics and economic values that should make it competitive. We will have the range to serve the routes, but it is taking us longer. It is more important to be right than first: recall that the unsuccessful British Comet and French Caravelle preceded the American 707 and 727.

Mr. Hechler. From the problems that you uncovered in your testimony, the threat is equally great internally as externally. We have emerging problems and crises confronting us in aviation and aeronautics.

Chairman Miller. I think, Mr. Chairman, it would be well for you to perhaps take a look at what has been done down at Langley Research Center in the past few years. This is an airfield that you don't hear much about, except when planes used to slip off the runways in wet weather and kill people. Langley has experimented successfully with various types of runway surfaces to the point where the California Department of Highways is contemplating using these serrated surfaces on some of its sharp roadway curves. These have been developed without too much publicity by NASA. If you go back into the field, I can remember some of the troubles we uncovered years ago on the Armed Services Committee that were solved by NACA, the forerunner of NASA. NASA has carried on great technical research in other areas other than noise abatement.

Now, you have already touched on one of the big factors in aviation, the transportation between airports and towns. This is the one, I believe, that falls directly into the new Department of Transportation.

If you read the history of early transportation, about 130 years ago when the railroads were first being built in our cities, it was necessary that a railroad engine be preceded by a man on horseback waving a red flag because the trains caused the horses to bolt. We had problems with the railroad engine whistles.

Then, when the motor truck came into being, the peaceful countryside ceased to exist because of trucks rolling down the highways all night long and climbing grades.

I live in an area where we have drawbridges. Boats going through these bridges give the same sort of disturbance. With all forms of transportation, I think we have introduced new effects which have harrassed people. We have learned to live with them. I am satisfied that with competent people and the encouragement we can give them, we can solve any of the problems that confront us today.

Mr. HECHLER. Thank you, Mr. Chairman.

Any other members of the committee have questions before we get to Dr. Harper?

Mr. HUNT. Are you familiar with the situation that involves the metropolitan areas with regard to the supersonic transport, so far as the jet ports are concerned? Have you considered this in any of your research?

Dr. PAINE. A great deal of work is going into this. As you know, one of the primary economic factors dealing with the supersonic transport is its ability not only to handle the landing pattern, but also the land overflight question, and a good deal of research and attention has gone into SST noise levels. What sort of specifications should be set on them, this is one of the primary conditions. Also whether anything can be done about the supersonic boom. The over water flights are enough to economically justify supersonic flight. It would be an enormous benefit if overland flights could be brought in. At the present time we don't know how to lick the supersonic boom problem. It is something that is receiving increasing attention. You get into this psychoacoustics area where it isn't enough to designate decibels of noise levels. You are trying to understand the interaction of the noise spectra with people, the whole questions of sonic peaks and durations. It is a very complex question which is receiving a great deal of attention. I believe it is treated reasonably well in the Academy of Engineering report we were discussing earlier. I am sure when the FAA Administrator testifies this will be a subject he will want to discuss in some detail.

Mr. HUNT. That is what I was leading to. I had the occasion to attend a 3-hour briefing on the situation involving the Boston-Philadelphia-Wilmington complex. I had the opportunity of seeing some of the plans that were projected for a new type of airport which would, of course, involve the problem of transportation to and from it. For these airports the planning is taking into consideration the decibel levels and noise abatement problem. The plan I saw calls for 24,000 acres for the airport proper, 10 runways, five terminals, and interconnecting subway. It also calls for a 55,000-acre buffer zone.

On the east coast we are getting crowded. My State, New Jersey, has the highest population density in the Nation with over 925 people per square mile. This is beginning to pose a problem not only to the geography itself which is rapidly being occupied, but is also giving us some concern in the area of water supply from the various watersheds. I have a full dossier on this problem area and I will make it available to you so that you might see what planning is being done for the eastern seaboard. Thus you will have an advance notice of what the aeronautic people are looking at.

Dr. PAINE. Thank you.

Mr. HECHLER. Mr. Gerardi, you have a couple of questions, sir?

Mr. GERARDI. You mentioned that the Russians are continuing to emphasize their aeronautical research and development programs.

Are they undertaking any programs for the use of experimental aircraft?

Dr. PAINE. I think that the general approach that we see the Soviets taking puts great emphasis upon the experimental aircraft approach. These tend to be prototypes perhaps of military aircraft that meet military requirements, but at the same time they are flying test bed types of aircraft. When they exhibit them in their air shows, you will see exhibits of such things as swing wing experiments which are very much along the lines of your question, yes.

Mr. HECHLER. I gather that the X-15 is the last of the series of experimental aircraft?

Dr. PAINE. Yes, sir; as of this moment.

Mr. HECHLER. And don't you foresee the need for some more experimental aircraft in the future to solve some of these problems which you identify?

Dr. PAINE. The question of the degree to which NASA should carry its forward-looking R. & D.; to what extent this should be embodied in experimental hardware is a rather difficult one which we are thinking about a great deal now. The X-15 aircraft has played a very major role in the aircraft development in the United States.

At the same time a number of NASA developments have been carried along and then flown as components which were later put together in systems. NASA is now flying the XB70, the F-111 A and B, and many other advanced prototypes, as well as parawings, lifting reentry bodies, and the many highly advanced vehicles in the manned space program.

Such things as the swing wing were first tried out in NASA wind tunnels 20 years ago and brought forward to the point where they could be applied to military or commercial prototypes. At the moment our thinking is that this is a tried and true system which we would propose to continue.

Mr. HECHLER. You don't mean that the swing wing is a tried and true system?

Dr. PAINE. There are difficulties.

Chairman MILLER. I think eventually it will come into being.

Dr. PAINE. It is a sound long-term concept. With anything new you are liable to get into a number of bugs, and this program has certainly had more than its share.

The prototype aircraft procedure is one that moves a new concept between NASA which does the basic research, and the Department of Defense which has the requirement for a new weapons system. The resulting prototype is really then an Air Force prototype.

Mr. HECHLER. Why was the decision made to stop experimental aircraft by NASA?

Was this a budgetary decision?

Dr. PAINE. I don't believe it was a budgetary decision as much as it was a case of the these particular experimental rocket aircraft essentially reaching the end of that line of high-speed development. The aerodynamic and control problems that we were experimenting with in the X-15 type of aircraft were carried through the wind tunnel, and then through the actual flying phases to the point where we had learned a great deal about the theoretical and actual problems involved in this flight regime. As you know, the X series aircraft were financed by DOD.

Chairman MILLER. Mr. Chairman. Doctor, you spoke of NASA's having worked with the swing wing 20 years ago. That was the old NACA?

Dr. PAINE. Yes, in 1947, NACA first worked with the swing wing.

Chairman MILLER. Isn't it substantially true that every breakthrough in aviation, every big breakthrough in the past, came out of DOD and NACA working closely together. As the swept back wing, the delta wing, and many other items were developed contracts for fabricating these items were awarded to the successful bidder. Now we have the swept back wing and the delta wing. We associate this with the private companies under contract with DOD. But all of the research and engineering was done at that time in NACA laboratories?

Dr. PAINE. Yes; in many instances that is the case. At Langley and other locations, advanced engines and aerodynamic structures were the result of research done by the fine teams in NACA.

Chairman MILLER. We are talking about the future and what is going to happen.

A man recently wrote a book in France that sold 500,000 paperback copies before it was translated into English. You could only get it in English starting a little over 3 weeks ago. It is called "American Challenge" or "Le Defi Americaine." Have you read it?

Dr. PAINE. Yes.

Chairman MILLER. Two years ago in England at a meeting of the British Aviation Corp., the French and the British were talking about how they were going to bring back to Europe the aviation knowledge and the superiority that once belonged there. But Mr. Servan-Schreiber, who is apparently taken quite seriously, says the trouble with the Concorde lies with its aluminum construction in that it can't travel faster than mach 2.

Dr. PAINE. Yes.

Chairman MILLER. If it does, it will begin to melt. Whereas the SST that we are building with titanium and other metals can sustain mach 2.7. He said that the Concorde is going to be good and is going to be available in 3 years but that it will be obsolete. Do you agree with his conclusions?

Dr. PAINE. Yes; I think so. As you know, NASA has done a great deal of work with the high temperature metallurgical problems of supersonic flight, and it is our judgment that the FAA's project is indeed on the right track, and that the aluminum Concorde is a very risky financial venture, as Mr. Servan-Schreiber points out.

Chairman MILLER. And the Concorde is going to be with us for quite some time. It has slipped and continues to slip?

Dr. PAINE. They have had the high-speed taxi tests.

Chairman MILLER. Despite the fact that American companies are supposed to have ordered some 74 of them? I don't know. I didn't get to the Farnborough airshow this year.

It may be interesting to note that 2 years ago when we went to the Farnborough Airshow, FAA invited us to go over in a stretched DC–8. It got on the ground over there and was parked not far from where the Concorde was parked. There were lines of people three blocks long waiting to go through the DC–8, but there was no trouble getting on board the Concorde at all. Of course, it was a prototype Concorde. I went on it.

Mr. Hechler. Mr. Gerardi, did you have anything more?

Mr. Gerardi. In your statement you mentioned the difficulties in applying to research and the field of civil aeronautics the same sort of teamwork you have had in the field of military.

On pages 4, 5, and 6, you pose some basic questions of what should be the proper role of government and which agencies would be most effective in fostering advances in the field of civil aeronautics.

The general proposition has been made that NASA should be the research arm for civil aeronautics. Do you agree with that general proposition?

Dr. Paine. Yes. I think that NASA has very strong responsibilities under the act which founded it to carry out the research in this area. I think the difficulty you get into is not the research area. It is in all of the many problems involved in going from the research phase to the successful commercial model. A model is not successful in the sense it flies, but successful if it has indeed the lowest cost and is the most reliable; if it is the airframe and engine combination that essentially sweeps the commercial world and makes money for the manufacturer and the world's airlines.

This involves, then, some very fine lines of interaction between NASA, the Department of Transportation, the airframe and engine manufacturers, and the airlines. It is this very complex institutional interaction that we have to be successful at. America's success at this is the basic challenge to Europe postulated in Servan-Schreiber's book.

NASA is carrying out its traditional role and, I believe, carrying it out well. In my opinion, the institutional interactions among NASA, the FAA, and industry in areas such as the SST are encouraging. In discussing U.S. institutional patterns I wouldn't like to conclude without mentioning the importance of getting strong university support in the research area, too. Here again, we are exploring new ways whereby we can take our complex facilities in NASA centers and attract more university professors and graduate students into experiments here. We are making progress in this area. It is the whole process that we have to be concerned with.

Mr. Gerardi. I was addressing my question only to the flight vehicle portion of aeronautics.

Do you feel that there is sufficient new talent becoming available for aeronautic research?

Dr. Paine. As we look at the young graduates that we are able to attract, we are getting very well-trained people. They are strongly motivated people, but with the current budgetary pinch I don't think we are doing as much as we should be in this area.

Mr. Hechler. Is the National Science Foundation in its grants in aeronautics concentrating on what you consider to be critical areas? Do you work any with them in conjunction with their grants on aeronautic matters?

Dr. Paine. I am really not close enough to that to be able to answer that question now. This is something I should look into. I have been very concerned with our own university program, and we have had discussions with the Department of Defense on their support in this area. University support has been declining in our budget, as you know, and I am not at all satisfied that we are doing what we should be doing here.

Mr. HECHLER. Thank you, Dr. Paine.

Mr. HECHLER. We will proceed now with Mr. Charles W. Harper, Deputy Associate Administrator for Aeronautics of the Office of Advanced Research and Technology, an old friend of this committee who has contributed a great deal in the development of aeronautics by NASA.

(The biography of Charles W. Harper follows:)

CHARLES W. HARPER, DEPUTY ASSOCIATE ADMINISTRATOR (AERONAUTICS), ADVANCED RESEARCH AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Charles W. Harper was appointed to this position on May 3, 1967. He is responsible for coordination and management of the aeronautics research and technology development activities conducted in the various divisions of the Office of Advanced Research and Technology (OART).

Prior to this assignment, Mr. Harper had been Director of the OART Aeronautics Division since October 1964.

Born in Canada on September 24, 1913, Harper became a United States citizen in 1941. He was graduated from the University of California at Berkeley in 1941, with a degree in Mechanical Engineering, Aeronautics Option. He joined the NACA Ames Research Center in 1941. Successively he became Assistant Chief of the 7 x 10′ Wind Tunnel Branch, Assistant Chief, then Chief of the 40 x 80′ Wind Tunnel Branch, then replacing H. J. Goett as Chief of the Full Scale and Systems Research Division until transferring to Headquarters. This division specialized in wind tunnel and flight research directed at achieving low flight speeds, in the development and use of ground based simulation as an aerospace research technique, in guidance, navigation and control system studies for manned and unmanned aerospace vehicles, and in the physical research associated with guidance, navigation and control systems.

Harper was elected as a member of the Tau Beta Pi and Sigma Xi and is a member of the American Institute of Aeronautics and Astronautics.

He lives with his wife at 4764 Reservoir Rd., Washington, D.C.

STATEMENT OF CHARLES W. HARPER, DEPUTY ASSOCIATE ADMINISTRATOR (AERONAUTICS), OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the subcommittee, a number of recent studies, for example that of the Library of Congress for the Senate,[1] that of the Transportation Workshop, cochaired by General Schriever and Dean Seifert of MIT,[2] and that of the National Academy of Engineering,[3] have emphasized the present and future importance of aviation. The studies have emphasized the need for rapid advances in air transportation capabilities, have emphasized the lack of exploitation of new technology developed from research, have pointed out the need for more research in many areas and have stressed the importance of national planning for aeronautics.

The problem is perhaps a most critical one from the standpoint of

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[1] "Policy Planning for Aeronautical Research and Development," 89th Cong., 2d sess., S. Doc. 90, May 19, 1966.

[2] "Air Transportation 1975 and Beyond, a Systems Approach," Report of the Transportation Workshop, 1967.

[3] "Civil Aviation Research and Development," an assessment of Federal Government involvement, by the Aeronautics and Space Engineering Board of NAE.

civil aviation. The following comments, then, are directed toward civil aviation although some of the problems considered undoubtedly have military counterparts or implications.

In these comments I am mindful of the fact that NASA's principal role is in the assessment and advancement of aeronautical technology. However, the problems of civil aviation are characterized by the interaction of technology with nontechnological factors which are highly complex and on which many different views are possible. In order to be of the most assistance to the committee, my comments will include some views and suggestions on matters outside of NASA's purview in order to place into a meaningful context my statements about the technological aspects of the problem with which NASA is directly concerned.

The problems of aviation can be separated into a few broad categories. First, with so many possible directions for development to follow it is extremely difficult to choose the proper ones to emphasize at any one time, as measured against the ultimate national benefit. The need for national planning stems directly from this situation. Second, with so many choices possible, the available research resoures become diffused and shallow unless constrained by agreed-to objectives. Related to this is the fact that the separate elements of a system, that is, the vehicle, its operating environment and related ground services, have in the past been studied as relatively separate entities when, in fact, they are closely interconnected; use of the integrated systems approach by DOD in the development of military aviation has enabled considerably more progress here to overcome this problem than is seen in civil aviation. Third, the implementation of new technology to achieve desirable new capabilities has been inhibited through rapidly rising financial and technical risks.

Although the problems related to aviation development obviously are many and complex, it does seem possible to consider specific actions which would lead toward solutions. In the following discussion an attempt is made to consider these problems in more detail and arrive at conclusions and recommendations worthy of specific examination.

Examples of specific problems are numerous. The proposals by some groups to limit air transport to control increasing noise are matched by the proposals of other groups to remove air traffic control constraints which prevent increased availability of needed air transportation. The proposals that public air transport be given precedence over private are countered by arguments that industry cannot function without corporate air transport. The attempts to place airports and their annoyance away from congested areas ultimately fail because business and people, attracted by quick access to distant areas, relocate to be close to remote airports. Competition for a share of the major aircraft industry is intense; and while the U.S. industry exerts itself to the limit to maintain its lead in providing the now dominant jet transport capability, foreign nations are moving ahead aggressively in the areas of very short haul operations and supersonic transport capabilities; thus we see French, German, English, Canadian, and Japanese aircraft being placed on trial service to satisfy growing U.S. transport needs. As ground transportation saturates, a continuing struggle exists to maintain helicopter services which generally cannot operate without some form of subsidy, but which services are considered a necessity in many cases. The International Air Tranport Association and the Civil Aeronautics Board strive constantly to maintain healthy economic competition while, at the same time, assuring vital-service, and their decisions affect not only the future of major elements of the industry, but of the development of areas in the world.

Some attempts to deal with all these problems individually have revealed a task of such magnitude that usually the study concludes by giving serious consideration to only a few of the problems. Other attempts arrive at the logical conclusion that an overall national aeronautics program be established through systems analysis, relating air transportation to other transport modes and to national goals, and working backward to define critical problems for solution.

Mr. Hechler. May I interrupt with this observation as I read that and did you have in mind at what level this could or should be done in the Government?

Mr. Harper. It must be a joint effort. I am certain more than just NASA, certainly, and this is part of the reason for our beginning these studies with the Department of Transportation. It obviously involves several Government agencies, and I am certain others will come into the picture later. I think it is really a bigger problem than one agency can handle.

Mr. Hechler. It is directly related to national goals which are perhaps even above the agency level.

Mr. Harper. Yes, I think you are right. The example of the national noise alleviation problem is one element of this whole activity.

Mr. Hechler. It is really a small one. What you are talking about is the whole ball of wax.

Mr. Harper. Yes, sir.

Mr. Hechler. You may proceed.

Mr. Harper. History shows that, with the first approach, solutions to one problem can create more problems; for example, achievement of efficient jet transports created noise and traffic congestion problems to be solved.

The second approach, while certainly the most rational and clearly necessary, is impractical as a sole choice since it implies that the present situation with all its problems be accepted until the long-term study can be completed and its conclusions effected. To resolve this dilemma, it appears necessary to anticipate those long-range conclusions which are of importance for immediate action without waiting to obtain irrefutable evidence as to their correctness. If this is done, then the various roles of Government and industry in research and development can be examined and the best means found to implement them within the resources available. Resource limits will serve to establish a priority for goal achievement.

Some of the conclusions the long-term study will reach appear so obvious from projections of current requirements, that there appears little reason to delay active implementation to the extent possible within the present state of technology. Among these are the following:

(1) The present subsonic jet will remain the basic longer range transport system. It must be made quieter, require less runway

length, require less time in landing to increase airport acceptance rate, and normal operation must be more automatic for safety.

(2) The hover capability of the rotorcraft will leave it the outstanding airborne contender to meet rapid air transport demands within congested areas. It must be made more efficient, exhibit much reduced vibration and fatigue, achieve higher degrees of stability for ease of control and safety, and produce less noise.

(3) The short runway (1,000 to 1,500 feet) capability of the 50- to 100-passenger STOL transport will fill an important gap between the rotor craft and the short-range jet transport to satisfy interurban transport requirements. It must have high reliability to allow frequent trips, be extremely quiet, and have great flexibility of operation in congested airspace. Smaller, less sophisticated versions will be required to meet the expanding third-level (scheduled or air taxi) carrier needs.

(4) The large, longer range VTOL transport requirement will not become critical for a decade or more.

(5) Demands for long range with short traveltime will continue to emphasize the need for development of the supersonic transport.

The technologies required to achieve these classes of air transport must be examined in three areas: The vehicle itself, the environment in which it operates, and its interface with necessary surface modes. As will be discussed, the levels of technology in these three areas are different as a consequence of the past research efforts applied to each.

Considering first the technology associated with the vehicle itself, it is found that the technology is well advanced through the research stage in many, but not all, of the areas required. This, of course, would be expected in view of the long support given NACA/NASA aeronautical research programs as well as research by other groups.

(1) Techniques for reducing approach speeds of subsonic transports by one-third, and runway requirements by one-half, have been exposed; analysis shows how to reduce approach and landing times by up to two-thirds to increase airport acceptance; progress has been made toward automatic operation for normal conditions; major steps have been taken toward achievement of noise alleviation through quieter engines, sound suppression techniques, and new operational techniques.

(2) Promising avenues have been opened up for overcoming the rotorcraft problems; the rigid and jet flap rotors offer major reductions in vibration and fatigue; the tilt rotor offers, in addition, near-airplane cruise performance.

(3) The success of the STOL aircraft depends on the ability to use its installed power to create lift; several promising techniques for accomplishing this for both propeller and jet-driven aircraft have been investigated.

In several areas of technology, the research needs additional effort.

(1) Gas turbine engine technology requires a broader base so that engine development costs can be reduced to the point where it is possible to develop engines for specific application rather than having to accept off-the-shelf items for most applications.

(2) Research on the application of new materials must be expanded to enable these to move more rapidly from the laboratory into practice.

(3) VTOL aircraft research must be expanded to take advantage of specific new propulsion systems and new materials in order to achieve economic viability.

Although continued research is required to provide a flow of new technology, in many cases it appears the vehicle technology is available for exploitation to meet pressing current air transportation requirements, at least for next generation machines.

The situation with regard to the technology related to the environment within which the vehicle operates is not so satisfactory. Two interfaces are of particular concern; the interface with the man who operates the machine and the interface with other vehicles in the airspace—the air traffic control. Both problems present a similar difficulty of solution; they are so complex as to defy rigorous analysis. Thus, progress toward solution tends to be evolutionary, moving slowly from an operable but unsatisfactory state toward what is believed desirable. Revolutionary or major steps are inhibited because of the cost of failure; an airplane of good performance is valueless unless it can be flown acceptably; an air traffic control system losing control over only one small element of the system would be chaotic even though otherwise perfect. In the absence of rigorous analysis, solutions to these problems must be found through expanded use of very sophisticated simulators made possible by the high-speed digital computer. With this research tool, relatively low-cost examination can be made of new designs proposed to solve these complex problems. Demonstrated success in this way can provide the confidence to proceed with the very heavy investments involved in a major new system.

However, before the simulation studies can be undertaken, the technologies involved in the new system to be studied must be well understood and integrated into proposed design(s). In the case of the air vehicle, much of the technology exists to do this, and the limitations of the process are found largely in the level of development of the simulation technique. It does not appear possible to make the same statement with regard to air traffic control. The present system is based on logic established in the late 1940's. Advances have been made by adding elements to the system and modernizing elements of the system to accomplish the same purposes more efficiently. Within these constraints, very remarkable success has been achieved in handling a wholly unpredicted growth in traffic. However, continued evolutionary modernization alone may not suffice. One of the most promising avenues for a new approach lies through exploiting the experience and technologies developed in the space networks required for tracking, control, and data retrieval. Even if these developed systems are accepted as the basis for a future ATC system, much additional research is required to establish the detailed technology necessary for an ATC system based on these principles.

The third area of technology, that of interface with the surface modes, has not been the subject of extensive specific research effort. Although many ideas have been proposed for collection and dispersal of passengers and freight, few have been supported by a directed research effort. At the present stage it cannot be stated with certainty that a technology research program would be rewarding; it is hard to conceive, however, that some success could not be achieved toward resolving this pressing problem through a directed research effort. Since major advances here undoubtedly are a long-term program, this problem must be an important facet of any overall transportation systems study.

Despite the gaps which can be identified in technology related to air transportation, it is still evident that a great deal of technology exists which as not been exploited through development. If developed and applied, this technology could provide, if not the optimum or final answer, an adequate answer to some pressing transport problems and from which improved systems could evolve. Thus it does appear possible to satisfy some of the conclusions expected to be drawn from a long-range study; it is also possible to identify areas where additional research is needed critically if solutions to other serious problems are to be found.

The question of implementing new technology through development is much more difficult to resolve than that of identifying needs and providing technology through research. The problem involves factors such as the following: The investment involved in preparing a new type of aircraft for certification is high. However, until certification has been achieved it is difficult for the user to plan for the aircraft's operation, for such groups as the FAA to plan for new air traffic control requirements, and for local communities to prepare for necessary ground interfaces. This emphasizes why air transportation has developed along evolutionary lines with major differences appearing in size and engine placement, factors not likely to cause serious deviations from previous experience, and designed only to provide a variant to a basic transportation capability. Major technical advances in new aircraft are found primarily in subsystems which are capable of substantial modification without serious disruption of production lines.

It is important to note that the foregoing circumstances exist even where no serious technical problems arise when the first vehicle is flown. Unfortunately, this is not necessarily the case where wholly new vehicles are concerned. Assembly of a group of individually satisfactory new technologies into the complex represented by the modern aircraft can result in an unsatisfactory whole through poor interactions between the elements; although simulation can assist greatly in preventing this, the technique is not so well developed yet as to enable complete avoidance of this problem.

Implementation of new technology can be considered one major constraining factor in the continued development of air transportation, perhaps more than research, although more would be required of research if implementation were accelerated. Solution to this implementation problem, then, is the key issue.

In the past, the Government through the military services, has provided the path to implementation. Air Force bomber and tanker developments provided the proving ground for the present subsonic jet transports and their engines. Navy and Army programs provided the current group of commercial helicopter transports. Military programs here and abroad provided the base for many of the small STOL aircraft now being considered for use. It has been pointed out repeatedly, however, that future military programs will probably not provide the same base in the future both because of their less experimental nature and because of the growing difference between commercial and military requirements. If accelerated implementation is desired or required for national purposes, some substitute for military programs must be found to reduce the industry risk.

One solution is, of course, direct Government support as is found in the supersonic transport program. This may be the only solution for a task of this magnitude and where the competition is truly international. For the smaller, though more numerous elements of the air transport system, it would be preferable to maintain industry competition.

To examine the technology in depth generally requires construction of experimental demonstration hardware to gain confidence that the several new technologies required to achieve a total new system will interact satisfactorily, to retain the advances of each as found in the laboratory; this is particularly true where the interaction between the human and the vehicle is critical. Historically the NACA and NASA have not carried this responsibility in aeronautics to any great degree; historically the DOD has, and in the past NACA/NASA have leaned heavily on DOD for support in this regard, for example in the X series of research aircraft.

In the case of the national noise alleviation program, NASA was assigned the responsibility for continuing its research into demonstration hardware. A closer examination of this program is illustrative of the actions required. Before initiation of the national program, NACA/NASA laboratory research had shown three potential paths to noise alleviation. First, to absorb annoying noise frequencies through acoustic treatment of nacelles; second, to double the aircraft descent angle in approach; third, to redesign the engine to lower the noise generated. The laboratory research results alone did not provide the confidence, that they could be achieved in practice, required to justify the major investments by industry (in aircraft and engine development) and by Government (in new airport guidance systems). With its assigned responsibility, NASA undertook to provide this confidence. Modified nacelles incorporating acoustic treatment are under construction and will be flown in 1969 to determine the noise suppression achieveable and related operational costs.

A 707 aircraft has been modified in a manner that NASA pilots have judged steeper descents are possible with no loss in safety; FAA and industry pilots have evaluated the systems and are determining the acceptability and necessary action to implement the operation. Components of a quieter engine are under test, and industry is designing demonstration engines around these components for test in NASA facilities.

The total cost to the Government, for NASA's share in the noise alleviation program, will probably approach $75 million considering both funds spent with industry for support and funds to support NASA personnel and research facility operation as required in the program. Industry is contributing additionally through its own past activities and in augumenting the Government-supported program by in-house design and research.

Despite the cost of the demonstration phase of the program, the projected costs for implementation of the results in the future are very much greater and fully justify the present program to establish confidence necessary to proceed with the additional investment. Various estimates of the cost of applying acoustic treatment to nacelles of one aircraft range between $500,000 and $1.25 million; considering the several thousand jet transports involved, considerable confidence in success is required before such an investment can be undertaken even at the lower figure. Developmental costs of a flight-rated engine, even after successful operation of a demonstration, will be in the $100 million to $150 million range if past experience is used as a guide; beyond this, of course, is the large investment in engine production. The cost of modifying airport terminal guidance systems for steeper descents has not been assessed, but it cannot be expected to be small.

An important conclusion to be drawn from this illustrative example is that the cost to the Government of these demonstration programs, if confined to that level of activity, should always be a very small fraction of the total cost of achieving an implemented advance in air transportation. Nevertheless, the absolute cost to the Government may be substantial and careful choice must be made to identify those having high chance of success and of satisfying transportation requirements when successful. The value of such proof-of-concept programs is, of course, in the substantial reduction in the total risk of proceeding with implementation of new technology.

Mr. Chairman, this concludes my statement.

Mr. HECHLER. Thank you, Mr. Harper.

Earlier when Chairman Miller was alluding to some of the pioneer development in the NACA, it brought to mind the fact that this organization accomplished spectacular results in strengthening the Nation in areonautics. When alumni of the NACA get together they always get somewhat dewey eyed about how things were in the old NACA days.

Here is an organization that had a low budget and high morale and tremendous accomplishment. Are there lessons that can be learned by what NACA was able to accomplish that can be applied in strengthening our aeronautics program in the future?

Perhaps I should address that question to Dr. Paine.

Dr. PAINE. I would be very interested in hearing Mr. Harper's reply.

Mr. HARPER. I don't think the problem is in the lack of enthusiasm. I am quite sure that what has happened is that the complications of the problems have grown enormously.

In the time of NACA, airplanes were generally of the type which were designed along one line. It did not have to consider the various interfaces to the degree it does now. For example, the operations did not impinge upon the design of the control system. It was not troubling the public with noise the way it is now.

So I think the difficulty is that the complication of the problems and the very wide variety of directions we can go has grown much faster than the research activity that has been directed toward it.

Mr. HECHLER. I would like to ask one further question, then other members may have questions.

In your discussion of STOL, you concentrate largely on the technical aspects in development of technology in order to make STOL feasible.

Have you thought about the economic side of how these planes are going to be used?

Mr. HARPER. Yes, we have to a great degree. In fact, we have used the assistance of the industry to help us analyze this.

Mr. HECHLER. What is your concept of how STOL will be used in the future?

Mr. HARPER. The first application, I think, would be a replacement for the sort of service now represented by the Eastern shuttle, and obviously Eastern is thinking exactly the same way. This would let it use presently unused airspace around major terminals, also unused ground space at major terminals.

But the real advantage from this point on will be its ability to serve less well developed areas which may be urban areas with light industry, or simply living areas.

The important thing is a vehicle that can land on relatively short and relatively unprepared strips, and be sufficiently quiet to be able to come into a living area without unacceptable noise. I see a very great future for this kind of an aircraft as our population spreads, and we are not faced with operating out of such densely populated areas.

Mr. HECHLER. How will this relate, then, to the larger airports and trunk carriers?

Mr. HARPER. I would hope that this would enable centralization of some of the major truck areas away from the metropolitan area with the STOL aircraft serving as a feeder service into a major trunk carrier center from 200 or 300 miles. This is getting pretty speculative, however.

Mr. HECHLER. Mr. Chairman?

Chairman MILLER. I have no questions. I enjoyed the presentation very much.

Mr. HECHLER. Mr. Pelly?

Mr. PELLY. Mr. Chairman, I don't like to seem provincial in bringing up the Boeing 747 again, but isn't it true that the Boeing 747 will create less noise than the Boeing 707? Isn't that due to research in noise suppression?

Mr. HARPER. I would say this, Mr. Pelly, it will certainly have less noise than if engines of this thrust were designed as were the engines for the 707, although the final answer will not be until the airplane has flown, of course. I expect the absolute noise level will not be a great deal lower than the present aircraft.

What I can't give you is a very good answer on the annoyance level. We have discussed the difference between measurable noise and annoyance.

This type of engine, however, that the 747 is employing is one that is amenable to further noise suppression if it proves in flight that the aircraft is truly objectionable.

Mr. PELLY. As I gathered from your remarks, Dr. Paine, you have great confidence in the team that is working on the SST and you are confident that it will succeed in overcoming its problems?

Dr. Paine. Yes. In the long run we have great confidence in this.

Mr. Pelly. Very encouraging.

Mr. Hechler. Mr. Hunt?

Mr. Hunt. No questions.

Mr. Hechler. Mr. Harper, I am disturbed about what seems to be a larger number of accidents in helicopters. Have you devoted any attention to this question?

Mr. Harper. Yes, we have, Mr. Hechler, an increasing attention, but I am afraid not with increasing success.

This is an extremely difficult problem. In fact, we were discussing it with our counterparts in England just yesterday, from the Royal Aeronautical Establishment, possible cooperative efforts to predict these problems of fatigue which is the source of many of the helicopter accidents.

There is no valid technical approach to solving this problem at the moment. We are only beginning to understand some of the basic mechanisms of fatigue cracking of the parts of helicopters. In its conventional form it has high vibratory modes putting high frequency stresses on the metal structure in the hub. The only real approach to the problem at the moment is one of trial and error, and this is disturbing. It is disturbing, as I said, also, to our English counterparts.

We are looking toward methods of reducing this vibratory stress which is one good solution to the problem. The jet flap rotor, the development of which was sponsored by the Army with NASA assistance, shows, as I think we mentioned before, the capability of reducing these vibratory stresses by some 80 or 90 percent, and this would go a long way to increasing the life of the helicopter.

The difficulty is partly a financial one. If you change the blades frequently enough and the hubs frequently, you would not have this problem, but you couldn't have an economical system.

Mr. Hechler. Are you getting reports on the cause of helicopter accidents in Vietnam?

Mr. Harper. Yes, we have fairly close reporting from the armed services on their operations there. The problems are not related closely, however, to the operation of the civilian aircraft that has a much longer life expectancy. They are operating under such adverse conditions that the total overhaul is much less, so there are different problems in this case.

Mr. Hechler. Mr. Gerardi?

Mr. Gerardi. Do you have any established procedure for dealing with development programs, for example, VTOL and STOL, that are going on overseas?

Mr. Harper. Yes. We have a direct agreement with the Royal Aeronautical Establishment so that we exchange our views to the point at least where they become proprietary and international competition gets into the picture.

We have, through our military liaison offices in France and Germany, arranged joint efforts, and we are considering now a joint program with the Dornier people.

Mr. Gerardi. You have kept up with the developments?

Mr. Harper. Yes.

Mr. Gerardi. Are you keeping up with the British developments?

Mr. Harper. Yes. We have at Langley Research Center one of the P–1127 aircraft, which is the prior version of the Herrier.

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Mr. GERARDI. How are we doing in these particular fields? Are they ahead of us?

Mr. HARPER. Not in a research effort, no, they are not ahead of us. They have taken somewhat more of a risk toward implementing the research than we have in this country.

We did go through this series of so-called testbed VTOL aircraft some years ago, supported by the military. I think, really through government sponsorship, abroad they have backed more VTOL work rather than waiting for the industry to do it on their own initiative.

Mr. GERARDI. Possibly the Government should go further and actually produce an experimental piece of hardware. This apparently is what is going on.

Mr. HARPER. Yes, it certainly is one solution to accelerating implementation. There is no question that there is a very high risk in going from classic NACA or NASA type of research to a vehicle that incorporates this new technology.

Mr. GERARDI. Even if that were to happen, would that be sufficient in view of the past history of many of our aeronautical developments where DOD has not only sponsored the testing of experimental prototypes but actually placed large initial orders so as to permit producers to furnish the civilian users a product that was relatively inexpensive?

Mr. HARPER. I doubt it would ever reduce the risk to that level, but perhaps that isn't necessary. It could solve a number of problems that the industry faces at the moment.

One that I mentioned is the fact that an aircraft now is certificated at the time the FAA can fly it. At this point the manufacturer has a very substantial investment. If this is an evolutionary type of aircraft, such as you can see in the derivatives from the 707, the DC–8, 747, which are all of a type, the manufacturer and the operator are taking relatively little risk and gamble with regard to certification of the aircraft. However, in something totally new, where the Government has no experience in certification and where it has no way to turn to get it, the risk to the industry becomes very much higher.

This, of course, is one of the reasons this Eastern STOL experiment is of such tremendous value. It gives the FAA—for the first time—a chance to determine how you certify a STOL aircraft.

Mr. GERARDI. This certification is not only with regard to the flight vehicle, but also the inner phase.

Mr. HARPER. Yes, surely.

Mr. GERARDI. You imply that this might serve to inhibit the application of technology to some degree. Is there any interim certification procedure that would still permit the technology to move forward without delaying the final certification?

Mr. HARPER. I think the quiet-engine program is one of this nature. Also, the experiments we carried out on the steep descent program were brought to the point where the NASA pilots judged it an acceptable procedure from the standpoint of safety; it was then made available to the FAA to evaluate. This will give the FAA the basis to judge whether they can accept this kind of proposal from the industry.

Mr. HECHLER. Mr. Hines?

Mr. HINES. In your paper on page 11, you mentioned the Department of Defense has had the responsibility for new designs. NACA–NASA has not had that responsibility.

Can you suggest any alternatives if the DOD is going to be phasing out of this role?

Mr. HARPER. Yes, certainly the Department of Transportation could, I think, with NASA's engineering technical background, undertake to sponsor aircraft like this.

Mr. HINES. One further question. How has the economics of the aviation industry and the requirements for R. & D. support been cranked into your thinking and the thinking of the DOT?

Mr. HARPER. The direct mechanism has always been through our research advisory committees and their concern over economics is very apparent in all of our meetings.

Mr. HINES. This would dictate the research options that would be open to you?

Mr. HARPER. It has a very strong influence.

Mr. HECHLER. Do other members of the committee have any further questions?

(No response.)

Mr. HECHLER. If not, I want to thank you, Dr. Paine and Mr. Harper and associates, for this excellent beginning of our hearings in aeronautics.

The committee will stand adjourned until 10 a.m. tomorrow.

(Whereupon, at 11:50 a.m., the committee was adjourned until 10 a.m., Wednesday, September 24, 1968.)

(Questions and answers for the record on statement by Mr. Harper.)

QUESTIONS SUBMITTED TO CHARLES W. HARPER BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. On page 2 of your statement, you state that NASA's role is the assessment and advancement of aeronautical technology. Setting aside the non-technological factors which interact with technology, how does NASA specifically identify the technological needs of the next decade? Does NASA regularly survey the scientific community, the aerospace industry and the air transport industry in securing inputs for its assessment as to the adequacy of aeronautical technology to meet the needs of the next decade?

Answer 1. In identifying future technological needs in both aeronautics and space, NASA relies heavily on the recommendations of knowledgeable individuals from the aerospace industry, the users of aerospace equipment, and the scientific community. Although much relevant information is acquired through normal contacts with individuals from these areas during the course of NASA activities, formal channels have been established to assure that outside expertise is properly utilized in NASA planning. The principal advisory group insofar as research and technology are concerned is the Research and Technology Advisory Council and its 20 associated committees, subcommittees, and panels. The functions of this advisory organization are to advise NASA on advanced research and technology goals and critical problem areas in both aeronautics and space, and to review and evaluate work in progress and plan and assess its technical worth to advanced research and technology goals. The Council is the apex of the pyramidal advisory structure; it integrates the inputs of all elements of the organization and formulates advice and recommendations which are provided to the Associate Administrator for Advanced Research and Technology and to the Deputy Administrator.

The membership of the various Research and Technology Advisory organization elements includes approximately 250 outstanding experts from industry, universities, non-profit institutions, and other government agencies. The membership also includes approximately 140 NASA personnel representing both headquarters and the field centers.

Meetings therefore provide information exchange, discussion, and advice at the working level, in addition to supplying advice and recommendations through the Council to top NASA management. Each group normally holds two meetings usually of two-day duration, each fiscal year.

The Research and Technology Advisory Committee on Aeronautics is specifically responsible for consideration of research and technology related to aeronautics. Under the Aeronautics Committee are 5 Subcommittees (Aircraft Aerodynamics, Aircraft Structures, Airbreathing Propulsion, Aircraft Operating Problems, and Aircraft Flight Dynamics), and one Panel (Fatigue of Aircraft Structures). Membership of these groups includes 48 individuals from the aerospace industry, 7 from the air transport industry, 14 from universities or nonprofit institutions, and 27 from government agencies other than NASA. Typical of the aerospace industry representatives are Chief Research and Development Engineer, Director of Engineering, and Vice President—Research. Members from the air transport industry include officials such as Assistant Vice President—Research and Development, and Vice President—Equipment Planning and Development. Typical of the representation from the scientific community are President of an independent research institution, Director—Aeronautics Division of a university-associated research laboratory, and Chairman, Department of Aeronautics of a university.

In addition to the aeronautics committees above, other elements of the advisory organization contribute to the definition of aeronautics-related technology needs through their consideration of disciplinary areas pertinent to aeronautics goals. Among these are the Committee on Biotechnology, the Committee on Electronics (including 3 subcommittees) and the Committee on Basic Research (including 2 of its subcommittees and one panel). The membership of these elements includes 42 individuals from the aerospace industry, 34 from the scientific community, and 19 from other government agencies.

Question 2. On pages 2, 3 and 4, you make a compelling argument for the use of an overall systems analysis of the national transportation system to arrive at an optimum national aeronautics program. You then state that such an analysis is impractical as a sole choice because it implies that current problems may remain unsolved pending the completion of such an analysis. Would it not be possible to proceed with such a study, develop several orders of priority tasks and several models so that the more pressing problems can be attacked now but consistent with the desired long range goals?

Answer 2. A systems analysis of the total national transportation system would not purport to be totally inclusive of all problem areas in all modes. Instead, it serves as a guide for anticipating the types of service and the growth rate expected of these types. At the next finer level of detail, the types of service can be translated into optimum modes and the integration requirements of these modes. Many levels of detail may be extended from this point—each guiding activity in a more specific fashion.

However, each level of detail serves as a guide. A total study need not be completed prior to beginning action. The relative importance of different areas becomes clear in the earliest phase of analysis. Emphasis can be shifted accordingly—and refined as the analysis progresses.

A second notable characteristic of a systems study designed to project national requirements is that it can not terminate. It is intended as a continuing guide, not a one time survey. Implementation of results is, therefore, a continuing data input to the analysis.

NASA is now developing guidelines from the systems analysis effort being conducted by our Mission Analysis Division in cooperation with DOT. These guidelines are consistent with the level of detail now emerging from the system.

In addition to this, NASA places R. & D. effort on areas of significance to aeronautics but which would not be expected to emerge from the system's analysis of the national transportation network. Such problems as efficiency, safety and noise level of private aircraft, as well as larger commercial aircraft, are examples.

The effort directed toward solving these problems is, of course, fully consistent with the long range goals of the transportation study.

Question 3. On pages 5, 6, and 7 of your statement, you have outlined certain critical aeronautical research and development problems, many of which are currently under study or in the process of being resolved. Some, however, still require solution. Is research being conducted in these areas? If so, by whom? Is NASA capable of performing more research with its current physical plant *and personnel, assuming that sufficient funds were made available? In your opinion, should more research be done in these unresolved areas and should it be done by NASA, either in-house or by contract?*

Answer 3. *Subsonic jet-transport technology requirements.*—Research has indicated methods of reducing approach speeds by 1/3, runway requirements by 1/2, and progress has been made towards automatic operation of normal conditions; major steps have been taken to reduce noise by use of quieter engines, sound suppression techniques, and new operational techniques. The present NASA quiet engine program is aimed specifically at subsonic jet aircraft application. Continued effort at the Electronics Research Center is planned related to automatic operation; a particular need is for additional effort to improve component reliability, enabling eventual automatic operation under near all-weather conditions.

Rotocraft technology requirements.—Several rotor concepts have evolved, promising alleviation of some of the current helicopter problems and limitations; the rigid and jet-flap rotors offer major reductions in vibration and fatigue, as well as improved stability and control; combining such rotors with a winged version of the helicopter should also improve the efficiency; the tilt-rotor appears to offer further improvement in efficiency; approaching that of conventional aircraft. Proof-of-concept studies are planned on these concepts by the NASA.

STOL transport technology requirements.—Several promising concepts have evolved which use installed power to augment the normal aerodynamic lift; these include the rotating-cylinder flap for propeller-driven aircraft and the augmentor-wing and externally-blown flap for jet-powered STOL vehicles. Proof-of-concept studies are planned or being considered on these concepts by the NASA.

General technology research needs.—Additional research effort is required to provide a broader base in gas-turbine engine technology, to reduce the costs of engine developments for specific conventional and V/STOL aircraft applications. Some increase in NASA effort is planned at the Lewis Research Center.

Needed expanded NASA research on the application of new materials, enabling their practical use in conventional and V/STOL aircraft, could be supported by the NASA in-house and under contract.

Much of the work outlined above could and should be expanded; additional manpower would have to be made available along with additional funding. The work would be conducted in-house and under contract.

Question 4. On pages 9 and 10, you state that the development of existing technology could be expected to satisfy some of the conclusions from a long range overall analysis but that it is also possible to identify areas where additional research is critically needed if solutions to other problems are to be found. Could you provide some examples of these areas where additional research in critical areas is needed?

Answer 4. Research has indicated methods of reducing approach speeds with a resulting decrease in runway length requirements and an attendant decrease in approach and landing times. The effort in this area should be expanded and expedited to relieve congestion at large city airports and to bring needed service to smaller cities that do not have large airport facilities; and also to improve safety through better control of the aircraft with reduced pilot workload during the critical approach and landing phase of flight and inherently through reduced landing speeds.

Automatic landing of aircraft is feasible under normal operating conditions but the systems must be made reliable for foul-weather operations and more effort is needed to accomplish this.

The Air Traffic Control System is becoming saturated and a comprehensive research effort is required to provide the technology for an advanced integrated system to handle the volume of traffic that will be required in the late 1970's and early 1980's to satisfy the needs of U.S. commerce (cargo and passengers) nationally and internationally. Such a system will also be required to handle the wide range of aircraft from SST's to VTOL and STOL vehicles foreseen as operational in the 1970's.

The development of new materials and new structural concepts utilizing new materials and the development of fabrication techniques is an area in need of greatly expanded effort for improved airframes and engines to reduce structural weight and to permit high engine operating temperatures resulting in reduced fuel consumption.

Gas turbine engine technology requires a broader base so that engine development costs can be reduced to make it practical to develop engines for specific applications rather than having to accept off-the-shelf engines for most applications. This is particularly important to VTOL and STOL aircraft. A number of V/STOL aircraft concepts show considerable promise of fulfilling the transportation needs of the country and several areas of research have been identified as needing increased effort. For example, research has shown means of increasing the performance of rotorcraft and of markedly reducing vibration with its resulting short rotor fatigue life and high maintainability costs and lowered reliability. Research on lift-fans has indicated large improvements in thrust-to-weight ratio and noise. These efforts should be expanded. Several techniques have been studied in the wind tunnel that show promise of efficiently and effectively creating lift by using the aircraft installed power to achieve true STOL operation. These concepts should be tested in flight with modified existing aircraft to prove the concept in the real and dynamic environment of full-scale flight including the integration of the pilot in the system.

Question 5. On page 10, you refer to the difficulty with proceeding with wholly new vehicles. As far as the problem of interactions between various elements in a new vehicle is concerned, would not NASA be of significant assistance here? NASA has been able within a period of less than ten years to achieve satisfactory interfaces between highly sophisticated and complex space vehicles and payloads.

Answer 5. The NASA can be of considerable assistance with regard to the interaction of the various elements of new aeronautical vehicles and new design concepts.

The principal problem lies in the need for a manufacturer or airline to be relatively assured of success prior to the development of a new vehicle and the investment of large sums of money which such a venture entails. The NASA is in a position to pursue new ideas and innovative concepts from the fundamental research through applied research in wind tunnels and on simulators to define promising applications. At this stage a promising new concept can be incorporated in an existing aircraft or perhaps a new research aircraft for flight test without the necessity of incorporating the other complete systems and requirements of aircraft intended for airline use. This permits the exploration of and investigation of the new concept in the real and dynamic environment of full-scale flight to prove the concept. For example, in a planned proof-of-concept study of a rotating cylinder flap which wind tunnel test results have indicated to be capable of increasing lift about 3 times that of a conventional flap, an OV–10A (COIN) aircraft has been obtained from the Army and the rotating cylinder will be installed. However, it is not necessary that the modified aircraft have the sophisticated navigation system or range capability of the original aircraft. It is not even necessary that it have a retractable landing gear since the concept to be tested is to provide STOL capability and the problems to be studied are involved with low speed approach and landing only. The other system requirements for cruise flight remain unchanged. Such proof of concept could provide a manufacturer or airline operator with the confidence to proceed with vehicle development.

Another facet of the problem is the need to obtain FAA certification for new aircraft and the NASA can be of assistance here also with regard to criteria needed by the FAA for defining handling qualities requirements for new vehicles, particularly where new innovations are involved. The NASA works closely with the FAA and is presently engaged in a joint effort to develop such criteria for STOL aircraft. When such criteria are defined and FAA's requirements established the manufacturer will then know what requirements his design must meet.

These problems have not existed in the development of space vehicles because the NASA has been the sole customer with control of requirements and objectives.

Question 6. On pages 11 and 12 of your statement, you mention the need to construct experimental demonstration hardware to gain confidence in the application of new technologies. You also state that the Department of Defense has in the past been the great supporter of this concept. Assuming that we can find a substitute source of funding for this function, do we not have missing a very important factor before a new vehicle is acceptable to the air transport sector? Is it not true that in many cases, the Department of Defense, sometimes with the help of NASA, supported the developmental cycle through prototype construc-

tion and testing, but more importantly placed such large initial orders for the new vehicles that the product, in a modified form, was then available to the private sector at a cost much less than otherwise available? Do you believe that private interests would be willing to assume the responsibility for a desired technology after it had been reduced to a prototype and successfully tested? Might there be a need for a cost sharing between the private and government sector after this point?

Answer 6. Higher production and lower unit costs are related. There is no question about this. The high production of engines and air frames for the military, and the subsequent lower cost production as well as the sale of low cost surplus equipment to the civil sector was a siné qua non for civil aviation during the period between the First World War and World War II. Following World War II, the overflow of military aeronautical goods and developments was still important but no longer a siné qua non. This bonus to civil aeronautics has decreased in importance as civil aeronautics has secured its economic foothold in the economy. At present, the exchange between the military and civil sectors is more one of a transfer of data than a cost reduction associated with production of goods. The actual production rate of military aviation goods is no longer a noteworthy factor in civil aeronautical costs.

Civil aeronautics, however, is not yet able to accept the high technical gambles new development requires. Prototype development does reduce this gamble to an adequate level. However, there are other ways to stimulate civil aeronautical development. Cost sharing is only one approach. Greater government participation in the cost of ground facilities, testing assistance, and more rapid certification are others.

Question 7. In your example of the noise abatement program as mentioned on page 13 of your statement, you refer to the fact that private industry is augmenting the government effort through in-house effort. How are these efforts coordinated between the government and the many firms involved so as to insure full and expeditious interchange of information and results and to prevent duplication of effort? Is there or should there be any effort to seek an agreed upon division of tasks and funding between industry and government for this as well as other critical aeronautical research programs?

Answer 7. The results of noise abatement research efforts supported by private industry funds have been presented to the Government and other organizations involved with the noise problem through formal coordination committees such as the Interagency Aircraft Noise Abatement Program. The Interagency Aircraft Noise Abatement Program, which is composed of government, industry, and individual experts, was established by the Government, under the direction of the Department of Transportation, for the exchange of aircraft noise abatement information and to identify, investigate and recommend specific actions which would enhance the effectiveness of the noise abatement program. Formal briefings on industry results are also presented to government and industry members of the National Aeronautics and Space Administration's Subcommittees on Fluid Mechanics, Aircraft Operating Problems and Air breathing Propulsion. Informal discussions and reviews are also held for cognizant staffs of the Department of Transportation, Federal Aviation Administration, Department of Housing and Urban Development, and the Environmental Sciences Service Administration.

The NASA has recognized the need for coordinating and interchange of results obtained from private industry sponsored research with government sponsored research in order to prevent unnecessary duplication of effort. This need has been reflected in the recent NASA contracts awarded to Boeing and Douglas for the study and development of turbofan nacelle modifications to minimize fan-compressor noise radiation. The Boeing and Douglas contracts both contain the following clause that insures the availability, to government and other interested organizations, of noise alleviation research data resulting from research conducted with Boeing and Douglas funds (Independent Research and Development and in-house) :

CONTRACTOR-SPONSORED R. & D. NOISE ALLEVIATION RESEARCH DATA

A. "The Contractor will provide NASA with a record of all company-funded research and development effort on noise alleviation to date and will update this list at regular intervals during the term of this contract. 'Noise

Alleviation' as used herein is limited to the alleviation of airport community noise by engine nacelle and engine modifications that reduce noise radiation."

B. "All data generated under research and development effort on noise alleviation by the Contractor will be furnished to NASA upon request. The Government may duplicate, use, and disclose in any manner and for any purpose whatsoever, and have others so do, all data delivered under this clause."

C. "The standard Rights in Data clause and Data Requirements clause of the General Provisions have no application to data delivered pursuant to paragraphs A. and B. of this clause."

The National Aeronautics and Space Administration has always supported a continuing effort to seek an agreed upon division of tasks and funding between industry and government for noise abatement programs as well as other critical aeronautical research programs. Along these lines, it should be noted that at the present time there is no indication that industry is willing to design engines for minimum noise without the technological assurance provided by actual engine test experience such as proposed in the National Aeronautics and Space Administration's Quiet Engine Program. It is anticipated that as a result of decreased technological risk, industry will incorporate the noise abatement techniques expected to be demonstrated in the Quiet Engine Program into their engine designs. The results of the supporting research and technology program and its status are being provided to the engine industry on a continuing basis.

Question 8. In your statement, you mentioned the Report of the Transportation Workshop chaired by General Schriever and Dean Seifert of MIT on the subject of a systems approach to air transportation needs in 1975 and beyond. What are the more important conclusions from the systems approach in this report as they relate to possible adoption and utilization by NASA?

Answer 8. The study viewed the entire field of aeronautics as a responsible element in the total social and economic system of the nation. The most important conclusion of the study is that progression in Aeronautics must be coupled to the growth pattern of the society which sponsors it. Aeronautical research, products and services must have the guidance of analyses in which the patterns of a developing national and world society define the role expected of it.

NASA recognizes this and is now applying this type of analysis in a cooperative effort with DOT. The results will serve as a planning guide for NASA aeronautical research and development programs.

Numerous technical recommendations were made, the synthesis of which urged higher levels of effort in aeronautics with an emphasis on systems which increase the utility of existing airports and air traffic control and systems which will decrease the dependence of air transportation on large conventional airports, i.e., V/STOL. NASA has increased its study effort in both areas, and accelerated its R. & D. program for V/STOL systems.

Priorities for specific research or specific developments were not suggested in the study. Guidance at this level of detail must emerge from the systems analysis approach now being applied.

AERONAUTICAL RESEARCH AND DEVELOPMENT

WEDNESDAY, SEPTEMBER 25, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to call, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. HECHLER. The committee will be in order.

I am pleased to welcome back this morning Charles W. Harper, Deputy Associate Administrator for Aeronautics for NASA, and James M. Beggs, Associate Administrator for Advanced Research and Technology.

Even though you were here with us yesterday, Mr. Beggs, I would just like to extend a special welcome since this is the first set of hearings at which you are testifying in your new capacity as an Associate Administrator in charge of the Office of Advanced Research and Technology.

Also, we would like to welcome James E. Elms, Director of the Electronic Research Center of NASA, and we are pleased to have Dr. Edgar M. Cortright, an old friend of the committee, and now Director of the Langley Research Center.

Mr. Beggs, how much of NASA's work in aeronautics is under your jurisdiction in OART?

Mr. BEGGS. I would say almost 90 percent of the work. This includes the advanced research and technology work in aeronautics and its related technology. and applied work directed to aeronautics as well as electronics research as it relates to the aeronautical efforts.

There is, however, some work in the other offices of NASA. In particular, the OSSA Office covers basic study work and applied work directed to things like our advanced technology satellites which relate to the aeronautical effort.

This is a longer range kind of a look at aeronautics, but a very important one.

Mr. HECHLER. I would just like to ask you a general question before we proceed with the presentation. Mr. Welsh mentioned in his letter the extent to which space and aeronautics have become very firmly married. Has this been your experience in the way in which your Office is operating?

Mr. BEGGS. Yes. In several areas there are mutual benefits from the research we are carrying out.

In the materials area where we are advancing the art, looking for lighter weight, higher strength materials, we are pushing the art in a way that will aid both the space effort and the aeronautical effort in a very beneficial way.

In the area of structures, looking into the advanced mathematical areas and into the applied areas of making stronger, lighter weight structures, this is beneficial to both space and aeronautics.

In the electronics area I might mention a number of areas such as antennas, the work that Mr. Elms is doing in electronic components, the work that we have done in setting up the manned space flight network, information network, data network, is definitely beneficial to both the space and the aeronautical viewpoint.

There are a number of other areas which are mutually beneficial. The two areas in general support one another.

Mr. HECHLER. Mr. Elms remarked at the Electronics Research Center that when he is talking to space people, he says 80 percent of ERC wo... is done in space. When aeronautical people ask, he says 80 percent is done in aeronautics.

Mr. ELMS. That is a very good quote because it means that much of the work is basic to both.

Mr. HECHLER. Mr. Beggs, did you have some initial remarks to make that you and your associates might care to use in describing the work that NASA is doing in aeronautics?

Mr. BEGGS. Yes, Mr. Chairman. I would like to give you just a brief overview of our program. I am sure you are familiar with it, but some of it might be updating information which you received before, and then I would like Mr. Elms to discuss briefly the electronic area as it relates to aeronautics.

Mr. HECHLER. All right. You may proceed.

(The biography of James M. Beggs follows:)

JAMES M. BEGGS, ASSOCIATE ADMINISTRATOR, ADVANCED RESEARCH AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

James M. Beggs is the Associate Administrator for Advanced Research and Technology at NASA Headquarters, Washington, D.C. The Office of Advanced Research and Technology (OART) is one of four major NASA program offices.

Responsibilities assigned to OART include the planning, conduct, documentation and dissemination of the results of all NASA research and technology efforts related to space and aeronautics and the coordination of the agency's total program of supporting research and technology required to carry out specific flight missions. NASA centers over which OART exercises institutional responsibility are: Ames Research Center, Electronics Research Center, Lewis Research Center, Flight Research Center, Langley Research Center and the AEC–NASA Space Nuclear Propulsion Office.

Beggs was appointed Associate Administrator for OART June 1. He had served as a consultant to NASA since January 1968. He came to NASA from the position of Director of Purchases and Traffic, Westinghouse Electric Corp., Pittsburgh.

Beggs had been with Westinghouse since 1955. Earlier he served concurrently as General Manager of Westinghouse's Surface Division in Baltimore and as the Vice President of the company's Defense and Space Center.

Beggs was repsonsible for the development of several major weapons systems including research and feasibility studies in the underwater and surface armament fields.

A 1947 graduate of the U.S. Naval Academy, he served as a line officer in destroyers and submarines for several years before leaving the service as a lieutenant commander. He received his master's degree in business administration from Harvard University in 1955.

His professional memberships include the American Ordnance Association, the American Society of Naval Engineers, Sigma Tau, an engineering society, and the Armed Forces Communications and Electronics Assocation.

A native of Dallas, Tex., Beggs now makes his home with his wife, the former Mary Harrison, and their four children, in Ellicott City, Md.

STATEMENT OF JAMES M. BEGGS, ASSOCIATE ADMINISTRATOR FOR ADVANCED RESEARCH AND TECHNOLOGY, NASA

Mr. Beggs. First, it is a distinct pleasure to be here for the first time. I am looking forward to many more of these meetings.

Let me describe just briefly in several areas the work we are doing in OART related to aeronautics.

In the advanced research and technology area, we are doing a great deal of fundamental work that is performed with little constraint on applications.

I might point out at this point that it has been stated in certain quarters and assumed in others that aeronautics is a mature science and, therefore, one can dispense with much of the advanced research that has been going on in the past.

In my view, nothing could be further from the truth. Indeed, the art probably is advancing faster today than ever before in history.

The work we are doing here is devoted to looking at advanced ideas and concepts such as advanced airfoil design and other components of aeronautical design, and then building models—small-scale models—and testing in wind tunnels.

Out of this work have come some new concepts for wing design.

We are also looking into the full-scale dynamics of flight and the integration of the pilot into the total aerodynamics system.

The funding in this area, of course, also relates to the wind tunnel equipment, computers and, of course, the before-mentioned test models. This equipment has been in place for a number of years, and at this point in time probably could use some upgrading, and indeed we have started a program of upgrading some of our wind tunnel equipment and computer equipment, particularly as it relates to simulation and to the basic operation of the tunnels.

I might add that there is a problem that has been developing in this area in the area of our administrative operations budget. In view of the fact that we have had constraints over the past several years requiring cutbacks in our personnel, which, as you know, are covered fully in the AO budget, we are not operating our facilities at their full capability.

As mentioned, some of our equipment needs upgrading, and we have certain items in the current budget, and we are proposing items for the coming budget to upgrade our capability and give priority to the problems of aeronautics.

Turning to the area of general aviation, which Mr. Harper mentioned yesterday as one of the fastest growing areas of aeronautics, our work here is emphasizing the safety aspects of general aviation. As you know, there has been a very rapid growth in general aviation, particularly in business aircraft, private flying, and also the very rapidly growing field of the small feeder airlines. Our work here is directed to improving the reliability of aircraft and the maintainability of those aircraft, and this is done primarily by investigating improved structures and powerplants for these small aircraft.

In the VTOL-STOL area, which was touched on yesterday as well, our major emphasis is in work directed toward rotorcraft, and the STOL craft; that is, the short landing aircraft operating from runways of 1,000 to 1,500 feet.

The VTOL craft is a long range kind of problem, as Mr. Harper mentioned yesterday, and so we are not doing as much in that area.

For vehicles which must have the hover capability, the rotor, of course, is unsurpassed, but the conventional rotors, as mentioned yesterday, have undesirable vibrational characteristics that reduce its reliability, and also limit its cruise performance.

This has led to a number of accidents, as you know, that were related to the problems of fatigue, and we are investigating in our basic research programs the problems of fatigue and in our applied programs the problems of how to reduce vibrations in the craft itself. Programs in the jet flap rotor and tilt rotor design are directed toward these kinds of problems.

In about a year we should be ready for testing of this concept to try to prove whether or not we have indeed gotten at the basic problem of vibration.

In the STOL area we are looking at a number of possibilities that will increase the lift of these aircraft. The rotating cylinder flap and the jet-augmented wing are two of these developments. These will increase the performance and effectiveness.

Turning to the area of subsonic aircraft, our work in this area emphasizes the noise problem which we have been given, a national objective to attempt to reduce the noise.

It is in three areas. The first is to reduce the noise of the basic engine itself. This is the quiet-engine program, which is about to get underway, directed toward reducing noise in the engine itself.

The second area is to try to muffle the noise, and this has been to provide acoustic treatment to the nacelle in order to suppress the noise generated by the jet engine.

The third area is to keep the noise away from the people on the ground, which means a steep approach and by direct lift control of the wing. This was touched on yesterday.

We are currently in a program to modify the nacelles of a Boeing 707, and this will be finished in the coming year.

The steep approach program utilizing a Boeing 707 prototype was completed this past summer, and the FAA is currently analyzing the approach with FAA pilots testing the system.

We are also working on a supercritical wing which has the potential of increasing utilization of subsonic jets now in the air.

In addition to this work, we are conducting several studies at our mission analysis division. We are looking at the problem of the air transport problem in a broad way from a systems standpoint. This is a continuing study which we intend to keep in being for several years. It is in conjunction with the Department of Transportation, and we hope to have some preliminary recommendations, as I mentioned yesterday, by the spring of next year.

That concludes my statement, and I would like Mr. Elms to speak to the aeronautics program as the electronics work relates to it.

Mr. HECHLER. All right, Mr. Elms. If you want to proceed, we will then have some questions after you have given your presentation.

Mr. ELMS. Thank you, Mr. Chairman.

(The biography of James C. Elms follows:)

JAMES C. ELMS, DIRECTOR, ELECTRONICS RESEARCH CENTER, CAMBRIDGE, MASS.

James C. Elms has served in three major management roles in the National Aeronautics and Space Administration.

He is presently Director of the Electronics Research Center, NASA, to which he was appointed on October 1, 1966. He reports to the Associate Administrator for Advanced Research and Technology, NASA. In this position Mr. Elms directs the Electronics Research Center's mission which is to organize, sponsor, and conduct the basic and applied electronics research required for pre-eminence in space and aeronautics, to develop special electronics skills to respond to aeronautics and space problems arising in NASA, and to undertake the management of specific programs in space and aeronautics where ERC has the unique skills upon which those programs are dependent.

The research at the Electronics Research Center involves many scientific and engineering disciplines. The research areas include electronic components and devices, reliability and standards, power system components, guidance and control, avionics, instrumentation research, data processing, computer software, communications, microwave and optics. All of these electronic research areas are applicable to aeronautics and space activities.

In 1965–66 Mr. Elms was Deputy Associate Administrator for Manned Space Flight, NASA, in Washington, D.C.

Before that (1964–65) he was corporate Vice President of Raytheon Company and General Manager of its Space and Information Systems Division, Sudbury, Massachusetts.

Mr. Elms' first association with NASA began in February 1963 when he was appointed Deputy Director of the agency's Manned Spacecraft Center, Houston, Texas.

He also served in key management roles at North American Aviation between 1950 and 1957, in the development of fire control and radar bombing systems. He did work on the Titan I missile while at the Denver Division of the Martin Company from 1957 to 1959.

He was Executive Vice President of the Crosley Division of AVCO in 1959 and 1960 and was Director of Space and Electronics for the Ford Motor Company's Aeronutronic Division from September 1960 to February 1963.

Mr. Elms was born May 16, 1916, in East Orange, N.J. He received his B.S. degree in physics from the California Institute of Technology in 1948 and his M.A. degree in physics from the University of California at Los Angeles in 1950. At the university, he was a member of the faculty as a Research Associate in the Institute of Geophysics.

Mr. Elms holds patents in the fields of instrumentation, computers, radar and mechanisms. He is a senior member of the Institute of Electrical and Electronics Engineers, and Associate Fellow in the American Institute of Aeronautics and Astronautics, and a member of the American Physical Society.

In World War II, he served in the Air Force as a Captain and during that service was head of the Guided Missile Unit of the Armament Laboratory.

He is married to the former Patricia Marguerite Pafford. They have four children: Christopher, Suzanne, Francesca, and Deborah, and live in Wellesley Hills, Massachusetts.

STATEMENT OF JAMES C. ELMS, DIRECTOR, ELECTRONICS RESEARCH CENTER, NASA

Mr. Elms. I think I will start by reviewing very briefly the six areas of research that ERC is involved in. I am doing this for two reasons: One, so that when we talk about the specific aeronautics projects, I can tie them back to our basic program, and the other is as was stated a little earlier here. It would be very shortsighted on our part in attempting to help with the electronic problem in aeronautics to use just current state-of-the-art electronics. There are many people capable of doing that. We are looking into the future for improvements in electronics.

Of the areas we are looking into the first one is the area of components and devices, a very broad area. We are doing work in components that you could call basic research. We are doing work in applied research and also some development.

I will only mention two examples. One, we are very much involved in the new electronics involved in microelectronics and large-scale integration. These are important areas in the future when the electronics requirements become bigger, and you must make the parts smaller.

Second, in connection with our basic work, we had some people looking into a rather old-fashioned subject, the subject of electrical engineering, not electronics. Our power systems people have done some very basic work on an old device, the transformer, and found indeed that transformers, which are used throughout the industry, produce dangerous spikes of voltage which, in turn, cause breakdowns in the rest of the system.

You will recall, Mr. Chairman, that Mr. Thomas of the FAA pointed out to both of us that he felt that one of the large sources of problems in aircraft is connected with electrical power.

Another general area that we are involved in is in the area of computer research. I want to emphasize here that we are looking into the future concerning what computers should be, and what they should do, and how man should interact with these computers. We are not involved in developing a computer in any sense of the word in competition with the very competent industrial work. Rather, we are involved in the relationship of man to these computers in the space environment, and in the aircraft environment. This is an example of the sort of thing you mentioned earlier, Mr. Chairman, when people started this program, they thought of it as a space-related project where an astronaut communicates with his computer in a space mission. As our emphasis changed into aeronautics, the basic work being done on the computer problem didn't change a bit. We just added some new inputs for these people to think about.

In the general area of instrumentation, we are involved in research on instrumentation. There are very competent groups of people throughout NASA who are involved in developing specific instruments. In our case, we have been concentrating on the new techniques that may be useful in the future. One example only, the so-called detached occulometer is a device which has resulted from some very basic work. It is a device which tells you which way the eyeball is looking, and the applications of this in space and in aeronautics are relatively obvious, instead of pointing with your finger or moving a switch, you can look in a certain direction and cause something to happen.

In the field of radar and optics, our work begins with some very fundamental investigations, and, as I will mention in a few moments, we have been able to apply some of these things directly to aeronautics.

One of the largest areas that we are involved in is guidance research. Here we are doing two rather different things. We are supporting research efforts to push to the physical limit, current instrumentation—gyroscopes and accelerometers.

We are also taking another path, and that is to consider guidance systems using much cheaper instruments. I will talk about that in a moment.

Now, as far as direct programs that ERC is involved in of an aeronautical nature, the largest one by far is what we call our V/STOL project. Mr. Beggs talked about V/STOL from the standpoint of the overall aircraft. We at ERC are involved in the problem of guidance of the VTOL aircraft which is one of the key areas.

Our program consists of testing a guidance system installed in a helicopter. The helicopter is being used to simulate VTOL aircraft. We are working in conjunction with people from Langley. The tests are being performed at the Wallops Island Station. We are making trade-off studies between the accuracy of the guidance system and the number of times that you update or correct the guidance system by signals from the ground. This is a very important parametric study because if we are going to use these systems in the future to help with this very difficult problem of guiding the V/STOL aircraft into the landing strips accurately and safely we will have an economic problem. It may turn out that a cheaper guidance system with more updates is a better system from an economic standpoint than a more expensive guidance system that doesn't require as much updating. In any case, inertial guidance puts some of the basic control of the airplane back into the aircraft and does not involve ground control throughout the entire landing activity.

The VTOL project is significant in one other way. It is an answer to the question which was asked a few moments ago about relationship between space and aeronautics. It is interesting that the research equipment which is in that helicopter is, in fact, a guidance system out of a Gemini spacecraft. There is no intention of ultimately using that guidance system in a commercial airplane, but it is available for use in this research project.

It is also significant that the people working on this project got some of their experience in working on the LM guidance problem. There is certainly to a first order of approximation a great similarity between landing an LM on the moon and coming in on a very steep glidepath in landing a VTOL aircraft. We are, indeed, using both equipment that has been in space and techniques developed for space projects in this aeronautics project.

Mr. HECHLER. The time may well come when NASA will be much more interested in labeling certain things as aeronautics rather than space.

Mr. ELMS. Right.

Mr. HECHLER. In terms of support by the Nation and by Congress?

Mr. ELMS. Well, indeed, in this case, we are getting a payoff from space directly into aeronautics.

The next thing I would like to mention is PWI. Those initials stand for pilot warning indicator, or proximity warning indicator. This came out of our optics research. It is a very simple system which we have in the early breadboard stages but it is operating. We saw it the other day, Mr. Chairman, set up at ERC. It involves an xenon flashing light which could be carried on every aircraft. It is a relatively inexpensive device. The other part of the system is a simple optical system and an electronic detector which rings an alarm when it sees this flashing light.

Now, to give you an idea of where we are, on a day when you can just barely see the light with your naked eye at a mile, this PWI breadboard system that we have will pick it up at, say, 3 miles. More than that, it will ring an alarm. This is important because even in the case where one can see it at 1 mile, one has to know where it is and really concentrate in order to see it. This is the beginning of a system that could be very useful in avoiding certain types of air collisions. In the future we intend to work on an improvement of this system. If one is willing to spend more money on the receiving end of this equipment, one can enhance the image and perhaps extend the range to more than 10 miles.

We have this situation even in fog, one can detect the signal at 2 miles with relatively simple receiving equipment of the type that perhaps could be afforded by owners of general aviation. With more sophisticated equipment which might someday go on airliners we expect to see more than 10 miles under similar conditions.

Mr. HECHLER. I don't want to scoop Dr. Stever who is going to testify in the second hour. But I think your testimony is very significant.

Dr. Stever will mention the fact that the accident rate in general aviation is more than seven times that of general driving and 14 times that of turnpike driving. I think this is an area where we are pleased that you are making some progress, because of the rising accident rate.

Mr. ELMS. Thank you, Mr. Chairman. It is also a good example of what I tried to refer to earlier. We would never have gotten into this PWI area if we hadn't had scientists doing other things.

Mr. HECHLER. Let me interrupt at that point. Is that the real reason you get into these things? Doesn't somebody stimulate you from the outside to say this is an important problem, we are going to need some research on it, or is it only because you have some related research going on?

Mr. ELMS. I think the answer to that is both things happen. This is very significant for our whole NASA effort in advanced research and technology. Two kinds of things happen. One does know of general areas of interest. For example, we are aware of the resurgence of aeronautics in NASA. Our V/STOL program is an example where Mr. Beggs' predecessor, Dr. Adams, said to me "This is an extremely important area. You have the general capability. Will you take on the job?" I said we would, and we got the program from nothing to where you saw it the other day, Mr. Chairman, in 1 year. In other words, sometimes you are directed to do something, and you make use of your general talents and capabilities. Other times you do, indeed, stumble into things because you are pushing forward the area of basic knowledge. For this reason, I think the job of a research director is to try not to point people too directly. He should not say "please invent a certain system." Rather, he should guide them into the general area where interest arises, but give them enough freedom so that they can poke around in areas that have not yet been discovered.

Mr. HECHLER. We may want to discuss this subject in greater depth.

Mr. BEGGS. The people who are doing the work have to know the general area of application, but I agree with Mr. Elms that when you start out to do basic research or even applied research, you don't necessarily know all the areas that you should investigate to lead to a solution. You might get a discovery in one area which has an application in an entirely different area, and this is not necessarily obvious when you start the work.

Mr. HECHLER. Now that we have gotten into this, Mr. Cortright, do you have any observation on this immediate point that we are discussing? The question I raised was whether you tackle problems at Langley just because you happen to have the people around, or does somebody tell you on the outside that this is a highly important problem on which we ought to be concentrating our research? What has been your experience?

Mr. CORTRIGHT. I have only been at Langley a few months, and I have been trying to get a feel for this. The amount which you attempt to direct researchers is a basic question. If you overdirect a group, you can become overenamored with end products and, in fact, you will probably discourage people that work on ideas that may seem impractical, and they are frequently the ideas you should be working on. The major gains that have been made in aviation and other fields generally can be categorized as being made by people who didn't know the problem they were working on couldn't be solved, so they went ahead and solved it.

On the other hand, a certain amount of directed research does inject some realism in some of the work, and it results in short-term gains which are necessary to maintain the support for the program, and which all of us would want to see continue to come out of the program. On balance, I would say that there should be an element of directed research and probably in the case Mr. Elms talked about both factors entered in. He had some people who were interested, and he also knew it was a problem.

On the other hand, we have got to, in aeronautics and space and other fields, retain the opportunity for bright people to work on the exotic problem that doesn't seem practical at the time.

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Mr. HECHLER. The committee will have a lot of questions on this because it involves the whole question of priorities, emphasis, policy planning in aeronautics, but I would prefer you to continue.

Mr. ELMS. I think I will just say one more thing about PWI. Let me tell you what happened there. People were interested in something very fundamental concerning the transmission of electromagnetic energy at various frequencies through the atmosphere. We had people who are aware of the fact that xenon lights contain an invisible infrared light that can be seen at great distances by electronic devices.

When we heard about this, we discussed this application with the scientists that were involved, and they were delighted to convert themselves a little bit in the applied direction and go to work on this thing.

The next step is to put some people who have program experience to work on this thing, and let the scientists go back to looking further into the general research area. So it is true that the particular thing we are talking about here came out of basic research, but as soon as we recognized it, we did focus it. Kind of a classic example.

Now, there is another area of interest that hasn't gone quite as far yet, but it has similar characteristics. This is in the area of clear air turbulence. Some research scientists in the same laboratory were looking at the transmission of radiation through the atmosphere—something so remote from aeronautics as what spectral lines generated on the planets can we detect through our atmosphere with sensitive radiometers. They began to discover some very interesting correlations between small changes of temperature in the atmosphere and the effect on their radiometers. As a result, we now have in a very early stage a system where you look ahead of an aircraft and measure the radiation passing through the atmosphere, and by this means we have indication that we can find areas, say, a few miles long and a half mile high where the temperature is 2° or 3° C. different than the surrounding areas. I don't mean to say we have the answer to clear air turbulence. But we did start out looking at the planets and end up with what looks like a possibility of getting at the very difficult problem of clear air turbulence.

I think I will just mention one more thing. Mr. Beggs pointed out that he is responsible for most of the aeronautics work in NASA. There is one exception in my center. The Office of Space Science and Applications has a program which they are evolving for a navigation/traffic control satellite. We are doing research concerning the electronics involved in that. This could develop into a system of surveillance from great heights which could be an important part of an advanced aircraft traffic control system. This is another example of a very specific program that is not coming out of basic research. It is, instead, a directed program.

I think that that, perhaps, is a quick review of our activities at ERC. There is more that could be said.

Mr. HECHLER. Since you mentioned the word "quick," I wonder if you would also submit for the record so that the record of our hearings may be complete, an updated rundown of precisely what ERC is doing and plans to do in the field of aeronautics. Do you think that would be useful for the entire OART area?

Mr. BEGGS. Yes, sir. Did you want to call on any of the other center representatives?

(Information for the record is as follows:)

SUMMARY OF ACTIVITIES—AMES RESEARCH CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Ames Research Center appreciates the opportunity to enter in the record of this Subcommittee a statement summarizing our effort in Aircraft Technology. This effort is a major element of the research programs at Ames and one which with your support, we expect to pursue vigorously in the coming years. Ames' effort is an integral part of the agency's program to provide solutions to current aeronautical problems and to lay the foundation necessary to achieve the national goals in aeronautics. Specifically, Ames makes unique contributions in the Aeronautical Vehicles Program in the areas of advanced research and technology, general aviation aircraft, V/STOL aircraft, subsonic aircraft, supersonic aircraft, and hypersonic aircraft. In addition, the Center pursues aeronautical research programs in avionics, basic research, and human factors. A brief description of these research programs follows:

Advanced Research and Technology.—Research is conducted on the performance, stability, and control of aeronautical vehicles to provide basic research information and techniques for predicting and improving the characteristics of various aircraft types. For this general area of advanced research the program plan includes: (1) theoretical studies to enable more accurate prediction of forces, moments and pressures on aircraft, flow fields about aircraft, and methods of lift and thrust augmentation, (2) theoretical and experimental studies of configuration effects on sonic boom intensity, skin friction, transition and shock-boundary layer interaction, transonic buffet and aircraft response, and panel flutter, (3) advanced instrumentation for better study of aircraft and inlet aero- and thermo-dynamics, and (4) analytical and experimental studies of aircraft/propulsion system integration problems.

General Aviation Aircraft Technology.—Program includes analytical and experimental studies of airframe aerodynamics unique to the general aviation class aircraft by virtue of their size, power-plant configuration, and operational environment. Research on V/STOL concepts for general aviation and executive transport use could be very rewarding in leading toward practical use of V/STOL aircraft for general aviation and executive transport.

V/STOL Aircraft Technology.—Research is an important area because of its implication relative to great improvements in the short-haul transportation, such as city center to city center air travel, and because of the great potential it affords the military use of aircraft.

Research in aerodynamics is directed toward improving lift, stability, and control characteristics of promising concepts of VTOL and STOL aircraft. This includes experimental studies in the 40- by 80-foot wind tunnel of advanced V/STOL transport concepts, such as the tandem lift-fan concept, theoretical and large-scale experimental studies of high-velocity rotors, stowed and stopped rotor systems, and experimental studies of an advanced lift-fan fighter model.

In the propulsion area, analytical and experimental studies are being conducted to furnish promising design information on advanced lift fans, means of alleviating problems of hot-exhaust-gas reingestion and noise, and to provide information on propulsive components of hot-jet-propulsion flaps.

Research in flight dynamics is directed toward providing handling qualities criteria for VTOL and STOL aircraft, and information on requirements for VTOL and STOL landing displays. Special studies require use of ground-based flight simulators and V/STOL research aircraft such as the variable-stability X–14A, and the XV–5B.

V/STOL Aircraft Proof-of-Concept.—Programs include:

(*a*) Determination of the performance and operational characteristics of the rotating-cylinder flap concept for application to commercial and military prop-driven STOL aircraft and completion of modifications of OV–10A aircraft to incorporate rotating-cylinder flaps.

(*b*) Determination of the performance and operational characteristics of the augmentor-wing concept for application to future jet-powered STOL aircraft and modification of a C–8A aircraft in continuing cooperative program with the Canadian Government.

(*c*) Determination of the performance and operational characteristics of an improved tilt-rotor aircraft, preliminary design of the aircraft, and wind tunnel tests of a full-scale rotor.

Subsonic Aircraft Technology.—Research objectives are improved performance, safety, and reliability of operation. Efforts under way to accomplish these objectives include: (1) theoretical and experimental studies of problems peculiar to the airbus-type of aircraft now under development (such as disturbed flow at center engine inlet, direct lift control, and improved flaps), (2) the provision of high-by-pass engines for aircraft models in the 40- by 80-foot wind tunnel so that propulsion interactions with the airframe can be more accurately represented on advanced subsonic aircraft model studies, (3) use of ground-based, piloted simulators and the Boeing 367–80 aircraft, or the Convair 990 aircraft with modifications, to study pilot-managed automatic flight control systems for automatic landing of transport aircraft, and (4) wind tunnel tests in support of the development of government-sponsored and industry-sponsored aircraft (on fee basis for industry).

Subsonic Aircraft Proof-of-Concept.—Program includes: An extensive flight research program using the highly-modified Boeing 367–80 variable-stability aircraft, to study methods of providing adequate flight-path control and handling qualities for noise abatement, steep landing approaches for large aircraft.

Supersonic Aircraft Technology.—Directed at improved performance, stability and control. The program includes the following plans to meet these objectives: (1) modifications to models for tests in wind tunnels to study improvements in the aerodynamic characteristics of transport designs with particular emphasis on handling qualities at the low speeds of take-off and landing, (2) experimental studies to improve aerodynamic characteristics of new military aircraft such as FX and VFX, (3) experimental and theoretical studies of air inlet systems with particular emphasis on design methods, inlet dynamics, additive drag, growth versions for higher speed applications, and inlet-airframe integration, (4) theoretical and experimental studies to validate methods of prediction of performance, stability and control characteristics, (5) use of improved piloted simulators to allow studies of problems of flight dynamics, such as longitudinal-control-power requirements, basic studies to provide information establishing certification criteria, etc., and (6) studies of gains in performance by trade-off between inherent aerodynamic stability and control and automatic stabilization and control.

Hypersonic Aircraft Technology.—These programs have major emphasis on fundamental problem areas. For example, research on hypersonic inlets stresses fundamental studies of boundary layer growth in regions of pressure gradients and through regions of shock impingements. While this fundamental knowledge is essential to the understanding of flows in hypersonic inlets, it is of equal value in other applications involving viscous flows in supersonic streams. A significant part of the effort also is devoted to the devolpment of test instrumentation and techniques which will be required in hypersonic aircraft research. Research areas include (1) experimental and theoretical studies to assess and improve methods for predicting forces, moments, and pressures on complex aerodynamic shapes in hypersonic flight, (2) development of an understanding of the complex flow fields in hypersonic inlets, leading to the development of design methodology and the establishment of performance potentials, (3) studies, theoretical and experimental, of supersonic burning ramjet combustors in combination with air inlets, and (4) theoretical and experimental studies to assess aerodynamic characteristics and performance potentials of hypersonic aircraft concepts, including studies to define problem areas throughout their operational speed range and in landing and take-off configuration.

Avionics.—Research at Ames is concerned primarily with guidance systems concepts for landing aircraft under zero visibility and ceiling conditions, with emphasis on airborne system concepts for STOL aircraft. Under way are experimental studies of concepts for obtaining and presenting landing guidance information in which research hardware translates various analytically-derived guidance schemes into the real life situation of pilot, airplane, and landing problem. This includes an airborne computer-derived display and a rapid-scan radar concept for zero-zero landing. Additional studies are aimed at assessing control and display system concepts that will enhance the performance, reliability, and safety of flight of advanced supersonic transports. Pilot-managed automatic flight control systems for automatic landing of transport aircraft are being considered.

Basic Research.—Includes theoretical and experimental studies to develop an understanding of heat transfer and skin friction in hypersonic turbulent boundary layers, determination of means for producing boundary layer transition with minimum secondary effects on the boundary layer, and studies directed at evolving or extending available analytical methods for determining the pressure field around aircraft of arbitrary shape with the object of alleviating the sonic boom problem of supersonic aircraft.

Human Factors.—Research includes studies of human performance, man-systems integration, life support and protective systems and environmental factors as they affect humans in the aeronautical flight environment. Specific programs emphasized are cardiovascular physiology, respiratory physiology, stress-level predictions, human pilot tracking performance under environmental stress, control and display requirements, and advanced techniques in training and research flight simulation.

SUMMARY OF ACTIVITIES—NASA ELECTRONICS RESEARCH CENTER

In order to establish a proper framework and perspective for the activities of NASA's Electronics Research Center, a review of that Center's status is helpful. The extent of the applications to aeronautics of the research conducted at NASA's Electronics Research Center (ERC) is greatly affected by the size and capability of that Center.

At the end of FY 1968 there were 794 people at ERC. 402 are professionals (Chart 1) with a distribution of about 30% Ph. D.'s, 30% Masters, and the rest Bachelors. This is a rather large percentage of high level degrees and reflects

Electronics Research Center

Distribution of Permanent Positions by Type

	6-30-67	6-30-68
Scientific and Engineering Professionals	336	402
Supp. Technicians	61	79
Administrative Professional	104	114
Clerical and Assistants	190	188
Wage Board	9	11
Totals	700	794

CHART 1

the research nature of the Center. When the Center was initiated it was planned to have around 2100 people here by the end of this fiscal year. This rapid build up was projected at a time when budgets were forecasted to be much higher. Approximately a year ago, ERC set for itself an immediate goal of approximately 1000 people in order to be able to use our resources most effectively. The 1000 level is considered to be an intermediate asymptote from which a new growth goal can be projected when the need arises.

Six buildings for ERC's permanent site in Kendall Square, Cambridge, are now under construction. Because of under-estimation of the cost of construction and other architectural problems, the initiation of construction was considerably delayed. The FY 65/66 increment was under contract in December 1967; and the FY 67 increment, in April 1968 (Chart 2).

CHART 2

The Electronics Research Center is operating at a level of about 25 million dollars in R&D funds. These funds provide for university contracts and grants and industrial research contracts. The 17 million dollar Administrative Operations budget (Chart 3) includes the salaries of all ERC personnel including research scientists and engineers.

August 29, 1968

FINANCIAL SUMMARY

($000)

	FY 64	FY 65	FY 66	FY 67	FY 68	FY 69 Budget
Administrative Operations		$ 3,201	$ 6,346	$12,219	$15,360	$17,237
Research and Development		2,682	8,791	16,381	26,966	22,257
Construction of Facilities	$ 1,243	10,500	5,250	7,500	0	0
Facilities Planning & Design	1,070	695	919	133		
TOTAL	$ 2,313	$17,078	$21,306	$36,233	$42,326	$39,484

CHART 3

There are six areas of electronics research, and we emphasize the term *research*, in which ERC is active—components and devices, reliability and standards, instrumentation research, data processing, communications, guidance and control (Chart 4). Each category will be treated in more detail below.

Electronics Research Center — August 28, 1968

R&D Program -- By Research Category

FY69

Components & Devices	$ 4,672
Instrumentation Research	2,340
Data Processing	3,043
Communications	2,519
Guidance Research	2,463
Reliability & Standards	2,510
Aeronautics	
V/STOL & Advanced Avionics	2,500
General Aviation	580
Space Applications	
Earth Resources	560
Navigation/Traffic Control	535
Meteorology	535
TOTAL	$ 22,257

CHART 4

One third of our R&D money at ERC is spent in the general area of basic electronics—components, devices, reliability and standards—which are common to all electronic activities. Some of that money is for exploratory research; most of the rest is applied research with a small amount of advanced development. It is the intention of ERC to guide its components research into areas of technology required for NASA's future missions. A great amount of effort has been expended to determine the areas within this large category where a comparatively small amount of R&D funds can accomplish the most. Because ERC is a relatively small Center—approximately $25,000,000 of R&D funding annually—we must invest our efforts in those research areas which are most needed for the future of aeronautics and space, which are not already sufficiently funded by other government agencies or by industry.

A large percentage, perhaps as high as 75% of the basic work being carried on at ERC in electronic components and devices is equally beneficial to space and aeronautics. Some examples are given later in this statement.

Among the electronic components and devices work are some fundamental investigations into familiar power components such as transformers and inverters. More detail on this research appears below. The advances being achieved in this field of power processing will be directly applicable to aeronautics.

A quite different, somewhat more applied, activity at ERC is instrumentation research. This is principally research on how measurements are made and not on the development of specific instruments. There are many organizations throughout NASA and throughout the government which are doing development on instruments. At the moment, ERC's role is to help these organizations with its research. An area of special interest is that of atraumatic instrumentation which results from the requirements for monitoring astronauts and which has already found useful applications in the medical profession. A more complete description appears in the technical section appended below. As we develop practical techniques in physiological monitoring, they can be adopted directly for aircraft pilots. This is another example of ERC's work which is equally pertinent to aeronautics and space.

The emphasis in the data processing research area at ERC is on how computing machines should be constituted, the man-machine interface, and software problems, instead of the development of specific computers. ERC is not in the business of competing with industry in building the next generation computer. Instead research is being conducted in the area of future computer applications. The man-machine interface—the problem of getting information into a computer and out of a computer in the most expeditious manner possible—has been and continues to be one of the most important NASA-related problems. For example, there is an interface system in the Apollo spacecraft wherein a highly skilled, highly trained astronaut, in effect, talks to the computer and listens to it. But he does so by punching in numbers and reading out numbers. As problems become more severe or the requirement continues for a greater number of less skilled operators, a more sophisticated interface will be required. A complete review of ERC's work in this area is given below. All of this effort should be beneficial not only for people in space activities but for commercial aviation—pilots, navigators, radar operators, air traffic controllers.

Communications is an area of research at ERC primarily because of the extreme demands for data, sensor output including video data, voice communications, command, control and telemetry in manned and unmanned space missions. However basic advances in communications will benefit all kinds of communications. For instance, before a satellite navigation system can be used for guidance and traffic control of aircraft and shipping, a major communications problem will have to be solved. In a later section of this statement, the research leading to navigation satellites is described. Communication at L-band is a critical part of the system. ERC's basic research in communications will contribute to making the navigation system a practical reality.

Communicating at either optical or microwave frequencies involves a basic understanding concerning transmission of electromagnetic energy through the atmosphere, the ionosphere and the stratosphere, through plasmas, and through the great variety of ambient conditions in our atmosphere or in the envelope surrounding other planets. Classic examples of how practical technology grows out of basic research are ERC's projects on pilot warning indicators, derived from optical transmission studies, and clear air turbulence, an outgrowth of research on the attenuation of microwave radiation in the atmosphere. More details on these two endeavors are given below.

Holography is an optical phenomenon that, with the advent of the laser, has moved into the applied research stage at ERC and other laboratories. Holography is explained at some length in a later section. Possible adaptations of holography to pilot displays, to air traffic control displays and to 3-dimensional representations of airports for pilots during blind landings are being studied at ERC.

The sixth and last broad research category at ERC is guidance and control. Two different areas in guidance research are being emphasized. An inertial instrument development program with a goal to develop the most accurate gyro and the most accurate accelerometer possible is underway. Since the urgency of program deadlines has been removed, we have the opportunity for major advances. For the past 25 years, important projects have always been required to use instruments seven to ten-years old. For example, the Apollo system uses gyros originally developed in 1956. The current program is an attempt to alleviate this situation. The other research area involves a new approach to the problem of inertial guidance, namely the strapdown systems. This is discussed further below.

We have sketched above the six electronics research categories in which ERC is currently involved. This research supports applied and developmental space and aeronautics projects underway at ERC and elsewhere in NASA. It is the constant aim of ERC management to preserve a prudent balance between fundamental research and applications. We are eager to assist, through our special abilities, more project-oriented NASA Centers. ERC is primarily a research establishment, and NASA has several extremely competent multi-thousand man Centers experienced in development, in engineering and in space and aeronautics flight projects. By concentrating on electronics research, ERC will maintain a capability to respond to many situations and problems arising in the agency which should multiply ERC's value to NASA and to the Nation both in aeronautics and space activities. At the same time ERC has undertaken and will continue to undertake the management of specific programs, both in space and aeronautics, where ERC has unique skills upon which those programs are dependent.

The applications of space research in general, and electronics research in particular, to aeronautics are increasing. As mentioned earlier over three-quarters of the general research being conducted at ERC is both space-related and aeronautics-related. For example, the computer research program was initiated at a time when the Center was almost entirely preoccupied with space. The advent of our aeronautics programs has simply added a new set of inputs to the same computer research activities. Another example is the optics work which resulted in the PWI project to be discussed later. It began as a space-related physics project, as did the clear air turbulence work. As is well known, the primary task of a research director is to guide his scientists into areas which are of general interest to his institution, agency or firm. On the other hand, he should be careful to preserve a freedom of inquiry in his organization, because a researcher never knows all areas that should be investigated to lead to a solution. Also discoveries in one area may have applications in other areas which are not at all obvious when the research was started. So a research director must "guide" but must give enough freedom so that his researchers can "discover". Such "discoveries" have already occurred at ERC for the benefit of aeronautics.

DETAILED RESEARCH TASKS AND DEVELOPMENT PROGRAMS IN AERONAUTICS AT ERC

Electronic Components and Devices, Reliability and Standards

The state of the art in modern electronics permits a microelectronic assembly containing 794 components to be made on a very thin chip of silicon less than an eighth of an inch square. Over four hundred of these assemblies can be made from a standard wafer of silicon two inches in diameter and a few thousandths of an inch thick. Thus, using one piece of material and a standard processing sequence, we can manufacture several hundred thousand devices at one time, each one of which has the functional capability of a standard radio tube. Besides the three hundred thousand components in this wafer there are several hundred thousand interconnections, such as you see going from tube to tube in your radio set. Unfortunately some of the devices on a chip are inoperative. This is the result of an incomplete understanding of the processing problems of this extremely complex technology. While occasionally a lot will show all devices operational, in the majority of cases the wafers are failures. The NASA Electronics Research Center is involved in this problem for two reasons. First, there is a tremendous and natural application for these assemblies in small-sized, complex, rugged and reliable electronic equipments for space and aeronautics applications. Second, an advanced research capability with a scope and a range extending beyond that of the industrial or the university community is needed in order to (a) channel at least some of this technology to NASA's needs, and (b) to aid in the solution of some of the difficult problems remaining.

The development of the technology previously indicated is the result of the application of solid-state physics, extremely sophisticated materials research, and advanced device research. All three of these elements are involved in the components and devices research program of the Electronics Research Center.

We must not forget, however, that electronics involves other components than these microelectronics assemblies, and that standard electronic components such as tubes, transformers, relays, resistors, and capacitors must still be used. Many problems remain in providing the reliability of these devices to guarantee, for example, the success of a ten-year mission of either an orbiting satellite or a deep space probe. In addition there are many problems involved in improving the quality of aircraft power and communications equipment.

As an illustration of the studies at the Electronics Research Center which utilized the frontiers of solid-state physics, we have developed a miniature microwave generator known as the Gunn effect oscillator. This device, whose basic generating element is no bigger than a pinhead, replaces and has essentially the same capabilities as a microwave tube which may be as big as your fist. Microwave oscillations of many billions of waves per second are produced from a tiny chip of gallium arsenide on the application of dc voltage from a flashlight battery.

Using a small device of this kind, we have built a microwave communications system. A horn using a Gunn diode mounted in the throat, produces a microwave carrier at 6 billion cycles. Voice or other information is supplied by modulation of this carrier in bursts or pulses. Another horn receives the microwaves and converts them back to the original information by conventional means. We have used this particular arrangement to communicate between ERC and a mountain 81 miles away. The strength of the signal was such that we would have had good communication for over 400 miles. Such arrangements could have a major applicability to satellite and perhaps deep space communication systems. A major element of the ERC components and devices program relates both to reliability and to the problem of getting output of electronic components from a research program. We have attempted to solve these problems by setting up at ERC a microelectronics pilot plant for the production of microelectronic assemblies. This plant has the capability of producing almost any silicon microcircuit being produced commercially today. However, we think of it more as a research tool, rather than a production line, since it gives ERC the capability of independently evaluating industrial processes, of studying new process techniques, and seeing their effect on an actual finished product. Of course, the devices studied can actually be those needed for flight purposes, and it is possible that we may be able to furnish flight-qualified microelectronic circuits from this pilot plant for space and aeronautics applications.

Power Processing.—In the power processing area the Electronics Research Center has a unique capability. Since power system studies are neglected in the universities, we must develop and train the engineers ourselves in the sophisticated new techniques possible with modern electronic components. At the same time, we must try to improve the reliability of power components, which it is known cause a considerable fraction of failures in both space and aeronautical applications.

The power conditioning unit is that portion of a power system which takes the power from the prime source, say a generator or a solar battery, and converts it into the type and number of electrical currents and voltages required by the various loads, with the proper degree of regulation and provision of interference-free capability. New techniques of pulse modulation are being applied to power electronics. We have developed a light-weight, very efficient dc transformer for use in converting voltages from solar batteries to the higher voltages needed for electric thrustors (ion engines). It is not only lighter than conventional supplies, but has an efficiency of as high as 98 percent. In a high-power system, this can mean weight savings of many hundred pounds in the load, and correspondingly higher savings in the launch power required.

Reliability of power components is a complex matter, since failures are usually thermal, and result more from the misuse in design of the circuit, or the limitations of the circuit design, than from the intrinsic failure modes of the components. Hence not only circuit design is important, but the use of components having protective features is very important. Such a new component is a saturable core transformer of new design which, when used in the switching and pulse modulation circuits already discussed, has the effect of protecting the switching devices themselves, usually transistors or silicon controlled rectifiers. The current trace for a pulse circuit has sharp spikes normally occurring at the switching point, but also passing beyond the transformer used into the switching elements, which sooner or later are destroyed by them. When a conventional transformer in the circuit is replaced by the new device, the current trace has the spikes completely eliminated, so that there is no strain on the remaining circuit elements.

Instrumentation research

An important area of our work is concerned with measurements on man during high stress aerospace activity with emphasis on measurement techniques that offer minimum encumbrance and disturbance to the pilot. Two instruments under development which are good examples of our efforts in this area are (1) An unattached oculometer for the measurement of the eye-pointing direction, and (2) An unattached electrode monitoring system for measuring heart rate, respiration rate, and galvanic skin response from the palms.

Oculometer.—The oculometer is an electro-optical instrument which performs real-time dynamic measurements of human eye-pointing direction, pupil position, pupil diameter, and blink occurrence. The instrument is unattached to the user, and utilizes near-infrared radiation techniques to sense the eye, resulting in no impairment of normal vision. The output signals are either recorded for evaluation or used for control functions.

The oculometer consists of an optical unit, an electro-optical sensor and an electronics unit. The optical unit is designed to serve a triple purpose; it allows direct viewing by the user; it directs a collimated beam of near-infrared radiation into the eye; and it images the irradiated areas of the eye onto the photosensitive surface of the electro-optical sensor. The sensor, a scanning aperture image dissector, with a near-infrared sensitive photocathode, automatically searches for and acquires the pupil of the eye and the corneal reflection. After acquisition has occurred, the sensor scans around the corneal reflection and the pupil iris boundary and continuously tracks these eye details. The electronics unit supplies the appropriate power, generates the proper function signals for the electro-optical sensor, and processes the sensor output signals.

Output signals proportional to eye movements are generated instantaneously by the oculometer when measurements are being performed. Signals relating to eye-pointing direction are a function of the position of the corneal reflection of the radiation source relative to the center of the pupil. Pupil position signals are a measure of the distance of the center of the pupil away from the instrument optical axis. The pupil diameter signal is a function of the pupil/iris boundary circular scan, which is automatically and continually adjusted to fit the varying diameter of the pupil of the eye. Signals relating to blink occurrence are derived from the automatic tracking circuitry.

Oculometer measurements of eye-pointing direction have shown that eye angles can be determined to within 0.5 degree over a range of ± 15 degrees eye motion in both horizontal and vertical directions. The oculometer will accommodate lateral and longitudinal head displacements of approximately ± 1.3 centimeters and ± 2.5 centimeters, respectively. This feature allows relatively unrestricted head positioning. Measurements using simulated pupils have shown that the oculometer output is linear over a range of 2 to 9 millimeters pupil diameter.

Unattached Sensor Monitoring System.—We are concerned with how much information of physiological importance we can obtain from a pilot by palm contact with unattached electrodes. These electrodes could be mounted in a control stick, control wheel, or as here in the laboratory, mounted in the arms of a chair or on the handle bars of the bicycle ergometer. In the case of the chair one settles comfortably, hands resting lightly on the arm rests. As you relax, your heart rate, galvanic skin response and the rhythm of your respiratory system are automatically monitored. Changes can be noted within the moment of their occurrence. Multi-channel strip chart recorder simultaneously displays the cardiac-related events for later interpretation and analysis. Where necessary a computer can be interfaced for real-time data processing.

Data Processing

The ERC Computer Research Laboratory maintains an active research program in the hardware and software areas and the in-between area of man-computer interaction.

The orientation of the hardware research is on advanced computer configurations that hold the promise of higher reliability at lower overall systems cost for advanced aerospace missions. Emphasis is placed on areas which, because of economic characteristics, will not be pursued by the commercial computer industry. Wherever possible, advanced fabrication techniques such as large scale integration of microelectronics are utilized.

The Research Computing Facility at ERC consists of a high-capacity multi-processor computer for providing the basic computing capacity, a small-scale computer for supporting multiple displays and graphical devices, and various peripheral devices for communication and information storage. The hardware is of the latest design using integrated circuits, and provides memory paging and segmentation to aid in software development.

A multi-processor, multi-access, Graphically-Oriented Time-Sharing System is being developed as the major operating software system for this facility. This operating system will not only provide the console user with a file system for storage of all data and programs, but will also make available systems and application software for graphics and other interactive computing problems. Software for small graphic processor is already developed and consists of a single user Disk Operating System, and a compatible time-shared version.

The Graphics research work on this system is extensive. Great emphasis is placed on developing time-shared graphics hardware with large capacities. The present display generators are capable of supporting multiple displays with 128 graphics character sets, circle and line generation, etc. Color displays are also used and prove especially effective in highlighting specific features of images.

The Graphics software in development allows multi-modal, man-computer communication and provides a basis for connecting the meaning of a picture with its graphic image.

This Research Computing Facility is intended to provide the basis for a wide variety of hardware and software experiments, especially experiments in multiprocessor, multiaccess computation. Results of this research will be applicable to any future system involving a high degree of communication between man and machine, such as future manned aerospace missions and ground-based situations such as Air Traffic Control.

The software research activity has a broader character and is designed to attack the underlying causes for the slower growth of our ability to use large digital computers compared with our ability to build them. Hence, progress in this area can be of benefit to the nation as a whole. The ERC software program is embodied in Project SOFIX (Software Fix), a university-oriented program of coordinated software research. This project is currently being implemented and should be active by January 1968.

Communications Research

Pilot Warning Indicator.—Approximately three years ago research personnel at ERC were apprised of the increasing incidence of air crashes and near-miss occurrences in terminal areas by our NASA Headquarters staff and were asked to look into the matter. Our Optics people as a result of their work in optical sources, optical transmission through the atmosphere and optical detectors suggested using pulsed Xenon lights as a source and a sensitive silicon detector coupled to an audible alarm and/or a visual display as a pilot warning or proximity warning indicator (PWI). Consultations between NASA/ERC people and the FAA/COPAG Committee revealed the need for a low cost pilot warning indicator which could be used by the general aviation industry. It was felt by all of the participating parties that the scheme proposed by NASA/ERC could satisfy the low cost requirement. Further the indicator did not conflict with the use of the more expensive and intricate approaches such as CAS and EROS which perhaps could only receive cost justification by large commercial airlines. The operation of the pilot warning indicator is, in principle, very simple. The high intensity Xenon light emits a highly visible flash which is readily observable by the pilot of an aircraft and a pulse of very intense infrared energy which may be detected by an infrared detector mounted on the aircraft. At the present time we have fabricated such a pilot warning indicator and we have made some tests which are continuing.

Currently the tests indicate a range of detectability of the order of 10 miles on a clear day and 30 miles on a clear night. In the presence of fog this detectability distance is reduced to 1 to 2 miles using very simple instrumentation. The present indicator arrangement provides for a cathode ray oscillograph presentation calibrated in simple position coordinates and an audible alarm within the pilot's cabin. Detection is accomplished with a very simple receiver using silicon as the detecting element. Silicon detectors are characterized by high quantum efficiency, low noise and low power drain. Range information in the present indicator can only be obtained from detected signal amplitude and is highly variable due to the changing properties of the atmosphere. Preliminary cost analysis indicates that the present indicator could be purchased in quantity manufacture for under $1,000.00, and, therefore, would receive favorable consideration from the entire aviation industry. A more sophisticated unit which would provide more accurate range information, area signal blanking and other features would be more expensive. ERC plans to continue research in this area and to continue evaluation tests of the present unit.

Pulsed Xenon flash lights have had two prior applications in the aviation industry. The first of these is the STROBEACON landing aid in which a series of Xenon flash lights are geometrically positioned before the start of a runway and are flashed sequentially to provide a directed landing approach using VFR under moderately foggy conditions. The second of these is the aircraft recognition light system (ARLS) in which flashing Xenon lights are positioned along the wings of some commercial aircraft and simply indicates the presence and relative bearing of one aircraft to the pilot of another aircraft.

Microwave Radiometers for Detection of Clear Air Turbulence.—The variation in the propagation characteristics of the atmosphere represents another area of interest to aeronautics which is currently being studied by our research people. Our Microwave Laboratory is using microwave radiometers for this purpose. The microwave radiometer is an instrument which was conceived by Professor Dicke of Princeton University during World War II at which time he was a research scientist at the MIT Radiation Laboratory. It is, in essence, a very sensitive temperature measuring microwave receiver which operates in a purely passive sense (i.e., it transmits no microwave pulses or continuous microwave energy). When one considers that any material body, having a temperature in excess of absolute zero, emits electromagnetic radiation in the form of noise to its surroundings one can see how useful the radiometer is for the remote measurement of temperature.

The Microwave Laboratory at ERC has been using improved versions of the Dicke radiometer in its atmospheric investigations. Recently we have instrumented several World War II searchlight mounts at frequencies from 8 gigahertz (8×10^9 cycles/sec) up to 60 gigahertz for simultaneous observation of the propagation characteristics of the atmosphere. Data taken thus far have been on multichannel analog track recorders but soon will be processed by computer.

Our 35 gigahertz radiometer has recently been utilized with the Haystack 120 ft. dish to determine the beam width and antenna efficiency at 35 gigahertz. The Haystack dish was originally designed for operation at a much lower frequency. The experiment consisted of mounting the radiometer at the focus of the 120 ft. dish, finding the planet Jupiter in the heavens using previously developed radiometric boresighting techniques and then plotting a series of drift scans with the aid of the computer as the planet Jupiter moved along the ecliptic. Jupiter is, effectively, a point source when viewed from Earth having a diameter of approximately 34 arc seconds. From these data it was determined that the half power beam width of the antenna at 35 gigahertz was of the order of one minute of arc, which is about the same as the resolution of the human eye. The aperture efficiency of the 120 ft. dish turned out to be approximately 12%. Further collaboration with MIT personnel at Haystack is planned in which a map of the sun will be taken at 35 gigahertz and also a search for ammonia (NH_3) on the planets Venus and Jupiter using our 24 gigahertz radiometer. Ammonia exhibits a molecular absorption characteristic in the neighborhood of 24 gigahertz.

Our research people in the Microwave Laboratory at ERC are just now applying the results of their research in radiometry to another hazard sometimes encountered in air travel, clear air turbulence. They have used the remote temperature measurement capability of the radiometer in the design and fabrication of a two-frequency 60 gigahertz radiometer which will be applied to the clear air turbulence problem. Clear air turbulence is characterized by currents of air having temperature anomalies of 2 to 5° C with respect to ambient in addition to their pressure and air density variations. Previous observations have indicated that these areas are of the order of ½ mile in altitude and 5 to 10 miles in width. They are potentially dangerous to both subsonic and supersonic aircraft and cannot be visually detected. These areas are more or less uniformly dispersed throughout the United States and are usually found at altitudes between 20,000 and 70,000 feet. The instrument which we have fabricated has now been checked out and is ready for mounting in an aircraft pod. It is expected that flight tests will begin in late October or early November. The instrument incorporates an antenna having a beam width of 1° and a temperature sensitivity of 0.7° C. It will be capable of detecting turbulent areas as far away as 120 miles. Previously, the National Research Council of Canada and and Autonetics Division of North American Rockwell Inc., have flown infrared radiometers operating in the region of 13 microns to provide a detection capability of 40 miles.

Their instruments, however, have shown an unusually high false alarm rate. The microwave instrument because of certain inherent features in its design should exhibit a much lower false alarm rate. The frequency of 60 gigahertz was chosen because of the absorption characteristic of oxygen which is like a continuum of attenuation between 55 and 65 gigahertz at sea level but which takes on the appearance of line spectra or banks at high altitude. As a result one may get one range mark, say, the maximum (120 miles) by operating at 52 gigahertz and another range mark at some intermediate distance at say 60 miles by operating at the appropriate frequency within the oxygen microwave absorption spectrum. Indeed, one could have range marks every ten miles by employing a sufficient number of oscillators at proper frequencies and appropriate instrumentation. The instrument incorporates electronic switching capability between previously determined frequencies. This instrument has the capability of reducing the false alarm rate since one frequency may be used to confirm or reject the response obtained at some other frequency. Indication of a turbulent area will probably take the form of lights which will come on within the pilot's cabin at a given distance from the turbulent area. An audible alarm could also be synchronized with the appearance of the lights. In the first tests, however, an analog recorder will be used to record the temperature variations observed.

All of the radiometers designed and built by our ERC research personnel are absolute radiometers. By this we mean that there is always a known reference incorporated so that direct measurement of antenna temperature may be made. The instruments have vastly improved sensitivity over those in use during World War II. This is due in part to the advancements made in component technology such as the traveling wave tube, tunnel diode amplifier and semi-conductor detectors. The increased sensitivity of the radiometer means, of course, increased areas of applicability.

Holography.—Another area of potential value to aeronautics in which our ERC research people are engaged is that of holography. Holography is a wave front reconstruction process which is based on the use of interferometric methods to create standing waves whose images are recorded on film. When these wave patterns are later illuminated with a beam of coherent light, such as that from a laser, the viewer sees a replica of the original object in full three-dimensional imagery. The process may be carried out at any wavelength from microwaves to gamma rays. One may record a scene at one wavelength and reconstruct it at another. The plate which records the image produced is called a hologram. Normally lasers are used to photograph objects on photographic film without conventional cameras. If two lasers of different frequencies are employed in taking the original picture then the hologram can produce full color three-dimensional images when illuminated with white light.

We have been studying the basic optical requirements on a holographic image display for use as an aircraft landing aid. This application is suggested because of the unique ability of holography to store large amounts of three-dimensional pictorial information, on a two-dimensional medium such as photographic film. Once such information has been stored holographically it can then be "played back" i.e., projected to a viewer in such a way as to present a three-dimensional visual display in which various three-dimensional pictorial parameters such as perspective, viewing position, parallax, etc. can be controlled in a continuous and programable fashion.

The hologram display when used as an aircraft landing aid has the particularly difficult task of attempting to project a holographic image of a runway to roughly 20,000 ft. from the pilot and then magnify the image and at the same time change its perspective until a final image is produced which represents the same runway at a distance of 100 ft. For a real-time landing aid one can see that the perspective constraints dictate the minimum number of holographic views that are required as well as the rate of change of these views. Fortunately there is some information from other disciplines on which we may draw to assist us in this matter. For example from studies in eye physiology and visual psychology, a normal human observer ceases to obtain stereoptic information about relative distances of objects when the objects are placed beyond 100 ft. If we should adopt this as a criteria 200 different holograms would be required in our landing aid for a given airfield.

Actually this is an oversimplification of a very complex problem as there are numerous other factors to be considered. Currently we are studying some of these factors by constructing holograms and using related optical circuitry on a reduced scale basis. A vast amount of research will be required before a true assessment of the problem can be obtained.

Guidance and Control

Guidance and Control Technology.—The overall system research objectives of the Guidance and Control laboratories are listed on Chart 5 along with our approach to accomplishing these objectives. The range of technologies in which we conduct and sponsor research is given on Chart 6.

G, N, AND C SYSTEM OBJECTIVES

- UNRESTRICTED MEASUREMENT OF POSITION/VELOCITY/ATTITUDE
- OPTIMUM GUIDANCE
- VEHICLE/MISSION FLEXIBILITY
- HIGH RELIABILITY
- LOW COST

APPROACH

- RADIO/INERTIAL/OPTICAL DATA SOURCES
- MODULAR SYSTEMS DESIGN
- SYSTEM AND COMPONENT REDUNDANCY
- INTEGRATED FUNCTIONS

CHART 5

TECHNOLOGIES

- SYSTEMS DESIGN
- INERTIAL SENSING
- RADIO TECHNIQUES
- FLIGHT CONTROL
- DIGITAL COMPUTATION/DISPLAY
- FLIGHT THEORY
- ADVANCED LAB/FIELD TESTING

CHART 6

There are many guidance and control laboratories in the country and we are well aware of their activities. We are concentrating our in-house effort on areas in which there was a unique NASA requirement and which would not be done in other laboratories. In the inertial area, we recognized the tremendous capability of the MIT Instrumentation Laboratory in gimballed inertial system design. Thus, we chose to sponsor advanced research at MIT in new, improved, ultra-precise gyroscopes and accelerometers for gimballed system applications. At ERC, we concentrated our efforts on strapdown inertial system technology.

The results of four years' research on strapdown technology is a prototype strapdown unit employing three gyros and three accelerometers which is undergoing laboratory tests at the present time. There are many unique technology features of this unit such as the ability to easily replace a gyro and its associated electronics. The mechanical variable thermal control unit is another significant advance which we feel contributes to the objective of achieving a low cost, reliable inertial system.

The next generation of strapdown units in the research phase is the multi-sensor of "six pack" configuration. This unit has the same basic features of the previously described prototype except that six gyros and six accelerometers are included in the unit. Computer studies indicate that this assembly will have the same reliability as the three separate gimballed platform units containing nine gyros and nine accelerometers which are now being considered by commercial airlines for Boeing 747 applications. In addition, if the multi-sensor concept proves successful, the strapdown units can be less expensive than the present gimballed systems.

Both of the strapdown units described above employ the spinning wheel or classical gyroscope. We are also conducting research on another type of gyro known as the laser gyro which offers great promise for commercial application. This gyro is not as accurate as a gimballed gyro but has demonstraated performance of 0.01°/hr. in laboratory tests. By using radio aids to augment inertial systems, we feel that this type of performance will be adequate for commercial airplane applications. The advantages of the laser gyro are its inherent ruggedness, low cost, and direct digital readout. Considerable research remains to be accomplished before any of these systems could be considered for operational commercial use.

ERC's inertial research includes both gimballed and strapdown technology. They are not directly competitive systems and each has a unique mission requirement. Gimballed systems are now and probably will remain far more precise than strapdown system assemblies. However, precision is not the only requirement of advanced systems and the ERC research on strapdown units is designed to improve technology that is not available or likely to become available without a concentrated effort.

Another area of technology in which ERC is engaged is the use of satellites for navigation and traffic control of aircraft (Chart 7). A receiver and coding technique is being prepared for a flight test. The objective of this research is to investigate a digital code, known as BINOR for applicability in navigation satellites. The ephemeris of a satellite and other pertinent data would be relayed from a ground station through the satellite. Depending on the sophistication of the receiving equipment in aircraft, vehicle position can be calculated to better than 0.1 N.M. Without the use of a digital computer on board, the aircraft position can be determined using a slide rule calculator to within 3 N.M. The coding technique and L-Band receiver are being prepared for flight test where the effects of multi-path and other atmospheric disturbances on ranging accuracy will be investigated. ERC is sponsoring several studies of navigation satellite configurations. The flight test of the present laboratory device is to be accomplished as a "piggy-back" experiment on a satellite developed by Goddard Space Flight Center.

Avionics Flight Research

ERC's Avionics Laboratory is taking a systems approach to avionics research which is shown in Chart 8. The program includes the use of facilities at other NASA centers as well as coordination with FAA. ERC is concentrating on the design and fabrication of prototype avionics equipment which can be evaluated in simulators and flight vehicles at other centers. These units are prototypes for research evaluation and not operational use.

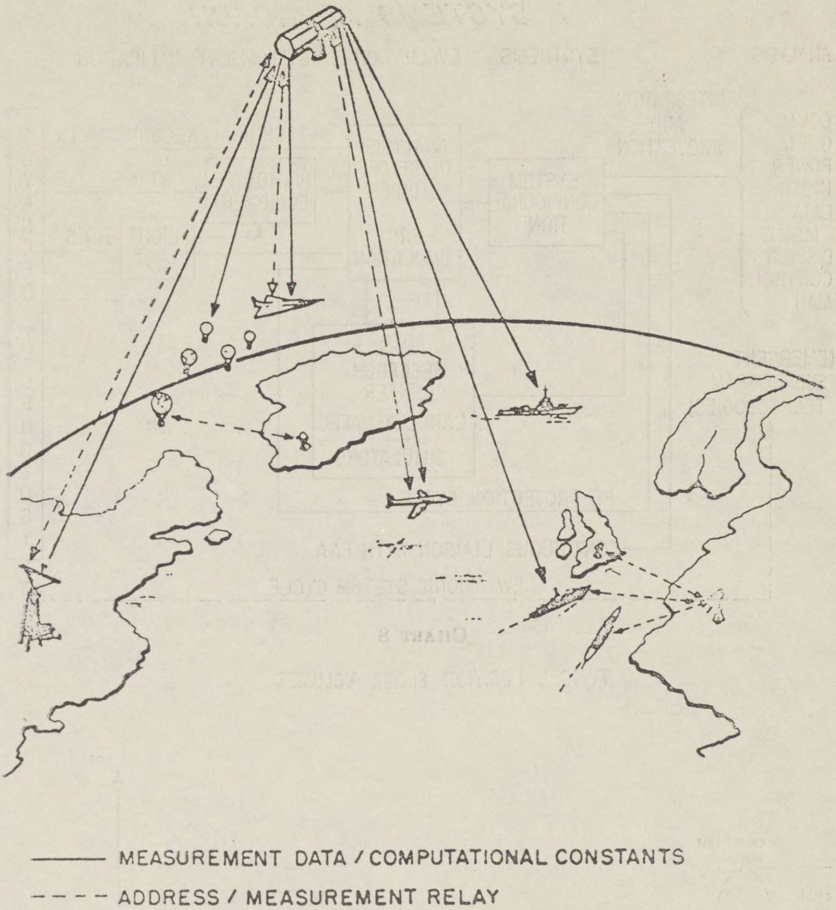

CHART 7

The largest single avionics flight program undertaken to date by ERC is the V/STOL avionics program. The objective of this flight research program is to develop and demonstrate the avionics equipment and techniques to enable this type of aircraft to operate safely in all weather conditions on the civil air route structure. One phase of this research is to investigate the use of radio aided inertial systems in the terminal area. Chart 9 shows the flight procedure and expected reduction in inertial system error volumes by updating the inertial system with radio aids during the final approach to an airport. To investigate this problem, ERC entered into a joint research effort with two other NASA centers, Langley and Wallops Station, Va. The avionics flight equipment used in the investigation is a Gemini inertial guidance system which was loaned to ERC by the USAF Manned Orbiting Laboratory Program Office. ERC, with the assistance of the industrial contractors who originally designed and built the Gemini guidance system, installed the equipment on a pallet, which can easily be installed in a Langley helicopter. Although the equipment is the same as that which flew in the successful Gemini space program, it was necessary to modify the power system and computer programs for this aircraft flight research investigation.

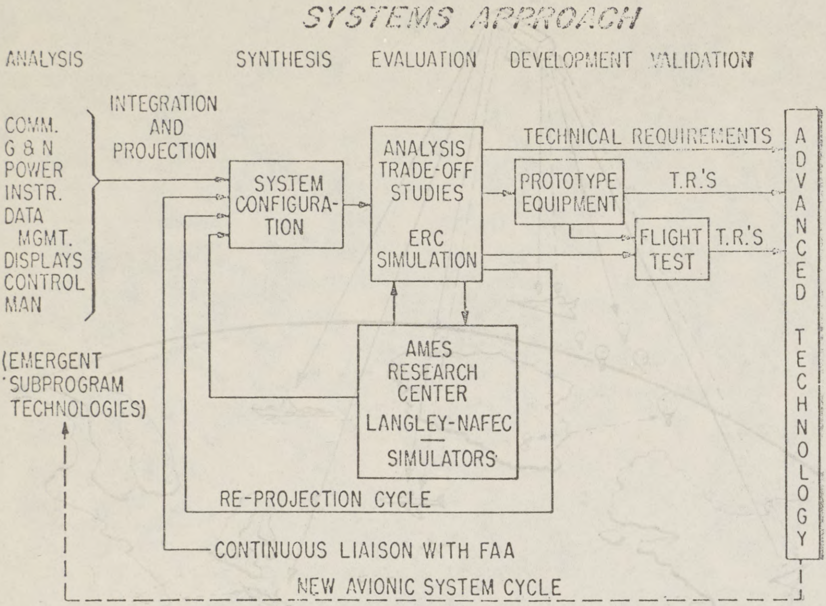

CHART 8

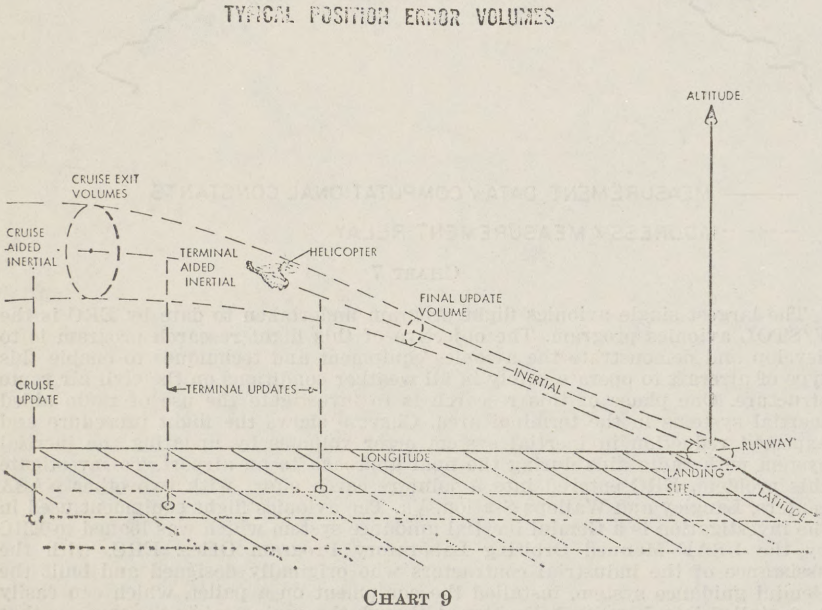

CHART 9

In flight tests run this summer using the inertial system without any updating from the ground tracking radar (GSN–5), the performance error varied from 1 NM per hour to around 5 NM/hour with an average performance over 20 flights of 3 NM per hour. This performance is typical of state of the art gimballed inertial systems today.

In September 1968, the investigation of updating the inertial system began. Data was transmitted from the ground every second and actual updating of the flight computer was accomplished every 10 seconds. The research program is continuing and further data will be obtained on updating techniques. The results to date indicate the desirability of aided inertial systems for aircraft operations. Chart 10 indicates the cost of this program to date, and Chart 11 indicates a

CONTRACTOR COSTS -- PHASE 1

FY68	$1,115K
FY69	485K
TO COMPLETE	325K
TOTAL	$1,925K

ITEMS TO COMPLETE

SUPPORT TO DECEMBER 31	$250K
INTERFACE FOR CH-46	25K
ADDITIONAL ENGINEERING	25K
TEN M/M CONTRACTOR SUPPORT	25K
	$325K

CHART 10

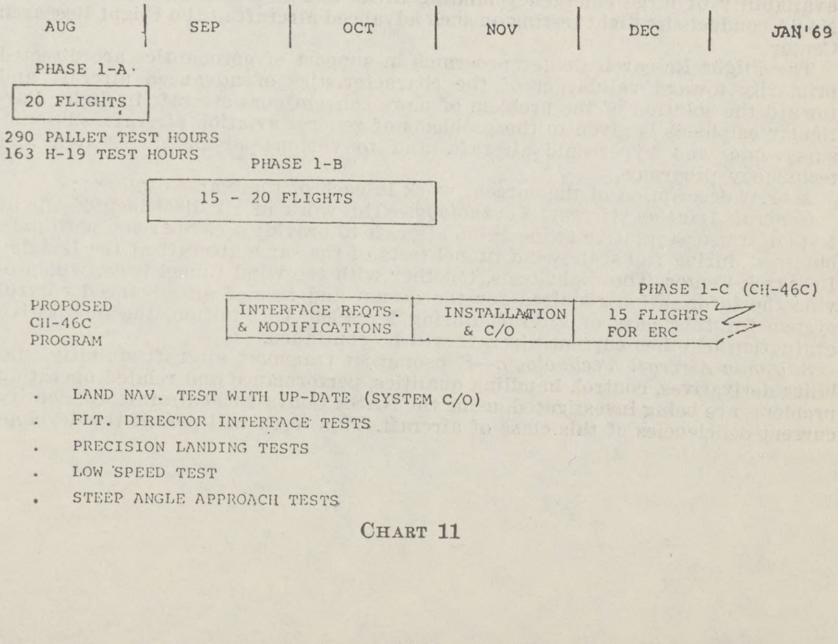

CHART 11

summary of the schedule. Towards the end of this year, the equipment is planned to be installed in a Langley CH–46C helicopter, and research tests will be conducted on integrating the guidance and navigation equipment with the CH–46C variable stability control system. The CH–46C will then be used to investigate the handling qualities of various V/STOL aircraft with an integrated guidance, navigation, control and display avionics system.

This program should determine the trade-off between on-board inertial accuracy and the number of ground-based radar updates. The investigation will lead us to a total cost comparison of inexpensive inertial systems with many updates versus more expensive and accurate inertial systems with less updates. The present Gemini system of course is only a test vehicle and far too expensive for commercial use.

After the investigation of terminal landing techniques, the program is planned to be extended to enroute and area control situations.

Command and Control Research

To date, most of the ERC effort in this direction has been in technology research. In recent months, we have initiated some applications research into Air Traffic Control in cooperation with the FAA. This year we plan to install a laboratory facility at ERC which will permit the investigation of V/STOL traffic control techniques using the Langley instrumented aircraft and various computer simulations of realistic traffic situations.

SUMMARY OF ACTIVITIES—FLIGHT RESEARCH CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA aeronautical research activities are carried out using both theoretical and experimental approaches. In the experimental approach, wind tunnels, simulators, propulsion, and structural test facilities, and many other types of ground-based facilities are used to validate theory and to extend this research into areas where theory is as yet inadequate. Flight research is another step in this cycle and in addition to providing the actual full-scale environment for aerodynamics, structural or propulsion research with the dynamic effects and the interaction of the pilot into the air vehicle system. The tools of flight research are either very advanced experimental research vehicles such as the X-series aircraft, e.g., the X–15; prototype aircraft such as the early F–111A models; modified conventional aircraft such as General Purpose Aircraft Simulator (modified Jet Star); and representative conventional aircraft which have developed problems in flight or which may be used in generalized aerodynamic or flight dynamic studies. Testing of high performance vehicles requires the support of the major tracking and communication facilities at Edwards Air Force Base and the availability of large emergency landing areas and it is for these reasons that NASA conducts its flight testing on such advanced aircraft at the Flight Research Center.

The Flight Research Center programs in support of aeronautics are directed primarily toward validation of the characteristics of advanced aircraft and toward the solution of the problem of more conventional aircraft in flight. Particular emphasis is given to the problems of general aviation aircraft, subsonic, supersonic, and hypersonic aircraft, and to various advanced research and technology programs.

A brief description of the current work in each of these areas follows:

General Aviation Aircraft Technology.—The work in FY 1969 includes flight tests of a representative twin-engine aircraft to provide a comparison with data obtained during full-scale wind tunnel tests of the same aircraft at the Langley Research Center. The flight tests, together with the wind tunnel tests, will provide the information required for the design and test of an advanced control system for this class of aircraft during FY 1969. In addition, the qualitative evaluation of other current aircraft will be continued.

Subsonic Aircraft Technology.—Subsonic jet transport aircraft stability, stability derivatives, control, handling qualities, performance and related operating problems are being investigated, using the NASA Convair 990 aircraft, to identify current deficiencies of this class of aircraft. This work will permit the development of improved certification criteria for future aircraft of this type. Improved quantitative criteria will enhance the safety and reliability of such aircraft.

Supersonic Aircraft Technology.—Flight tests of the XB–70, as a joint NASA-U.S. Air Force endeavor, are continuing. Current effort includes an investigation of the ability of an experimental system recently installed in the XB–70 to control the structural response of a large aircraft due to atmospheric turbulence. Pilot proficiency, aircraft fatigue life and passenger comfort should be improved significantly with the use of such a system. In a related investigation, instrumentation has been installed in the XB–70 to measure atmospheric turbulence (vertical and lateral gust velocities) at typical SST operating altitudes and velocities, for use in evaluating the analytical methods currently used for predicting the dynamic response of large flexible aircraft operating at supersonic speeds at high altitudes.

Flying qualities of the XB–70, together with its stability derivatives and control system data, are being obtained over the entire operating envelope to be used as baseline data for work related to the development of revised handling qualities criteria for aircraft of this type. Ground-based and in-flight simulation techniques are also being used.

The XB–70 is used also for studies of skin-friction drag, base pressures, boundary-layer noise, steady and dynamic structural loads, propulsion system and air induction system performance, overall operational performance characteristics of a large supersonic cruise vehicle, and the physiological effects on a flight crew during the operation of this type of cruise vehicle.

The handling qualities and performance characteristics of supersonic variable-sweep aircraft are being investigated, using an F–111A on loan from the Air Force. Engine/airframe integration problems are being investigated also, as part of a coordinated flight and wind-tunnel research program to determine the characteristics of the aerodynamic flow properties in both inlets and jet exits which influence the performance of current turbofan-powered jet aircraft. Special high-frequency instrumentation is being used in this investigation.

A second Air Force F–111A will be used, starting later this year, to investigate the airframe buffet characteristics of variable-sweep aircraft at transonic speeds. Various leading-edge slat and trailing-edge flap configurations will be tested.

The General Purpose Airborne Simulator (GPAS), a modified Lockheed Jet-Star aircraft, is being used to investigate, in flight, problem areas which have been identified during ground-based simulator studies. Particular emphasis during this investigation will be given to the supersonic transport in the cruise configuration and the NASA Convair 990 and the USAF Lockheed C–5A in the landing. A prime objective will be to predict the handling qualities and the controllability of the supersonic transport following an engine failure during cruise flight.

Hypersonic Aircraft Technology.—The basic research program for which the X–15 aircraft were procured has been completed. Flights of the X–15–1, however, are continuing in order to complete several Air Force high-priority experiments. Flights for the Air Force will continue for the next few months.

The reduction, analysis and reporting of the data obtained during the basic research program is continuing. Surface pressures and temperatures, boundary-layer impact pressures, stagnation temperatures, coldwall heat transfer, skin friction and drag of the basic airplane and drag induced by the large external tanks on the X–15–2 are being analyzed.

Advanced Research and Technology.—Flight experiments to develop new methods for investigating turbulent boundary layer characteristics (skin friction, noise, density, temperature profiles) and laminar-to-turbulent flow transition in the boundary layer, as well as aerodynamic loads, mechanical loads, thermodynamic loads and impulse loads will continue. Other work required to support flight research will be conducted, also, as part of a continuing program to develop instrumentation and test techniques.

Avionics and Aircraft Control Systems Research.—Investigation of the application of advanced guidance techniques to aeronautical vehicles is underway. Studies of advanced guidance systems, using the X–15's ALERT computer and the Air Force's PRIME strap-down inertial guidance system are scheduled first in the XB–70 followed by tests in a NASA F–104 and then interfaced with the adaptive control system in the F–111A aircraft. This effort is part of a coordinated FRC–ERC program. A command attitude director display will be tested during F–104 flights also.

Investigation of energy management concepts, using both ground-based simulators and high-performance aircraft (the X–15–3), has been underway as a joint FRC-ARC program. The work is being completed using the ground-based simulator. A program to develop advanced systems technology needed for contro/guidance systems for general aviation aircraft, to enable improvements in flight safety and utility, is underway also.

Development of other advanced flight-test instrumentation components and systems, required for more accurate measurement of vehicle accelerations, displacements, temperatures and pressures, velocity and position in flight, is continuing.

High-Temperature Aircraft Loads Laboratory.—The High Temperature Aircraft Loads Laboratory is being used for structural tests of present and future high performance vehicles. The primary objective is to evaluate the effects of aerodynamic loads, mechanical loads, thermodynamic loads and impulse loads on structural efficiency and integrity. This involves evaluations of structural analysis methods and measurement and analysis of structural loads and deflections in flight vehicles in subsonic to hypersonic flight environments.

A horizontal tail of the X–15 has been constructed and instrumented for high temperature strain-gage calibration technique development; it is currently undergoing laboratory testing. An XB–70 canard is being instrumented with newly-developed titanium weldable strain gages and will be tested in the FRC High Temperature Aircraft Loads Laboratory during this year.

SUMMARY OF ACTIVITIES—LANGLEY RESEARCH CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The objective of the Langley Research Center program in aeronautics is to provide the advanced technology necessary for the development of both civil and military aircraft having improved performance, utility, and safety. The Aeronautical Research Program is aimed more specifically at accomplishing the following objectives:

1. Generation, on the basis of research results, of new and advanced vehicle concepts.
2. Provision of scientific and engineering information which will permit the development of more refined, safer, and more useful aircraft at lower cost.
3. Provision of technical assistance to other agencies of the Government in the development of new aircraft or in the correction of serious deficiencies in existing aircraft.

In accomplishing these objectives, Langley operates numerous ground-based research facilities such as wind tunnels, structures and materials laboratories, and simulators, and performs flight research with the use of full-scale aircraft. The original cost of the facilities of the Langley Research Center which are devoted to aeronautical research was approximately $152 million. Langley utilizes about thirty percent of its manpower in carrying out the aeronautical research program, and in fiscal year 1968, spent approximately $22 million in R&D funds. Research is carried out in such technical disciplines as: performance aerodynamics, stability and control structures, materials, structural dynamics and loads, operational problems, airworthiness, and air-breathing propulsion. The goals of the Langley Research Program in Aeronautics could be described in relation to these technical disciplines. The description of the aeronautics program in terms of vehicle types, however, has been chosen, as this method appears to be the most meaningful way of expressing the impact of advances in technology, and serves as a necessary means for focusing research effort. The broad-based programs in the technical disciplines, however, must be clearly recognized as providing the essential basic technology necessary to support the aeronautical objectives to be described. The need for new experimental facilities and the modernization of older facilities must also be recognized as essential in order that the technology for future generations of sophisticated aircraft may be provided on a timely basis.

The broad goals of the Langley Research Center Aeronautics Program are outlined with respect to the following classes of aircraft:

1. Helicopters
2. V/STOL Aircraft

3. Subsonic Transport Aircraft
4. General Aviation Aircraft
5. Supersonic Aircraft
6. Hypersonic Aircraft

In most cases, research requested by other Government agencies in support of specific development projects, as for example F–111 and C–5, is not discussed. It is worth noting, however, that Langley has carried out approximately 100 such specifically requested research jobs since 1961.

HELICOPTERS

The helicopter has developed into a highly useful machine which is employed in a wide variety of applications. Nevertheless, these aircraft are far from optimum in many respects. Some of the major helicopter problems fall in the following areas:

1. The flying characteristics of the machine are such as to require a high degree of pilot skill and attention in all flight conditions, and is particularly difficult under IFR conditions in the terminal area.
2. The maneuver capability of the aircraft is limited and not well understood.
3. The efficiency of the aircraft is relatively low.
4. The aircraft has undesirable vibration characteristics.

The objectives of the Langley research program on helicopters are centered around these four problem areas. The study and solution of those problems is being undertaken through the use of various full-scale flight vehicles, such as the variable-stability Vertol YHC–1A and the Bell 204B, and through the use of various wind-tunnel facilities such as the 30- by 60-foot tunnel and the 16-foot transonic dynamics tunnel. Fundamental analytical studies are, of course, also being made.

V/STOL AIRCRAFT

Research on V/STOL aircraft began about 1948 in the NACA and has continued up to the present time. A profusion of concepts has been studied in the wind tunnel, and a number of test-bed-type V/STOL aircraft have been flown. That such aircraft can be made to fly has been amply demonstrated; however, these aircraft have indicated the existence of many problems. The performance has generally not been very good; piloting problems have been numerous, and very little has been learned about the problems of operating the aircraft under any but ideal test conditions. Langley's goals in the area of V/STOL aircraft are to generate the means for realizing the performance and operational potential of these aircraft, and to provide the design concepts and detailed quantitative data which will permit the development of refined and operationally useful types. A number of wind-tunnel facilities are being utilized in this program and a special VTOL wind tunnel, authorized in fiscal year 1967, is now under construction. In addition, flight studies are being carried out with the Hawker Siddeley P. 1127 and LTV XC–142.

SUBSONIC TRANSPORT AIRCRAFT

The modern transport is an efficient, and relatively safe and reliable aircraft. There are, nevertheless, areas in which large improvements are possible. The goals of the Langley program on subsonic aircraft are:

1. Increased safety
2. Reduction in noise
3. Higher cruising efficiency

In the quest for increased safety, the Langley program is focused on obtaining a better definition of the environment in which the aircraft must operate, the manner in which the aircraft and pilot respond to this environment, and the generation of new design and operational techniques and concepts for aircraft of increased safety.

The definition of atmospheric turbulence, the means for detection of turbulence, and the response of aircraft to such turbulence are areas in which Langley has been involved for many years and which will continue to receive attention. Studies of the fatigue of aircraft structures are also undertaken as a part of this problem. The study of the stopping and control characteristics of aircraft on wet runways is another area in which Langley continues to make important contributions to increased safety. These programs utilize full-scale aircraft, and special experimental apparatus such as the landing loads track and the new structural fatigue laboratory.

With regard to noise, Langley has a very active program in this area which involves not only fundamental theoretical and experimental studies of the generation and propagation of noise, but extensive hardware contracts which deal with the suppression of noise during the landing approach of jet aircraft. These hardware contracts will culminate in flight studies of two large jet transports employing noise suppression treatment in the engine nacelles.

In the realm of improved cruising efficiency, new wing design concepts are being explored at Langley. These concepts offer the possibility of achieving lower operating costs and higher speed.

GENERAL AVIATION AIRCRAFT

General aviation aircraft are usually defined is any civil aircraft which is not utilized in scheduled transport operations. A particular class of aircraft in this category which is of interest to Langley is that which is flown by an individual in the pursuit of his business. The usefulness of such an aircraft as a serious means of transportation seems to be limited by the following four interrelated problems.

1. The basic uncertainty of making or completing a trip due to adverse weather.
2. The difficulty of and current proficiency required to safely practice instrument flying.
3. The lack of forgiveness to human error in many types of flying together with the necessity for continued maintenance of currency and proficiency.
4. The high cost of all aspects of flying.

The Langley program for general aviation aircraft addresses certain aspects of these problems and involves analytical studies, flight tests, and wind-tunnel and laboratory studies.

SUPERSONIC AIRCRAFT

Military aircraft having a supersonic dash capability have been operational for many years. The supersonic cruising aircraft has been seriously studied since about 1955 and is now becoming a reality in the SR71 and in the future supersonic transport aircraft. There are, however, as yet many deficiencies in our knowledge of this class of aircraft. The most serious problems fall in the following three categories:

1. Achievement of potential performance characteristics
2. Operational problems in a varied environment
3. Public acceptance

The objectives of the Langley program on supersonic cruising aircraft are as follows:

A. Generation of design concepts which permit the achievement of optimum cruising efficiency at supersonic speeds while maintaining acceptable characteristics at subsonic speeds, and in the landing and take-off conditions. Some of the techniques involved in accomplishing this objective are:

1. Further development and refinement of analytical means for predicting and optimizing aircraft characteristics.
2. Wind-tunnel studies of new concepts at high and low speeds.
3. Analytical and wind-tunnel studies of concepts employing fuels other than hydrocarbons.
4. Investigation of jet nozzle efficiency.

B. Development of design and operational concepts for minimizing sonic boom. Both analytic experimental, and flight work are involved in this area.

C. Development of structural and material techniques aimed at achieving significant reductions in weight. The extensive structures and materials laboratories located at Langley are utilized in this work.

In the area of supersonic fighter type aircraft, Langley has a very active program of assistance to the Air Force and the Navy. This program is responsive to specific requests from the military services to study particular contractor designs. In addition, Langley has a program aimed at generating advanced aerodynamic concepts for this class of aircraft.

HYPERSONIC AIRCRAFT

Primary interest is focused on the hypersonic air breathers-reusable launch vehicles, transports, and reconnaissance vehicles. For the cruise-type vehicles, the mission and operational studies made to date have been to preliminary in nature to provide a definitive indication of their true potential or most effective modes of operation. However, when the prospects for all of the hypersonic air breathers are viewed in total, there is clear justification to proceed with an expanding advanced technology program supporting all of these vehicle classes.

The speed range of prime interest for this program is now clearly defined as Mach 6–8, with Mach 10–14 a more distant and less distinct goal.

Although the literature is well filled with drawings of Mach 6–8 vehicles and conclusions of "feasibility," the true facts about the present state of the art are as follows:

1. The postulated hypersonic air-breathing propulsion systems are actually nonexistent and a major growth in R&D in this area must materialize.
2. Detailed development of lightweight, high-temperature structural concepts and studies of significantly large structural test assemblies for both wings and cryogenic tankage have only recently been undertaken. At present, the literature shows such wide ranges of structural weight estimates that these vehicles can be made to look either attractive or impractical.
3. In the aerodynamic and heating areas studies of practical complete configurations are needed.

The Langley program on hypersonic aircraft is aimed at the three areas indicated. The Hypersonic Research Engine Project represents an attempt to define the true state of the art of hypersonic air-breathing propulsion and to point the way for future research in this area. Studies of large structural models representative of various concepts of cryogenic tankage are being undertaken in the Langley 8-foot high-temperature structures tunnel and in the structures laboratory. Aerodynamic configuration concepts are being studied in several Langley hypersonic wind tunnels. A large Reynolds number hypersonic facility is badly needed to lend realism to the aerodynamic results being obtained.

SUMMARY OF ACTIVITIES—LEWIS RESEARCH CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The United States is a world leader in aviation today and, in particular, is the world's major supplier of civil aircraft. This position was attained not without challenge from the international community by a process that proceeds from scientific concept through component research, system development, manufacturing, and finally utilization of the system as a military or civil airplane. NASA-Lewis's past efforts in the propulsion aspect of aeronautics have been in the first three areas, i.e., concept, research, and development, and have over the years contributed significantly to continuing improvements in our aircraft power plants.

During the past decade this country's space program has engendered tremendous technological advances which have provided encouragement to the developer, and others, to think in terms of bigger and broader problem areas as well as causing them to realize that the possible rate of progress far exceeds that visualized in the past. Concurrently, the spirit of inquiry has been nourished and heightened in many minds. Thus today we stand on the threshold of a new era in aeronautics, one where the current opportunities for increasing our transportation capability through flight are greater now than ever before. The field is wide open to realize some very substantial gains. With ideas, courage, and the necessary research this country can capitalize on this outstanding opportunity and meet the increasing challenge of the Europeans and the Russians.

The large past and future growth in the number of people and quantity of material to be transported by aircraft in congested areas presents both the opportunity and the requirement for STOL and VTOL aircraft. NASA-Lewis will be studying unique fan and jet-type propulsion systems which are integrated into the airframe to provide reduced power-plant weight, reduced initial and operating cost, improved operating reliability, and better performance. These improvements will be attained by conducting analytical and experimental research.

(*a*) To increase the aerodynamic loading and tolerance to distortion of both compressor and fan blades.

(*b*) To develop shorted and lighter weight combustors.

(*c*) To increase the turbine operating temperature by developing new cooling techniques and new materials.

(*d*) Develop new materials to permit lower cost and lighter weight engines.

The problem of propulsion system noise associated with V/STOL and subsonic aircraft operation has been receiving research attention and component tests have indicated that the noise levels can be reduced by judicious spacing of fan blades and by using acoustical liners. Optimization studies of these techniques as well as new fan blade design concepts will be conducted in the future. In addition, complete experimental engines will be designed, built, and tested to demonstrate the significantly lower noise levels that can be achieved. Also, increased effort is planned in the area of jet-exit noise suppression for the supersonic aircraft application. This will include research on ejectors, mixers, and sound absorbing materials.

The challenge in supersonic propulsion is particularly important from the point of view of military superiority. The demands of the future will be for higher speeds, above Mach 3 and possibly Mach 4 or more, and a capability to operate over much wider range of airplane maneuverability, i.e., angle of attack. Both component and complete system work has been conducted in the past and will continue into the future. For example, improvements in inlet pressure recovery and reductions in drag and distortion level have been demonstrated in the past. This technology must now be extended to higher speeds and cover a much wider range of aircraft maneuverability.

Also, technology has been generated which permits today's advanced compressors to have about half as many stages as those designed ten years ago. Future efforts will be aimed at further improvements in compressor efficiency, increased pressure ratio per stage, and, particularly, improved tolerance to stall and distortion to avoid limitations on aircraft performance. Another example of component research is the combustor for turbine engines. Recent research has resulted in a combustor having half the length of today's combustor but with performance equivalent to those in use today. Future research will be aimed at increasing the heat output of the combustors, reducing their sensitivity to flow variations and increasing their life or durability. Work aimed at developing combustors suitable for use with methane and hydrogen will also be initiated inasmuch as these fuels may be the key to the higher supersonic flight speeds. The supersonic engine propulsion cycle is such that fuel consumption and engine weight are decreased and thrust increased as the operating temperature increases. Unfortunately, the known materials melt at the desired temperatures and thus much research effort has been devoted to devising cooling techniques which permit today's turbines to operate at temperatures around 2000°F. Recent research revealed a new superior material for application with a special cooling method.

Other research is indicating new methods of fabricating complex cooled blade configurations that will permit more effective cooling. Also recent laboratory studies have shown that the addition of tungsten fibers to a super alloy results in a new material with at least 50% better strength-to-density ratio. In the near future, studies aimed at utilizing the heat sink or cooling capability of methane or hydrogen to cool turbines and other hot parts will be initiated. All of the above approaches will be continued in the future with the goal of being able to operate turbines perhaps as high as 3500°F in the future. The importance of component efficiency cannot be overstressed. For example, a 1% increase in exhaust nozzle efficiency increases the range 120 miles for a long-range supersonic aircraft. Recent research has resulted in the development of several design criteria for a new plug type of exhaust nozzle. For conventional exhaust nozzles, recent research has shown that the external drag can be significantly reduced with proper attention to the shape of the afterbody. Also new data showing how airplane drag can be reduced by proper location of the exhaust nozzle has been obtained. In the future it is planned to continue improving the internal and external characteristics of conventional and axi-symmetric plug nozzles. Additionally, the work will be expanded to cover applications to the higher supersonics Mach numbers and to include studies of two-dimensional wedge-type exhaust systems.

The individual component research discussed previously is a very necessary step in the evolution of propulsion systems. However, it is only part of the process since one engine component can interact in an adverse manner with another. Therefore it is necessary to study and analyze the complete propulsion system (combined components plus controls) in a ground facility which simulates the flight environment. In the past year NASA-Lewis has conducted such tests on engines for the F–111 airplane and on demonstrator engines for the proposed FX and VFX airplanes. These studies have shown the effect of steady and dynamic airflow-distortions on the engine characteristics, the interaction of the high pressure compressor with the low pressure compressor, and the effect of transients in fuel flow on engine characteristics. These and other dynamic effects will be studied in the future on these engines as well as on the more highly loaded and more aerodynamically complicated engines which will be built to satisfy the requirements for flight at Mach numbers above 3.0. NASA–Lewis historically conducts research in advance of their application to airplanes.

During the past few years, mission studies have indicated some promising engine cycles for hypersonic flight. Research and analysis during the next several years will narrow the list of candidate cycles. In the interim, Lewis is conducting a program which concentrates on the fundamentals, component design and testing related to a supersonic combustion ram-jet which uses hydrogen as a fuel. The present program emphasizes the fundamentals of supersonic fuel injection, the mixing characteristics in the combustor, the aerodynamic and chemical kinetic effects on ignition and combustion, hypersonic inlet design, research of facility techniques to permit the simulation and testing on the ground of the temperature, and pressure and velocities to be encountered in flight. These programs will continue for about two years. Subsequently, increased effort will have to be devoted to problems such as the exhaust nozzle heat transfer and cooling of the engine hardware and component and engine-vehicle interactions.

Mr. HECHLER. We would like to hear from Mr. Cortright, Director, Langley Research Center.

(The biography of Edgar M. Cortright follows:)

EDGAR M. CORTRIGHT, DIRECTOR, LANGLEY RESEARCH CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Edgar M. Cortright became Director of the National Aeronautics and Space Administration's Langley Research Center, Hampton, Virginia, on May 1, 1968.

Mr. Cortright plans and directs research designed to provide the science and technology for a variety of important national programs in aeronautics and manned and unmanned space flight.

Born July 29, 1923, in Hastings, Pennsylvania, Mr. Cortright served as an officer in the U.S. Navy from 1943 to 1946.

He received the Bachelor of Aeronautical Engineering degree in 1947 and an M.S. degree in Aeronautical Engineering in 1949, both from Rensselaer Polytechnic Institute.

Prior to his appointment as Langley Director, Mr. Cortright was an aerospace scientist and administrator for 20 years. He served at the Lewis Research Center, Cleveland, Ohio, from 1948 to 1958, and at NASA Headquarters in Washington, D.C., for the following ten years.

At the Lewis Research Center, Mr. Cortright was Head of the Small Supersonic Tunnels Section (1949–1954), Chief of the 8- by 6-foot Supersonic Wind Tunnel Branch (1954–1959), and Chief of the Plasma Physics Branch (1958). He specialized in high-speed aerodynamics, particularly on problems related to air induction system design, jet nozzle design, and interactions of a jet with external air flow.

Upon NASA's creation on October 1, 1959, Mr. Cortright became Chief of the agency's Advanced Technology Programs and directed initial formulation of NASA's Meteorological Satellite Program, including Tiros and Nimbus.

In February 1960 he became Assistant Director for lunar and planetary programs in the former Office of Space Flight Programs, where he directed the planning and implementation of NASA's automated lunar planetary programs. These included such projects as Mariner, Ranger, and Surveyor.

He was named Deputy Director of the Office of Space Sciences on November 1, 1961, and two years later was appointed as NASA's Deputy Associate Administrator for Space Science and Applications.

As general manager for the Office of Space Science and Applications, he carried major responsibility for planning and directing NASA's program for the automated scientific exploration and utilization of space. These programs included the lunar and planetary probes, the geophysical and astronomical satellites and probes, biosciences, meteorological and communications satellites, and the development and use of light and medium launch vehicles through the Atlas-Centaur class.

Mr. Cortright joined the Office of Manned Space Flight in NASA Headquarters as Deputy Associate Administrator in October 1967, where he served until his appointment as Director of the Langley Research Center.

Mr. Cortright is a Fellow of the American Astronautical Society and an Associate Fellow of the American Institute of Aeronautics and Astronautics. He is a member of Sigmi Xi, Tau Beta Pi, Gamma Alpha Rho, and Pi Delta Epsilon, honorary societies.

During his career devoted to the advancement of flight Mr. Cortright has been the author of numerous technical reports and articles. He has lectured and otherwise participated in a number of technical conferences both in this country and abroad.

He received the Authur S. Flemming Award from the Washington, D.C., Junior Chamber of Commerce in 1963; the NASA Medal for Outstanding Leadership in 1966 and the NASA Medal for Distinguished Service in 1967.

Mr. and Mrs. Cortright are the parents of two children.

STATEMENT OF EDGAR M. CORTRIGHT, DIRECTOR, LANGLEY RESEARCH CENTER, NASA

Mr. CORTRIGHT. Mr. Chairman, members of the committee, many of the aspects that we are working on at Langley have been touched on already, but there are a few to which I perhaps could add a little bit.

I think you know that we have about 30 percent of the effort of this 4,000-man laboratory working in aeronautics, in general. This covers the speed range all the way from the special aircraft of the vertical and short takeoff character, including the helicopter, up to hypersonic. I thought I would say just a few more words about the subsonic aircraft problems and the supersonic aircraft problems and then just a word about facilities. I hope what I have to say wasn't covered yesterday.

As you are well aware, because you have called these hearings, subsonic aviation is big business. It is very big business, and it has big problems. One thing that strikes me is the value of refinement of aircraft design in terms of profitmaking capability, salability of the aircraft, and safety of the passengers. I think that there is still a lot of work to be done in refinement of the subsonic aircraft.

Some of the things that we are working on in subsonic flight include the supercritical wing, which has been mentioned, which would permit the extension of about a tenth of a mach number in the transonic drag rise and an equivalent shift of the high lift buffet boundary. We are working on the handling quality of such aircraft and are doing work with simulators that is quite interesting. For example, we are simulating the landing operation itself. Also, in the case of military aircraft, we are simulating maneuvering one against the other. We have a "dual phase simulator" which is being developed to do this.

There is a basic question as to how large subsonic aircraft are going to get. As you know, we have gone to this very large 747 now, and there is some talk of them getting even bigger.

This raises special questions in aerodynamics as to how predictable these will be. Although sometimes one worries about the magnitude of an accident with an aircraft like that, it is conceivable that the terminal problem might even be relieved because there would be fewer aircraft in the air. That is a question, I think, of some importance.

Now in the area of supersonic aircraft, one thing that struck me very strongly these past few months is the trade-off problem; that is, what characteristics do you really find necessary or most desirable to build into supersonic aircraft.

For example, at Langley we have a great many wind tunnels, and we have concentrated very heavily in the field of aerodynamics and still are. Therefore, we have tended to work toward configurations which have maximum lift over drag ratios, which are a measure of the efficiency of aerodynamic design.

In attempting to incorporate some of our refinements into aircraft, such as variable-sweep wing and, more recently, a very highly swept fixed-wing design, the companies have found that these shapes are hard to build light. It turns out that although we have achieved considerably higher lift-drag ratios at supersonic cruise speed, that isn't necessary the overriding characteristic that we have to get to make these airplanes effective.

In addition, for a typical supersonic transport in the mach 28 class, which is what Boeing is working on, something like 40 percent of the fuel is committed to subsonic flight including reserves. This means that the lift-drag ratio as subsonic speed is also very important. There are also certain types of routes for these aircraft which penetrate the land masses more than others and hence require some subsonic cruise in order to make that route because the sonic boom would preclude flight at supersonic speed. This again makes the subsonic lift-drag ratios important.

We are also finding that controlling supersonic aircraft on a precise flight plan is very difficult, and we are beginning to look harder with ERC with the possibilities of incorporating the best of space age electronics into avionics for guidance and control. This is just relatively recent with us, but it will be important.

Supersonic fighters are becoming important again—witness the FX competition. There is a big trade-off problem there too. We know how to build very low drag machines with very fine maneuvering qualities, but the more a plane is asked to do at different altitudes and different speed ranges you have to make compromises. There are compromises made for maintainability. There are compromises made to fit airplanes on elevators on aircraft carriers. These are real, and they have to be carefully evaluated. We are beginning to pay more attention to these trade-offs to see if there are research areas which would make optimization easier. It is very important in conducting a trade-off that we don't give performance away unnecessarily. We have got to make every element of the plane perform to its maximum because the competition is doing that. There is considerable evidence that the competition has been very careful with its aircraft designs.

I have mentioned earlier the dual phase simulator. This is a very interesting device. It enables two pilots to sit in adjacent rooms and fly formation on one another and by formation I mean either friendly formation or combat situations.

We can program into each of these simulators the exact handling characteristics of the aircraft and the other aircraft is projected on a sky in each of the rooms with great realism. The aircraft appear to actually maneuver just as they would in the sky.

The reason we are doing this is to figure out how some of these trade-offs can best be made. What really makes a good fighter airplane? What makes a good fighter aircraft in one situation might not make the best in another, depending on what the opposition is.

Perhaps variable camber wings will become more important. We are quite sure they will in fighter aircraft of fixed-wing design.

The last thing I would like to say is with relation to facilities. Gen. James Ferguson coined a wise expression the other day. He was referring to the very large numbers of high quality facilities which the Soviets have built up in aeronautics, and the statement was: "By their facilities shall thee know them". I like it because facilities are long leadtime items. They are creative type items. It is hard to come up with good facilities and only periodically do you really recognize with a stroke of genius that you can build a facility, like a slotted wind tunnel, and suddenly open up a new flight regime.

I believe this is the time period to rebuild our facilities or extend our facilities in aeronautics to cope with the problems of the seventies. I believe this very strongly, and I hope that the Congress would be receptive to overtures along those lines for modernizing the aerospace facilities in this country for the seventies.

That brings me to one brief last thought, and that is manpower. I also think I have detected a reduction in the number of aeronautical engineers that has been produced in this country over the past 5 years.

Mr. Hechler. Can you document this?

Mr. Cortright. I think I could. I haven't yet, but I have talked with enough people who are worried about it that I think it is real. At least, a reduction in those who are going into aeronautics as opposed to spacework. I believe it is relatively serious. It occurred to me the other day, that whereas we once ran into a sonic barrier which was surmounted, we are facing an age barrier which can't be. We find the average age of our researchers has gone up considerably in the NASA laboratories, particularly in the aeronautics areas, and I believe this should be carefully examined.

Mr. Hechler. Are you sure these people just aren't going into private industry?

Mr. Cortright. I am not sure at this point, but I have sensed it very strongly in talking to experienced people in the field. Time and again they have told me that they cannot bring the young people into aeronautics work that they have needed, and they have also commented that the companies themselves have had difficulties in holding their design teams together, both in the face of an inability to get just the right kind of people, and the relatively low production of new aircraft types, particularly military types. This has caused some degeneration in the design teams around the country.

I believe that is a good point to stop.

Mr. Hechler. Do members of the committee have questions at this point?

Mr. PELLY. Mr. Chairman, I would just like to ask one question. What opportunities are given to pilots, airport operators, and others that are conscious of hazards and experiences to meet with scientists to stimulate their thinking in terms of other basic research or actual applications to these problems? I think it would be very stimulating for the scientists and engineers to talk with some of the people who had brought home to them the needs for greater safety and other needs.

Mr. HARPER. In two ways we try to achieve this. One is through our continuing research advisory committees that have membership from industry and operators.

Mr. PELLY. Is that a high level entity or does it get down to the grassroots?

Mr. HARPER. It gets to the grassroots. Our members are the technical staff from our centers. The members from the industry are pilot representatives, the operations managers from the various airlines. We have meetings between these groups, two to three times a year, in a number of different areas where we exchange our understanding of the operation problems with the people who are actively involved in operation.

The second case which occurs perhaps three or four times a year are conferences or symposia. I believe at Langley yesterday and today they have had a meeting on flying in rough air in which we present our views of the problem. We have representatives of the industry, again, like pilots and operational managers from the airlines themselves, who discuss with our people their experiences as related to our research.

Mr. PELLY. Are college scientists and engineers brought into these discussions?

Mr. HARPER. Yes. We have the universities represented, and they are always invited to all these symposia and conferences. Our difficulty is trying to respond to all of the requests for research that we have. This is the greatest problem.

Mr. PELLY. That is all.

Mr. HECHLER. It is an important point.

Mr. LUKENS. I have one question. I think you referred to a relatively new air stabilizer and supercritical wing. I wonder if you would cover that point?

Mr. CORTRIGHT. The supercritical wing is an airfoil shape which is so configured that it holds the transonic portion of the flow toward the trailing edge of the wing. This is done with a rather large curvature of the trailing edge which generates other problems. It results in high loads on the trailing edge of the wing which makes it difficult to build. By holding the transonic region and the shockwaves toward the trailing edges, it is possible to fly to higher speeds before running into buffet and before running into the transonic drag rise. What this might mean on an aircraft is that it would cruise faster. Perhaps more importantly, if it were cruising at mach .95, and if it got into a situation where its attitude changed, and it speeded up slightly, it wouldn't immediately run into the buffet problem which can be serious.

Mr. Harper referred to this as the margin—I guess Mr. Beggs did—the margin between stall and buffet and in general these high speed airplanes fly in a rather narrow range between stall and buffet.

Mr. LUKENS. This is achieved by the camber curvature of the wing?

Mr. CORTRIGHT. Yes, sir.

Mr. LUKENS. This is a problem of size. Because of this particular structure peculiarity to the camber of the wing, was it necessary to build a large aircraft or wing?

Mr. CORTRIGHT. That is a different point.

Mr. LUKENS. The size would have no immediate bearing on this supercritical wing?

Mr. CORTRIGHT. No.

Mr. HECHLER. Mr. Beggs, did you want to call on any other representatives?

Mr. BEGGS. I think we are about running out of time.

Mr. HECHLER. Yes.

I had one or two quick questions I would like to ask.

The joint study that has been referred to that you are doing with the Department of Transportation, when this is actually finished, who is going to get the results of this study?

Mr. BEGGS. The Department of Transportation.

Mr. HECHLER. And they will then presumably take action and have the responsibility to see that the recommendations of the study are carried out?

Mr. BEGGS. The assignment of primary responsibility for carrying out recommendations of the report will depend upon the nature of the recommendations. Some no doubt will relate to DOT primarily. Others may require a more extensive coordinated approach among Government agencies.

Mr. HECHLER. At the time that this excellent report on Policy Planning for Aeronautical Research and Development was prepared for the Senate committee in 1966 containing a number of questions, one of the questions was what groups within the executive branch are taking the leadership in policy and planning for aeronautical R. & D. At the time that Mr. Webb testified in January 1967, before the Senate committee, he indicated there wasn't any real lead being taken, but there was a kind of close working relationship between NASA, DOD, and others. What has happened since the Department of Transportation has become active in this area? Are they, according to your view, taking the lead in connection with these critical questions of the priorities for aeronautical research and development? What is different with what NASA now is doing as to what it used to do prior to the establishment of DOT?

Mr. BEGGS. In my view, DOT is wrestling with this problem. It is a difficult problem. It is a very, very complex area that they are wrestling with, but they have in the past several months come up with some approaches and there is in my view a good working relationship between the Department of Transportation and NASA, and they are recommending areas for us to work with them. We are working in several important areas. They are talking with us on several other areas. I think we are making progress.

I have read the report you referred to, and I certainly don't believe we have answered that question, but DOT is wrestling with the problem in a realistic way, and we are making progress.

Mr. HECHLER. We are about at 11 o'clock, and there are many, many other problems we would like to probe into, but we must proceed. We will take about a 1-minute recess.

(Recess taken.)

Mr. HECHLER. The subcommittee will be in order.

We are pleased indeed to extend a welcome to an old friend of our committee, Dr. H. Guyford Stever who is president of Carnegie-Mellon University, and also the Chairman of the Aeronautics and Space Engineering Board of the National Academy of Engineering.

Dr. Stever, of course, has done a great deal of work in connection with the Committee on Science and Astronautics as a member of the Panel on Science and Technology for the past 10 years which has met annually with the committee and provided very helpful assistance to the committee. His contribution has been outstanding.

It is a great pleasure to welcome you to the committee this morning, Dr. Stever.

(The biography of Dr. H. Guyford Stever follows:)

DR. H. GUYFORD STEVER

Educator: born Corning, N.Y., Oct. 24, 1916; son, Ralph Raymond and Alma (Mott); A.B., Colgate Univ., 1938, Sc.D. (hon.), 1958; Ph.D., California Inst. Tech., 1941 LL.D., Lafayette College, 1966; LL.D.. University of Pittsburgh, 1966; Sc.D., Northwestern University, 1966; D.Sc., Waynesburg College, 1967, LL.D., Lehigh Univ., 1967; married Louise Risley Floyd, June 29, 1946; children—Horton Guyford, Sara Newell, Margarette Risley, Roy Risley. Staff member, radiation lab., Mass. Inst. Tech. and instr., officers radar sch., 1941–42, asst. prof., aero. eng'g, 1951–56, prof. aeronautics and astronautics, 1956–65, asso. dean, eng'g 1956–59, head mechanical eng'g dept. and head, naval architecture and marine eng'g dept., 1961–65; pres., Carnegie-Mellon University, Feb. 1965—; exec. officer, guided missle program, 1946–48; chief scientist, USAF, 1955–56; consultant, aero. industry. Member, bd. dir., Fisher Scientific Co., Pittsburgh, Pa., and Koppers Co., Pittsburgh, Pa.; United Aircraft Corporation, East Hartford, Conn.; System Development Corporation, Santa Monica, Calif.; member, secretariat, guided missles com., Joint Chiefs of Staff, 1945; sci. liaison officer, London Mission, ORSD, 1942–45; member: guided missles tech. evaluation group, Research and Development Bd., 1946–48; sci. adv. bd. to chief of staff. USAF, 1947—, vice chmn, 1956–61 chmn, 1962—; steering com. of tech. adv. panel on ordnance to Asst. Sec. of Defense, 1954–56; steering com. tech. adv. panel on aero., Dept. Defense, 1956–60; Defense Sci. Bd.; adv. panel, Com. on Science and Astronautics, U.S. House of Representatives; chmn., spl., com. space tech., NASA; chmn., research adv. com. missle and spacecraft aerodynamics, Nat. Aeronautical and Space Authority, 1959—; member: Air Force Systems Command Bd. Visitors; add: member, National Academy of Engineering, adv. council, Dept. Aero. Eng'g, Princeton Univ.; Member, President's Commission on the Patent System, 1965–66; Recipient, President's Certificate of Merit, 1948; Exceptional Civilian Service award, USAF, 1956; Scott Gold medal from Am. Ordnance Assn., 1960. Fellow, Inst. Aero. Scis. (vice pres., 1958–59, pres. 1961), Am. Acad. Arts and Scis., A.A.A.S., Am. Phys. Soc., Am. Inst. Aeronautics and Astronautics, Royal Aeronautical Soc.; member: Phi Beta Kappa, Sigma Xi, Sigma Gamma Tau, Tau Beta Pi, Pi Tau Sigma, Am. Soc. Mechan. Engrs., Soc. Naval Archtects and Marine Engrs., Am. Soc. for Eng'g Education. Trustee, Colgate Univ., Sarah Mellon Scaife Foundation, Aerospace Education Fndn. of

21–064—69——6

Air Force Assn. Club: Cosmos (Washington) Duquesne Club, Rolling Rock Club, University Club (Pittsburgh). Episcopalian. Contrib. profl. publs. Home: 1045 Devon Road, Pittsburgh, Pa. 15213. Office: The President's Office, Carnegie-Mellon University, Pittsburgh, Pennsylvania, 15213.

Fields: Gas discharge geiger counters, cosmic rays, radar guided missiles, hypersonic dynamics, shocktubes, transonic aircraft, nuclear propulsion for aircraft, condensation in high speed flow.

STATEMENT OF DR. H. GUYFORD STEVER, CHAIRMAN, AERONAUTICS AND SPACE ENGINEERING BOARD, NATIONAL ACADEMY OF ENGINEERING, PRESIDENT, CARNEGIE-MELLON UNIVERSITY

Dr. Stever. Congressman Hechler, thank you very much.

I appreciate the opportunity to present to you and your colleagues on the subcommittee some of our ideas and thoughts and conclusions.

As you know, I am here as Chairman of the National Academy of Aeronautics and Space Engineering Board which has just completed a report as a result of approximately a year's study entitled "Civil Aviation Research and Development" and "Assessment of Federal Government Involvement." I believe that we have submitted enough copies for all of your members at an earlier date.

The vice chairman of the Aeornautics and Space Administration Board, Dr. Bisplinghoff who was going to be with me today found at the last moment an educational crisis that he had to take care of.

Colonel Berger, U.S. Air Force, retired, who is the executive secretary of our Board is with me to help out.

Mr. Hechler. Could you identify Colonel Berger fully?

Dr. Stever. Col. Robert J. Berger.

The Board which was established by the NAE in May of 1967, before it started this study, conducted a prestudy investigation with officials of the NASA, Department of Transportation, Federal Aviation Administration, President's Science Adviser, Department of Transportation, some Members of Congress, and also the National Aeronautics and Space Council.

We concluded that looking at the civil aviation problem from the standpoint of the Government's role in research and development was a worthwhile objective for our first year's activity.

You may be interested in the way we conducted this study. We received a great deal of help from several of the major engineering societies, particularly the American Institute of Aeronautics and Astronautics, the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the Society of Automotive Engineers.

We also formed a series of subcommittees of our own in each of six areas, flight vehicles, and propulsion, aircraft operations, air traffic control, airport and support facilities, and noise. The titles of those groups are significant because, while most of our group have sprung from the science and engineering professions, this breakdown of research and development is not the normal breakdown that technical people normally make. We concluded that we would look at this problem not from the standpoint of engineering and science, but from the standpoint of the problem of civil aviation and as it related to users in the whole country.

We also concluded that civil aviation can continue to grow. It can keep up its phenomenal growth of the past decades, but only if it has certain favorable elements in its future environment.

I think you have all been exposed to projections about the growth of civil aviation, doubling every 5 or 7 years. There are many different projections, most of which were based upon analyses in which there were no obstacles to that growth. In other words, it is usually assumed that there was a continuing increase in the gross national product and the general affluence of the Nation, and that there were no technical or political obstacles in the way.

Now, we believe that, there are three serious limiting factors. One has to do with the airport and the environment, the terminal environment; the second has to do with noise; and the third has to do with the air traffic control system.

If we can lick these obstacles, then we would predict a continuing growth as in the past. And the growth is quite phenomenal. I think I ought to mention it. As you know, by this time the air carriers have taken close to three-quarters of the entire city personal transportation, having grown from, in 1939, about 6 percent of that.

I won't go into the history to tell you all the reasons for this growth, but one of the reasons, and Chairman Hechler mentioned this at the earlier time today, had to do with the improving safety records. The improving safety of air transportation is, I think, one of its great successes and one of the reasons it has grown so phenomenally.

I have the figures, in which you might be interested, in scheduled air transportation domestic versus other forms of transportation. In the number of fatalities per 100 million passenger-miles over a 3-year average, 1965, 1966, and 1967, the railroads had 0.1.

Buses had 0.19 or practically 0.2.

Scheduled air transportation 0.25.

So it is very low along with those other commercial forms of transportation.

Turnpike driving is approximately five times as large as scheduled air transport. It has about 1.20 fatality per 100 million passenger-miles.

General driving is twice as bad, or about 2.4.

And unfortunately general aviation, that is, aviation outside of the scheduled airlines has 18, so it is much the worse part of civil aviation, and if one is working on the safety problems, one must devote a great deal of attention to it.

It is true that within general aviation there are elements, particularly the company planes and small airlines which operate on highly professional bases, which have a good record. But the rest of general aviation does not have, and pilot error plays an important part.

Let me talk about the three limiting points: airport and support facilities, noise, and air traffic control.

It is clear that our Nation's growth in air transportation has outstripped the Nation's airport and support facilities. Just as in automobile transportation, highway transportation, 10 years ago our automobile traffic outgrew our highway system, and we had to go to the Interstate Highway System that is still building.

The Nation's airports are in similar need of attention, and I think unless comprehensive action, both local and national action, is taken, the growth of civil aviation will very definitely be severely curtailed.

I don't have to describe what happens at airports. As in education, everyone who has ever been there is an expert. The same is true in flying and all of you know full well the problems at the terminals.

Financing and planning seem to be the weaknesses. I would add, I guess, there are also the problems of political jurisdiction at a local level. Someone pointed out that standing on at the top of the Empire State Building there were somewhere between 1,000 and 1,200 political entities within view. You can imagine the problem of getting agreement on anything at a local level.

But that is only part of it. Financing is low and planning is definitely weak. We are convinced that on the national level there should be help in those areas. Particularly we have a wonderful opportunity at this time because we are about to give birth to a whole new air transportation system which involves, on the one hand, short takeoff and vertical takeoff and landing aircraft, and on the other hand, jumbo jets. They are not coming in with a bang to replace everything else, but they are going to enter the system. At the local level, we can improve our terminal system before we get deeply into the problems which these new transports will bring.

Let me talk about noise and other limitations. The noise has crept up on us, and naturally so, as we have developed larger and faster aircraft. The generation of more power represents the generation of more noise. Things can be done to decrease the growth of noise, but not completely eliminate this growth.

Incidentally, at takeoff of 1,500 feet from the start of takeoff, the noise from the DC–3, which was our great transport in the late 1930's and early 1940's, compared to the noise of the later models of the Boeing 707, is increased by more than 1,000 times.

Now, when you see that expressed in DB's, it is the difference between 100 and 130, but you must remember that the DB scale is a sneaky one. It is logarithmic, and, in fact, that difference of 30 means a level of 1,000 in power. We do indeed have quite a problem with respect to noise.

It doesn't mean that things can't be done, and in our report we have made many recommendations about the kinds of studies that should be done at the research and development level and also in introducing new Federal and local regulations.

Air traffic control problems, in the 2 years since I last was before members of this group on an aeronautics problem, really have hit us.

And presumably they are going to grow. You have had testimony, I am sure, about the nature of the problem. Since our Board was looking at research and development, we considered this problem from the standpoint of years into the future. And we have concluded that the research and development phase of traffic control must be improved or we will never attain the best that air travel has to offer.

Actually, in air traffic control it is our belief that not only is there a shortcoming in the research, but also in the application of existing technology.

In other words, the technology that is being applied today is not even the most modern.

When I say that, I do not want to point the finger of accusation at any individuals or agencies. The Federal Aviation Administration has not had the money to build the necessary capability to do research nor to get the best applications of technology in the flight control area. They have had a very difficult time keeping up with their everyday business, and the fact that we have as good a transportation system as we do today is in large measure due to the FAA. I give them full credit for their performance. Especially FAA deserves a good measure of credit for the fine safety record of the scheduled airlines as well as the growth of our civil aviation system throughout.

We have made over a hundred specific technical recommendations, without giving an exact priority, except to point out that the technical work in the three limiting areas of airports and their environment, noise and air traffic control should be considered most seriously.

Our most important recommendation is that the Government must take a stronger role in the R. & D. for civil aviation.

Now, by that I don't mean that they are going to put the airlines or the air manufacturing people out of business, but there are broad systems studies and specific research that are needed.

For example, setting research and development goals, priorities, throughout the same, funding the applied research and serving as a stimulant to it, providing a society of fundamental information.

Also, funding development programs when the private economic resources or motivation just couldn't reach it, funding programs associated with public welfare and especially carrying out programs that require interaction among Government agencies.

In some senses we are now primed with the proper Government organization for a good attack on the existing civil aviation problems with the creation of the Department of Transportation to add to FAA and NASA. But we do not believe that we are getting the maximum out of these. The research-oriented organization is NASA. They are outstanding in research in the aeronautical field. They have done some very fine things, but their responsibilities for research are lopsided. They have research responsibilities in traditional fields of aeronautics, the flight vehicles and propulsion, and those kinds of things, but the responsibility for research in the air traffic control is not primarily theirs, it is FAA's. FAA is not a research-oriented organization. It is oriented toward operations and regulations and safety.

The Board believes that we ought to arrange these three agencies to make more sensible use of them.

DOT should have the responsibility of making the systems study. They will have to lean, I believe, on NASA and FAA and industry and the university. DOT should determine the priorities for research and development.

I think NASA is the best equipped and motivated to do the research and development, and I think FAA is the best equipped to do the systems testing and operations. I would like to see much closer relationship among these three agencies.

Now, I wouldn't want anyone to get the impression that we would recommend that all the aeronautics research that is done within NASA today is not helping the three major limiting areas.

The air transportation system presents a system problem technically as well as to our society, and every part impinges on the other.

I will not take up the 110 technical points unless you have questions on them. They are in our report which we have distributed to Government agencies and other interested parties.

Mr. HECHLER. Your entire statement will be incorporated in the record, also.

(The following is the prepared statement of Dr. H. Guyford Stever, Chairman of the Aeronautics and Space Engineering Board, National Academy of Engineering:)

PREPARED STATEMENT OF DR. H. GUYFORD STEVER, CHAIRMAN OF THE AERONAUTICS AND SPACE ENGINEERING BOARD, NATIONAL ACADEMY OF ENGINEERING

INTRODUCTION

Mr. Chairman and Members of the Subcommittee, Dr. Bisplinghoff and I appreciate this opportunity to present some of the highlights of our recently completed study and report on Civil Aviation Research and Development: An Assessment of Federal Government Involvement. I would like to begin the presentation by discussing briefly the background, organization and principal conclusions and recommendations of the study. I will conclude by reviewing the factors we believe will have a major effect on the growth of civil aviation. Dr. Bisplinghoff will summarize the broad issues and technical recommendations made by the Board.

The National Academy of Engineering established the Aeronautics and Space Engineering Board (ASEB) in May 1967 to advise the National Aeronautics and Space Administration and other agencies of government. After consultation with officials of NASA, the Department of Transportation, the Federal Aviation Administration, the President's Science Adviser, certain interested committees of Congress, and the National Aeronautics and Space Council, as well as other government and private groups, the Board decided that a study of the role of the Federal government in civil aviation research and development would be a timely and worthwhile first task for the Board.

The Board concluded that in a favorable economic climate civil aviation can continue to flourish; in fact it can accelerate its beneficial growth if a carefully conceived program of planning and research and development aimed specifically at the civil air transport system is carried out.

After considering the multiplicity of factors affecting the growth of civil aviation, the Board further concluded that the three most critical problem areas are (1) airport and support facilities, (2) noise, and (3) air traffic control.

The most important recommendation of the Board pertains to knitting together more tightly the civil aviation research and development activities of the Department of Transportation, its major operating unit, the Federal Aviation Administration, and the National Aeronautics and Space Administration, and especially to dividing their responsibilities according to capability. The DOT should provide the leadership in conducting systems studies to identify, analyze, and rank civil aviation goals as well as the research and development needed to attain these goals; NASA should be responsible for research and development in all the areas of importance to civil aeronautics; the FAA should, in addition to operating the airways network, be responsible for the systems testing of the resulting operational concepts and hardware.

The Board has also made many detailed technical recommendations concerning research and development needed to insure the growth of civil aviation. These pertain to most of the important facets of civil aviation—including systems, flight vehicles, aircraft operations, air traffic control, airports, and noise. Although many technical recommendations were made, no priority ordering was attempted beyond the conclusion that the three most critical areas are airport and support facilities, noise, and air traffic control. A recommended first step beyond this study is to examine the priorities to be assigned to each research and development objective in terms of its relative contribution to the effectiveness of the civil air transportation system.

The Board conferred with a large number of individuals during the course of its study and enlisted the aid of several technical societies. The Board is indebted to the American Institute of Aeronautics and Astronautics, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the Institute of Electrical and Electronic Engineers, and the Society of Automotive Engineers for conducting special studies, making available special reports, and identifying members for participation in an advisory capacity. The cooperation of these societies and individuals served to broaden the advisory base.

The Board assigned detailed work to six ad hoc committees, each of which had supervisors appointed from the Board membership, as follows:

1. Flight Vehicles and Airbreathing Propulsion
   Mr. Edward Wells, Senior Vice President, The Boeing Company
   Mr. Perry Pratt, Vice President and Chief Scientist, United Aircraft Corporation
2. Aircraft Operations
   Mr. Willis Hawkins, Vice President—Science and Engineering, Lockheed Aircraft Corporation
3. Air Traffic Control
   Dr. Allen Puckett, Executive Vice President and Assistant General Manager, Hughes Aircraft Company
   Dr. George Solomon, Vice President and Director, Systems Laboratories, TRW Systems Group
   Dr. Bernard Oliver, Vice President for Research and Development, Hewlett-Packard Company
4. Airport and Support Facilities
   Mr. John M. Kyle, Jr., Chief Engineer, The Port of New York Authority
5. Economics of Civil Aviation
   Mr. Carlos C. Wood, Division Vice President—Engineering, Sikorsky Aircraft
6. Noise
   Dr. Leo Beranek, President, Bolt Beranek and Newman, Inc.

The membership of each committee was made up of knowledgeable men from different parts of the aviation community, who made many valuable contributions to the study.

Dr. Raymond L. Bisplinghoff chaired a drafting committee composed of the ASEB supervisors which, together with the secretariat staff, was responsible for preparing the report which was published on August 13, 1968, and which summarizes the conclusions and recommendations of each of the six ad hoc committees.

I should like to discuss with you some of the principal factors that the Board identified as affecting the growth of civil aviation in this country. I will also touch on some statistics indicating the projected growth.

PRINCIPAL FACTORS AFFECTING THE FUTURE GROWTH OF CIVIL AVIATION

It became increasingly clear during the course of the Board's study that future flight vehicles for civil air transportation will be influenced not only by the advancements made possible by aeronautical technology but also by the extent to which they are assimilated by and compatible with the total transportation system and the population it serves. In the past, aviation research and development has been concerned primarily with improving the flight vehicle. But the flight vehicle is only one segment of the total air transportation system. In setting research and development objectives it is necessary to seek goals that improve the productivity of the total system—not just the flight vehicle. This implies that civil aviation research and development should be directed toward the most critical problems of the total system.

The growth rate of civil aviation will be the result of an equilibration of those forces that will tend to drive it to higher levels (such as increasing public demand for transportation facilities and a favorable economic climate) and those forces that will tend to impede its growth (such as technical limitations or social restrictions). A question frequently asked is whether the historic upward trend in the growth of civil aviation can be expected to continue through another decade in spite of these potential restrictions. The Board strongly believes that in a favorable economic climate this upward trend can be maintained and even accelerated if a carefully conceived program of planning, research, and development aimed specifically at the civil air transportation system is initiated.

Transporation is one of the major elements in any society. The history of civilization and the history of transportation have always been closely intertwined, since transportation assists in social developments, and society in turn demands better transportation. Starting within the last half century and accelerating greatly within the last 25 years, air transportaion of all types has become a major element in world affairs as an expression of national policy, corporate business policy, and individual personal policy.

While civil aviation is only a part of the transportation system, it is by far the most dynamic. Civil aviation provides some 1.2 percent of the total dollar contribution to the United States gross national product. However, the impact of civil aviation on the United States economy and on its people is far greater than its share of the gross national product would indicate. From 1939 to 1966, the air-carrier share of consumer outlay in dollars for domestic intercity travel increased from about 6 percent to about 72 percent, with the combined share for bus, rail, and other commercial carriers accounting for the remainder. If one accepts the FAA projections of civil aviation growth, the air share of the domestic commercial travel market in terms of passenger miles will have increased from about 10 percent to nearly 80 percent in the 30 years from 1947 to 1977.

The FAA assumed in making this forecast that the major factors behind the growth rates achieved in fiscal years 1964, 1965, and 1966 will, over the next ten years, continue to exert a positive influence on traffic volume. These factors are, for example, increasing gross national product, high disposable income, virtually full employment, improved service, and decreasing average fares. The forecast for growth of commercial air travel takes into account not only the increasing number of people flying, but the increasing frequency these people travel on the average. The percentage of people in the United States who had used air travel at least once in their life rose from 30 percent to 45 percent between 1961 and 1966. Each air traveler had flown an average of 1.07 times a year in 1961 and 1.28 times a year in 1966. By 1975 it is expected that with a continuing healthy economic climate, these figures will be 66 percent and 1.44 times a year, respectively. Figure 1 shows the past trends and estimates for the future use of the various modes of commercial transportation.

Although the later sections of this report point up in some detail the major research and development areas that will affect the growth of civil aviation, the members of the Board believe that three of these areas are of such critical importance that they should receive special attention. These are listed in order of importance:

1. Airport and Support Facilities
2. Noise
3. Air Traffic Control

Any of these can exert strong inhibiting influences on the growth of civil air transportation unless satisfactory solutions can be found to problems that are now developing.

The Board also recognizes that these three areas are closely coupled in that they all relate to the ability of our air transportation system to accept and dispatch aircraft at key terminal points with safety and efficiency as well as with acceptance by the surrounding community. This interrelationship serves to emphasize the viewpoint of the Board that an essential requirement for the future will be to identify and rank research and development goals through systems studies of the total civil air transportation system.

Airport and support facilities

A little over a decade ago, the nation's growth outstripped the capability of its highway system to support its vehicle transportation requirements. As a result, the Interstate Highway System was initiated.

Today, the nation's airports are in similar need of attention, and unless comprehensive action is taken, the growth of civil air transportation will be severely curtailed. Many airports are experiencing peak-hour saturation; terminal facilities have become strained; and airport access to the community is becoming increasingly difficult.

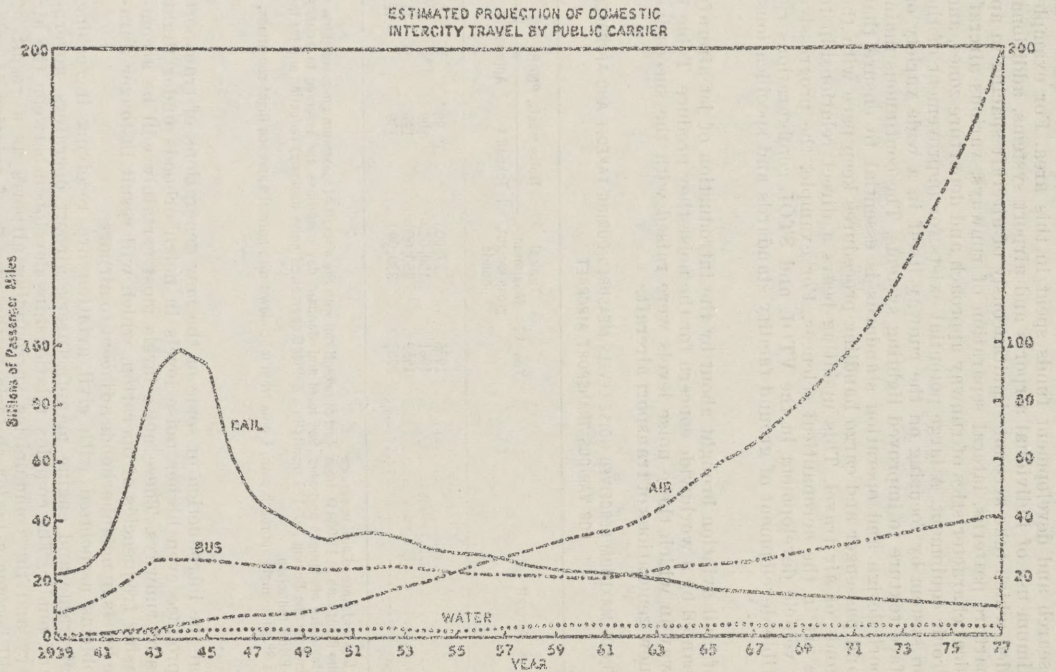

Figure 2

Sources:
Air – Transportation Association of America (TAA) to 1967. FAA estimate, 1968 to 1977.
Bus – TAA to 1967. National Association of Bus Owners, 1968 to 1977.
Train – TAA to 1967. (Estimated for 1967 through 1977 based on trend established during 1962-1967. Assumes no changes in present legislation.)
Water – TAA to 1967. (1967 to 1977, projection of the 1967 level)

FIGURE 1

At least two major obstacles hinder the required development of an adequate national airport system: financing and planning. The question of methods for acquiring and allocating funds for airport development is obviously outside the scope of this study. The Board is convinced, however, that before any effective action can be taken to solve the airport problem, it is essential to have sound and complete plans at both the national and regional levels that will assess capabilities, estimate demands, and identify steps necessary to meet requirements.

Although relatively modest research and development efforts have been directed toward airports in the past, the Board believes that substantial returns can accrue from research and development funds spent in this area. For example, to achieve maximum use of individual airports and airport systems, additional studies are needed which take account simultaneously of aircraft spacing in approach and departure patterns, lateral separation of runways, various aircraft categories, physical characteristics of runway approach and departure zones, and associated electronic equipment. A large potential exists for improvement of the nation's aviation system by focusing on the runway itself in a wide variety of areas from surface texture to improved lighting systems. The continuous maintenance of airport design and operation standards is essential to ensure that airport layout and passenger and cargo handling procedures keep pace with the expanding demands of air travel. This updating bears a direct relationship to the state of the art in the aeronautical sciences. For example, the progressive nature of flight vehicle development in the VTOL and STOL configurations requires a compatible development of ground facility standards and specifications.

Noise

The growth of civil aviation brought about by the introduction of jet aircraft has been accompanied by a worldwide concern for the noise they produce. Table 1 illustrates the way in which these noise levels were raised with the successive introduction of new generations of transport aircraft.

TABLE 1.—COMPARISON OF MAXIMUM PERCEIVED NOISE LEVELS MEASURED DURING TAKEOFF AND APPROACH FOR VARIOUS TRANSPORT AIRCRAFT

Aircraft	Year [1]	Typical Maximum gross weight, pounds	Noise levels, PNdB	
			Takeoff [2]	Approach [3]
Douglas DC-3	1936	27,000	98	96
Douglas DC-6B	1951	100,000	106	105
Boeing 707-120	1959	250,000	129	[4] 117
Boeing 707-320B	1963	330,000	130	[5] 121

[1] Year of introduction into widespread airline service.

[2] As measured under the flight path at 15,000 ft. from start of takeoff roll with the aircraft at maximum gross weight and with no power cutback for noise abatement purposes. Sea level and standard day conditions are assumed to exist. A power cutback to a 3° limit for the Boeing 707-120 results in a 6-PNdB (perceived noise decibels) reduction and for the Boeing 707-320B in a 1-PNdB reduction.

[3] As measured under a 3° glide-angle approach path, 1 mile from touchdown with normal approach flight conditions.

[4] 50° flaps.

[5] 40° flaps.

It is likely that the introduction of some of the new generations of transport aircraft might produce even higher noise levels in neighborhoods under flight paths or to sides of runways. These noise levels most certainly will be accompanied by increasing frequencies of operation, which will result in longer duration of high noise levels in neighborhoods adjacent to airports.

The noise problems associated with civil aviation are receiving increasing attention from airframe and engine manufacturers, airport operators, government agencies, and public. The complex relationships developed between the air transport industry and the communities surrounding airports as a result of aircraft noise will become a major obstacle to the growth of aviation if noise exposure and its effects on operations cannot be reseolved.

It is clear that any solution to the noise problem must include the development of quieter aircraft; the establishment of federal noise criteria and of noise standards for aircraft; the development of consistent land-use practices in areas surrounding airports; and the development of low- and moderate-cost building air-conditioning and sound-proofing techniques to reduce noise inside houses already in such areas. These problems are evidenced by the difficult situations now existing at many major commercial jet airports, and they could become even more pronounced around V/STOL terminals and under V/STOL flight corridors unless new solutions are found.

Air traffic control

The air transportation growth recorded in the last four years, coupled with forecasts for future growth, indicates that air traffic will be increasing at a greater rate than the present or programmed traffic control system can handle. An increasing number of terminal areas are already experiencing unusually long delays in receiving and dispatching aircraft.

Federal Aviation Administration forecasts through 1977 show that the demands placed on the national airspace system by air carrier and general aviation are expected to increase sharply and that military flying will continue to decline. Total aircraft operations at airports with FAA traffic control service will rise from 41.2 million operations in fiscal year 1966, to an estimated 139.0 million operations in fiscal year 1977, an increase of approximately 337 percent.

Increased air traffic volume with a greater proportion of larger high-performance aircraft will clearly require new approaches to air traffic control in the future. The forecasts indicate that deficiencies now evident in the nation's air traffic control system will become progressively worse unless strong measures are taken to correct the imbalance of volume of traffic and capability. The Board believes that there are areas where a more vigorous effort to apply existing technology can pay large dividends. At the same time, there are other areas where renewed emphasis on initating research and development is clearly needed.

The underlying element of safety is implicit in all considerations of the future growth of civil air transportation. It is obvious that a continuing high level of passenger safety must be maintained. Even maintaining present safety levels may not be acceptable as larger aircraft are introduced. An unassailable public image of safety must be maintained to avoid any inhibition to growth.

Although the safety record of scheduled air transportation is impressive and continues to improve in terms of fatalities per passenger miles flown, it is significant to observe that the accident rate has remained nearly constant for almost twenty years at approximately 0.2 accident per 100,000 hours flown. This rate figure has varied very little despite significant increases in airplane size and passenger load.

The trend toward increased size of aircraft in scheduled air transportation, with a constant accident rate, will expose more passengers to each occurrence. It follows that with the introduction of very large aircraft the current accident rate of the scheduled airlines must be reduced below the present average if the total number of fatalities is to be kept near the present levels.

In comparison with other forms of transportation, the safety record of general aviation is relatively poor. Using the measure of fatalities per 100 million passenger miles, the accident rate for general aviation* is more than seven times that of general driving and fourteen times that of turnpike driving. It should be pointed out, however, that over 80 percent of general aviation accidents involve pilot error and that pleasure flying by private pilots is responsible for over two-fifths of all civil aviation accidents. Corporation and executive aircraft flown by professional pilots and operated under standards similar to those used by the airlines are involved in less than 2 percent of general aviation accidents.

It seems clear to the Board that research and development activities aimed at those components of the civil aeronautics system that are beginning to affect critically the safety of scheduled air transportation and general aviation can have profound effects on the growth of civil aviation. Such activities should be given renewed emphasis.

I have reviewed the procedure we used in organizing and conducting our study and touched on the major problem areas inhibiting the projected growth of civil aviation. Dr. Bisplinghoff will summarize the general considerations and technical recommendations developed by the Board.

SUMMARY OF PROBLEMS AND RECOMMENDATIONS

The results of the Board's studies have been divided into two parts. The first, "General Considerations," expresses the view of the Board on the role and respon-

*General aviation here includes private, corporate, executive, and air-taxi aircraft operations; it excludes commercial airline operations.

sibilities of the federal government in civil aviation research and development. The second, "Technical Considerations," outlines in some detail the Board's view on important technical problems and presents its recommendations for research in civil aviation systems, flight vehicles and airbreathing propulsion, aircraft operations, air traffic control, airport and support facilities, and noise (including sonic boom).

GENERAL CONSIDERATIONS

In its general consideration of civil aviation the Board addressed itself to the broad issues of goals and priorities for research and development, government leadership and participation, and implementation of research and development responsibilities.

Goals and priorities for research and development

In reviewing the progress made by civil aviation during the past decade, the Board noted the randomness by which new technologies found their way into the total air transportation system and the dependence of these new new technologies on military research and development. Although there have been previous studies that dealt with elements of civil aviation, the Board was strong in its belief that an essential requirement of the future will be to undertake systems studies of the total civil air transportation system with the objective of identifying and ranking research and development goals. Such studies wouuld begin by relating civil aviation to the nation's transportation system and to national goals. They would end by identifying, analyzing, and ranking research and development goals in terms of safety, time, and economic advantages or penalties to the system as a whole.

Government leadership and participation

Although it has been traditional for most of the aeronautical research and development to be carried out by industry, universities, and nonprofit institutions, strong government leadership will be required in the future in certain areas. Federal involvement in civil aviation research and development will be required in the following ways:

1. Setting research and development goals and priorities through studies of the total transportation system.
2. Funding applied research that exceeds the resources of private industry but that serves as a stimulant to the industry and provides a source of fundamental information.
3. Funding development programs when private economic resources or motivation is inadequate for achieving national objectives.
4. Funding programs associated with public welfare.
5. Carrying out programs that require interaction among government agencies.

These precepts would suggest that government leadership and participation are needed in certain areas in order to ensure the growth of civil aviation. When the federal government does participate in the research and development process, its principal function is to bear the financial burden of advancing aeronautical technology to the point where the private sector can see the opportunity for profit or where user government agencies can proceed to systems development.

Implementation

The Board concluded that strong government participation and leadership will be required in research and development if civil aviation is to continue to grow as it has in the past. This participation and leadership must come from both the legislative and executive branches of the government through wise policies and their effective implementation. Viewpoints developed by the Board on the government's role in the nation's program of civil aviation research and development are described in the following sections.

Legislation.—With the creation of the Department of Transportation federal agencies and their charters are now structured such that the government can exert its proper leadership role in civil aviation research and development. It is the Board's belief, however, that all civil aviation legislation should be reviewed for consistency to eliminate unnecessary restrictions and duplication and to ensure that sound economic development is fostered.

Systems studies.—It is the consensus of the Board that leadership should be provided by the Department of Transportation (DOT) in carrying out systems studies to identify, analyze, and rank research and development goals. These goals should be formulated with reference to the nation's total transportation system, taking account of the increasing public demand for air transportation as well as the various economic factors that bear on civil aviation. Although an in-house government capability should be developed and maintained by the DOT in transportation systems analysis, it is strongly recommended that industry and other private institutions participate in carrying out these studies.

Research and development.—Lengthy discussions were held by the Board concerning the responsibilities that should be assumed by federal agencies in the sponship and conduct of civil aviation research and development. The long record of outstanding performance by NASA and its predecessor, NACA, in research and development clearly suggests that it should play an even greater role in this area. The Board believes that NASA's role should be expanded to involve not only flight vehicles and their propulsion systems, which have traditionally occupied its principal attention in the past, but all aspects of research and development of importance to civil aeronautics. It will be important for NASA to adopt a policy of directing its attention to those research and development goals, including the development and construction of carefully selected experimental hardware,* that optimize the productivity of the total civil aviation transportation system. Such expanded activities would involve, for example, the development of new technologies relating to air traffic control as well as to airports and their support facilities. With regard to air traffic control, the Board in no way suggests that the responsibilities and authorities of the DOT and the FAA be diminished. But, unlike NASA, which is oriented toward research and development, the DOT and the FAA are oriented primarily toward regulatory and operational activities. The FAA has been unusually effective as an instrument for the construction, maintenance, and operation of federal aids to air navigation. However, the technologies that formed the basis for the development of these aids were derived largely from military-supported research and development. It is the consensus of the Board that although the DOT and the FAA would continue their traditional role of establishment and operation of air navigation facilities, airspace control, and traffic management, the new technologies that will be required to support this difficult assignment are unlikely to come from research and development sponsored by these agencies. Some will result from continuing Department of Defense research and development activities and other from the private sector. However, in the view of the Board, it will be of primary importance to enlist the talents of NASA in the development of new technologies in air traffic control.

The Board makes this recommendation for several reasons. Recent developments in space technology, including the use of satellites for communications and navigation, offer new opportunities for improving air navigation. NASA's background in vehicle technology, together with its growing capability in the field of avionics, enables it to assess the important trade-offs that must be made between on-board and external avionics systems. For example, the Board believes that these trade-offs should be carefully studied before terminal air navigation facilities are developed for all-weather V/STOL operations. In recommending expanded responsibilities for NASA, the Board assumes that these responsibilities would be implemented by NASA in its traditional way of using its research centers for leadership and making use to the maximum extent possible of the talents of industry, universities, and private institutions.

TECHNICAL CONSIDERATIONS

The following sections summarize the detailed techincal recommendations that, in the Board's view, are critical to the future growth of civil aviation. The civil air transportation system is considered initially, followed by flight vehicles and airbreathing propulsion, aircraft operations, air traffic control, airport and support facilities, and noise.

The Board identified and recommended more than 100 specific actions in the above areas, which are discussed in more detail in the reports of the individual ad hoc committees to be published later this year.

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*The Board found a variety of terminology applied to experimental hardware as part of the research and development process. The meaning intended by the phrase *experimental hardware* is that of hardware developed and constructed to explore and demonstrate the feasibility of a new concept.

The civil air transportation system

A logical approach to the planning of research and development for civil aeronautics requires first the establishment of a framework in which to consider it. Since civil aviation is part of a national transportation system, it is desirable, therefore, to correlate both aviation and transportation goals. Going a step farther, the national transportation system must have goals that are compatible with those of the nation.

Modern methods of systems analysis should be useful in establishing this framework. It does not seem practicable to model the nation's transportation system in all its detail, but reasonable modeling to provide a frame of reference appears possible with today's analytical tools. Subsequently, more detailed modeling of individual elements may be feasible.

The Board made specific recommendations for the conduct of cost-benefit analyses to interrelate the various factors affecting the growth of civil aviation. The Board visualized for this process the type of analytical techniques used by the NASA Mission Analysis Division in analyzing prospective space missions as a basis for determining requirements for new technologies.

Flight vehicles and airbreathing propulsion

The flight vehicle with its propulsion system is only one segment of the total civil aeronautics system, albeit an important one. It is the area that heretofore has received by far the greatest attention in research and development. Attention focused on the air vehicle by military research and development has benefited civil aeronautics since the invention of the airplane. Civil aeronautics was at one time highly dependent upon prior research and development of military aircraft. However, the gap between military and civil aviation is growing. The military is relying increasingly on missiles and highly specialized flight vehicles. At the same time, the peculiar conditions under which civil aviation now operates demand transport aircraft that are specially designed for commercial use.

The need for high economic efficiency and productivity in civil aviation will create the necessity for new aeronautical technology just as forcefully as the need for high performance does in military aviation. Although other aspects of the air transportation system, such as airports and the air traffic control system, demand increasing research and development attention, continued efforts will be required to improve and adapt the flight vehicle and its propulsion system to the requirements of our society.

An examination by the Board of the several areas of technology underlying atmospheric flight vehicles and their propulsion systems led to several recommendations for continued research and development. The Board categorized its recommendations in the following subareas: flight vehicle electronic controls, designs for rough air penetration, aerodynamics, mechanical systems, structures, V/STOL systems, combustors, compressors, installed performance systems, instrumentation, and fuels.

Aircraft operations

The term *aircraft operations* is used to describe air transportation problems that relate to the environment of the flight vehicle, the role of man in the operation and maintenance of flight vehicles, the limitation of materials, and the interface between the flight environment and that of other systems. An examination by the Board of the current problems of aircraft operations led to a number of recommendations for research and development which were categorized in the following subareas: atmospheric environment, human factors, materials, and interface problems.

Air traffic control

The volume of air traffic is already far greater in many en route and terminal areas than the present system can handle effectively. Estimates for the future indicate that the deficiency will become progressively worse unless strong measures are taken to correct the imbalance of volume of traffic and capability. The Board is convinced that there are obstacles preventing the efficient application of the talents of government, industry, and the academic communities toward providing an adequate air traffic system. There are areas where a more vigorous effort to apply existing technology will pay large dividends. In other areas, renewed emphasis on initiating needed research and development is clearly needed.

In a number of instances, recommendations made by previous study groups to correct traffic control problems have not yet been implemented. The Board has included in its report several past recommendations that appear still valid in the present traffic control environment. This has been done with the hope that progress can be made by again bringing them to the attention of the agencies now responsible for implementation. Other Board recommendations include long-range actions believed necessary to correct the traffic system deficiencies; measures aimed at rapidly introducing existing technologies into the present air traffic control system; and provision for accommodating new modes of air transport that have been or are being introduced into the national transportation system since the earlier studies.

The Board's recommendations are covered in the sections concerned with clarification of government responsibility and with technology, under the subareas of navigation, communications, weather, and airborne collision avoidance systems.

Airport and support facilities

The airport complex, including the terminal and all its supporting facilities, is a key element in the air transportation system. Despite the obvious importance of this element to the continued growth of civil aviation, it appears to the Board that far too little attention has been given to the problem of matching present and future airport capacities to the ever-increasing demands of civil aviation.

There are at least two major obstacles hindering the required development of an adequate national airport system. Financing certainly has to rank as one of the major problems; planning is another. Since major emphasis in this study has been placed on research and development requirements for civil aviation, the question of methods for acquiring and allocating funds for airport development has been left to those agencies now engaged in studies of this issue.

The Board identified some general problems of airport development including planning and other specific areas where, in the opinion of the Board, increased research and development effort will be profitable. The recommendations were categorized under the following subareas: airport planning, government-industry steering group, educational programs, runway and taxiway capacity, airport standards, air freight, air terminal interface, and general aviation.

Noise

Basically, one may view the "aircraft noise problem" as a "noise pollution" or community environmental problem. The major problems considered by the Board result from noise produced by flight operations of aircraft. For most conventional aircraft, noise during takeoffs and landings is of primary concern, although noise from cruise-flight operations is of concern for some types of V/STOL aircraft flying at relatively low en route altitudes.

Noise produced by ground runup operations presents a problem in a limited number of localities. In general, however, means of limiting noise for extended ground runup operations are available, and no urgent technical problems appear to exist in this area.

However, the Board's survey of current and potential problems associated with aircraft noise resulted in the general conclusion that although emphasis and funds for noise research and development are increasing, the projected rate of progress may fall short of providing solutions when they are needed. The Board assessed the status of present and planned programs and made recommendations aimed at increasing research and development in the broad area of aircraft noise, including that associated with the sonic boom created by the supersonic transport. The recommendations were categorized under the following subareas: noise generation and propagation, flight operations, noise criteria, land use, and sonic boom. For this last category, the Board cited the recommendations of the three subcommittees of the National Academy of Sciences-National Research Council Committee on SST-Sonic Boom.

Mr. Hechler. You have raised a number of really fascinating questions, Dr. Stever. I don't know if we will have time to examine all of them.

There is a very useful article in the Wall Street Journal this morning which describes how Minneapolis and St. Paul solved their air transportation problems. This is an article I would like to put into the record.

(Following is the article above referred to from the Wall Street Journal of Sept. 25, 1968:)

[From the Wall Street Journal, Sept. 25, 1968]

How To Avoid The Rush: Minneapolis-St. Paul's Six-Airfield Concept Keeps Area Free of Traffic Tie-Up Woes

(By Dan Rottenberg)

Minneapolis.—The nation's 14th busiest airport is a surprisingly quiet place. No jets scream overhead; no crowds clog its terminal; no traffic congests its parking lots. Indeed, the biggest planes to land there are twin-propeller craft seating perhaps a half-dozen people.

The airport in question is Flying Cloud, one of five "satellite" airfields in and around Minneapolis-St. Paul designed to lure light aircraft away from the area's hub airfield, Wold-Chamberlain, a bright, modern international airport that lies just 10 miles east of Flying Cloud. The six airports will handle more than 1.5 million flight operations this year, twice the number at Chicago's O'Hare International Airport, the world's busiest.

Despite this heavy volume of traffic, flight delays at Wold-Chamberlain and the satellite airfields are almost nonexistent except in bad weather. This is in sharp contrast to the clutter at New York, Chicago, Washington, D.C., and several other major cities, where air travelers are rapidly becoming accustomed to costly, aggravating and potentially dangerous delays of up to an hour or more as their planes wait for landing or takeoff clearance.

Inter-City Feud Led to Concept

The balanced policy that ensures the Twin Cities' freedom from the air traffic tie-ups that plague other cities was fashioned by the Metropolitan Airports Commission, established by the state legislature in 1943 to halt feuding between Minneapolis and St. Paul over Federal funds, airlines and customers. "If this had been just one city, we may never have had this law and the commission," says Henry G. Kuitu (pronounced Kwee'too), executive director of the commission.

It's a measure of the commission's success that Flying Cloud, which was little more than a cow-pasture strip at the end of World War II, now has more flight operations than Wold-Chamberlain. Flying Cloud will handle an estimated 500,000 takeoffs and landings this year; Wold-Chamberlain will handle about 300,000 such operations. Perhaps more significant, the total volume of operations at Wold-Chamberlain is actually down from about 320,000 in 1947 despite a steady and rapid rise in commercial flights.

The Federal Aviation Administration and individual airports at other cities have come up with their own solutions for air congestion, of course. The FAA proposes restricting the number of hourly flights between 6 a.m. and midnight at five of the nation's largest airports, with the commercial air carriers being assigned the lion's share. And individual airports in New York have raised their landing fees to $25 from $5 in an attempt to discourage lighter, slower planes from mixing in with the big common carrier aircraft.

ADDED CAPACITY IS CALLED KEY

Both plans are bitterly opposed by private pilots, who contend that a public airport has no right to discriminate among its users. Feeling on the FAA's flight quota proposal is running so high that the FAA has added three extra dates for public hearings on the matter. The hearings open today in Washington.

Whether or not the FAA proposal is adopted, it will be only a temporary expedient, according to the man who runs the Twin Cities' airports commission. "To impose quotas or restrictions at airports is no solution to the long-range problem of congestion," says Mr. Kuitu. "The solution is to provide the capacity you need." Satellite airports such as those operated by the commission, he asserts, are "the best insurance you can buy against congestion."

The satellite system as practiced in Minneapolis-St. Paul effectively separates the big planes from the little ones without imposing landing fees or flight restrictions on anyone. Commercial airliners and the biggest corporation jets use Wold-

Chamberlain, but most of the corporation planes prefer to use St. Paul Downtown Airport, where they have spacious hangars and the run of what was once a commercial airport.

The rest of the area's pilots tend to gravitate toward the four other small airports that ring the Twin Cities region: Flying Cloud, Crystal, Anoka County and Lake Elmo. These cater to the smaller, lighter planes while providing basically the same services offered at Wold-Chamberlain and St. Paul Donwtown Airport, the fifth satellite airport.

Anoka's runway is long enough to handle jets; the other three are limited to propeller planes so that the latter won't have to tangle with the faster breed.

FLYING CLOUD'S OPERATIONS

Operations at Flying Cloud are fairly typical of the satellite airports. Basically, Flying Cloud is a cooperative venture among the owners of the 486 planes based there, seven fixed-base operators and the FAA flight controllers who operate the tower 16 hours daily. The airports commission has provided three asphalt runways, the longest 3,600 feet, and an instrument landing system that makes the airport usuable 24 hours daily. The commission has expanded Flying Cloud from its original 160 acres to 540, and provides two supervisors who inspect the runways, mow the grass, repair fences and plow snow. After that, the tenants are on their own.

Because the tenants provide most facilities themselves, they pay very little to the commission. There isn't any landing fee or gate fee at Flying Cloud; the only revenue the commission gets from incoming planes is a fuel fee of two cents a gallon. The commission also gets a small percentage of sales made by fixed-base operators, such as an air-taxi service and flight school.

Nonetheless, the satellite airports are paying their own way. Airport commission statistics show that the satellites handle 80% of all plane movements in the area, although only 6% of the commission's capital investment of $53 million is tied up in the five airfields. The commission funds are in the form of self-liquidating bonds, which are being paid off on schedule, and annual revenue from the five satellites slightly exceeds operating expenses.

The success of the airports commission is due in large part to the fact that its jurisdiction embraces suburbs as well as Minneapolis and St. Paul. In fact, it has jurisdiction over all public air facilities within 25 miles of the Minneapolis and St. Paul city halls. The mayors of each city, three residents of each city and a ninth member who by law must live elsewhere serve on the commission.

INSULATED FROM POLITICS

Mr. Kuitu believes the commission's independence from local governmental units "helps insulate airport matters from petty politics," such as that which long delayed establishment of a coordinated airports policy in the Dallas-Fort Worth area.

Not all residents of the Twin Cities are quite so sanguine, however. John Richter, spokesman for a group of Minneapolis residents who claim their homes are plagued by the noises of passing jets, suggests that the commission is too well insulated from partisan politics. "If we were in a city where the commission is directly responsible to the public," he asserts, "we wouldn't have this problem."

The commission and its concept of satellite airports aren't unique. Satellites have sprung up in such cities as Los Angeles, Chicago, Pittsburgh and Boston. And the Port of New York Authority not only transcends city lines but has airport jurisdiction in two states, New York and New Jersey.

But most satellite airports in other cities are privately owned and have little direct connection with the so-called hub airports, and the Port of New York Authority contends that its first order of business should be the construction of a fourth jetport, rather than additional satellite airfields. The Port Authority's only existing satellite airport is Teterboro in New Jersey, about 30 minutes by car from downtown Manhattan.

The difficulty and expense of obtaining enough land for airports close enough to major cities to supplement existing hub airports is one major factor working against satellite systems. The Twin Cities satellite airports are all within a radius of about 12 miles from the downtown areas.

FAA figures point up the large part played by noncommercial planes in clogging up New York airports. At the peak hour, noncommercial planes account for 30% of the traffic at Kennedy International Airport, 51% at LaGuardia, and 52% at Newark—and most noncommercial planes inevitably cause delays, if only because they're slower. While some airline people concede they're overscheduled at peak hours at Kennedy, they insist they have no place else to go in the New York area partly because of the large number of small planes at the city's other two airports.

Members of the Aircraft Owners and Pilots Association (AOPA),which speaks for the noncommercial planes, don't agree that they're to blame for congestion at major airports. "The airlines are unrealistic," says one New York-area private pilot. "They've been overscheduled during the peak hours."

Neverthless, noncommercial pilots like the Twin Cities' satellite system as much as the airlines do. A recent issue of the AOPA Pilot publication declared that the Twin Cities' airports commission "has come up with a healthy solution for solving major airport congestion problems in a natural way, without penalizing the little guy."

To the airports commission, "the little guy" is more than a reference to fairplay. "Individually owned aircraft serve a vital air transportation need," says Mr. Kuitu. A study completed in 1962 by an economic consulting firm indicated that general aviation in the Twin Cities area generated $233 million annually in business revenue in the Minneapolis-St. Paul area. The figure projected for 1975 was $386 million.

Mr. Kuitu gives Federal and state assistance much of the credit for development of the airports commission system, but he also believes lack of consistent long-range planning at the Federal level is partly responsible for today's congestion elsewhere. And he is equally critical of the airlines for what he believes is their failure to focus their needs into a policy to guide Federal planners.

"You can't develop a system such as ours with profit as a goal," he says. "That's the whole problem with air traffic today. Companies are only willing to finance projects which will come to seed rapidly, but the needs beyond the next decade must be planned for now."

The commission's own long-range plans call for a second major airport north of the Twin Cities, bigger than Wold-Chamberlain, to handdle the increased traffic expected by its completion about 1980. Meanwhile, Wold-Chamberlain's terminal will be expanded, indoor parking facilities will be built, and a 1,200-foot tunnel will be added to expedite the movement of cargo from the field to nearby highways.

Dr. Stever. I think there should be more planning by the Department of Transportation and NASA and FAA to help the people at the local level who have the problem. If we set out more standards for airports, if we look a little more carefully at such technical problems as what is really the best separation of runways and the best way to handle aircraft after they are off the runways, and if there could be more cooperation just on the technical and information level, led by the Federal Government, I think that all around the country the local airport groups would begin to pay attention and would look with pride to those standards instead of what one company or another wants to sell them. Designers have designed airports without enough knowledge about the total air transport problem and have designed something that architecturally may be very admirable, but fails to solve some of the critical airport problems, I think the Federal Government has a role.

Mr. Hechler. I think this is very important what you have just said.

Dr. Stever. I think the climate is better for help from the Federal Government than it has been in the past because of the recent air transportation crisis that we are living through.

I think it is better from the standpoint of the thinking you mentioned; namely, how does one separate general aviation from commercial aviation at the airports. There is a greater willingness to listen, looking for new solutions instead of trying the old. I think that as the local governments all over the country build new airports and improve their old airports, they are going to want to avoid these mistakes. I really believe that a better national look at this is a very important thing and I hope the Department of Transportation steps in and I hope they use all the capabilities that NASA and FAA and other technical people can bring to bear.

Mr. Hechler. I know other members of the committee have questions they would like to pose.

Mr. Pelly. I have one question. I wonder about the interest in the aeronautical education now. Is it lagging or is it keeping up with the growth of the industry?

Dr. Stever. I think it is a little better than a few years ago when space first appeared on the horizon, but it probably is running below where it should be. You know, many different educational fields contribute to the whole aviation field. It isn't just an aeronautical engineering department. It can be mechanical engineering, electrical engineering, computer sciences as well.

The problem that many people mention first is that the traditional aeronautical engineering departments have been abandoned for these other fields. I think we should try to get some more help in that area.

Mr. Pelly. I presume that the Vietnam war is probably a drain on our manpower.

Dr. Stever. I think I would rate the impact of the Vietnam War on the attitudes and morale of students higher than the impact on shifting numbers and taking away people to Vietnam.

Mr. Pelly. What is your analysis of the average age of aeronautical research personnel?

Dr. Stever. The one that was mentioned earlier?

Mr. Pelly. Yes.

Dr. Stever. I suspect—yes; I think one could easily show in many companies and Government agencies that the people who are called upon when a new aeronautical contract comes through are definitely the ones from the past. Without going into specifics, there are at least two companies where I know the people who have left the aeronautical part of the business and gone into the space end of this business 5 and 10 years ago who, when the company got a big aeronautical contract had to return to aeronautics the companies had to shift these people back. They did not have enough young people coming into aeronautics to do the job.

I think it is also noticeable in Russia, too, because the names of the chief designers you see listed with various Russian aeronautical achievements are the same old names that have been around for a long time. The same phenomenon exists in many places.

Mr. Pelly. I was interested to read in the newspaper the other day that one major airplane company was hiring in the Philippines and firing on the local level. That is something I don't understand. I assume that while certain departments are laying off, they are still looking for new talent.

Dr. Stever. Well, I am afraid I don't know this instance, but I am sure of the age phenomenon. There is truth to that.

Mr. PELLY. We have, of course, quite an interest in the development and enrichment of our scientific manpower through our scholarship programs.

Dr. STEVER. I know that.

Mr. PELLY. Do you think there is a real need in this area?

Dr. STEVER. As I say, the help from the Federal Government in the past has been a key item to most of our universities and colleges which have depended upon technical programs. We all continue to depend upon the Government.

We also recognize some of the funding problems of the Federal Government at the present time, and I assure you those cutbacks are having an impact at the college level.

I hope that as soon as we can straighten things out, we can get back to trying to fill the educational pipeline again.

Mr. PELLY. I would like you to comment as to whether or not it would be practical to try to channel our scholarships and grants for education through one agency rather than dissipate it through many agencies, such as the National Science Foundation and the Defense Department and NASA and so forth?

Dr. STEVER. I think that somebody has got to study this problem and get a degree of stability in it so that the young people and the colleges can do better planning with respect to their personnel resources. We are really all off base this year.

Mr. PELLY. I know.

Dr. STEVER. My own institution, for example, the associate dean of graduate studies reported proudly that our graduate enrollment was almost exactly as it was last year, sort of implying that we weren't hurt, but that is not the case. We have more foreign students involved in that graduate enrollment. We have made the enrollment, we have twisted it unnaturally in order not to have too large an economic impact, I think that has happened all around the country.

Whatever you do, no matter if it is one agency or many agencies, I hope you can build in a degree of stability so that the schools can make long-range plans which they must do. After all, they hire professors on long-range terms and short-range fluctuations lead to financial difficulties.

Mr. PELLY. Thank you, Mr. Chairman.

Mr. HECHLER. Mr. Hunt?

Mr. HUNT. Thank you, Mr. Chairman.

Doctor, I discussed very briefly yesterday with Dr. Paine the situation we have in New Jersey and in the metropolitan areas so far as the location of a jetport is concerned. I was privileged to be one of the persons to attend a several-hour briefing where they unveiled, as a result of a study, several perspective locations for a jetport in the metropolitan area. I was amazed to find the plans and concept to be quite well advanced. I think they have projections up to 1985 and as far as 1995.

We have a major problem of location of jetports in New Jersey.

Dr. STEVER. That is right.

Mr. HUNT. I am glad you spoke of the planning situation. There have been those who advocated placing the jetport in the northern part of the State so as to make it more accessible to the New York metropolitan area. However, in doing this, we find that we would compromise the plans in the overall concept and would contaminate our Spruce Run Reservoir and our Lone Valley Reservoir which have just been completed at a cost of many millions of dollars. Therefore, that proposition will probably not be considered. The plans also projected out one for the Pine Barrens which would include the extension of one runway at McGuire Air Force Base so as to connect it directly with supersonic traffic involving the Air Force and commercial traffic.

In other words, one runway would be extended. The airport plans call for 10 runways with provision made to permit landings and take-offs on three runways simultaneously. The terminal itself would not be one terminal but would consist of five terminals connected by a subway and underground connections for traffic.

Dr. STEVER. Yes.

Mr. HUNT. I did specifically inquire as to their plans for short-haul transportation to and from the airport. This was an item sadly lacking in the plans presented. We apparently have developed nothing in the way of rapid rail transportation such as they have in Japan and France. Why don't we take a page out of their book? In the case of an airport located in the Barrens of this magnitude to handle the traffic expected in the year 2,000, we need to go more extensively into the question of feeder lines coming in, because it would be about an hour from New York and very close to Philadelphia. The Wilmington-Philadelphia complex is the fastest growing area in the valley.

I had the occasion to ride the train from Mexicali into Mexico City, the train from Paris to Avignon, and the short-haul line in Chicago, the Skokie line. I wonder why more emphasis is not being placed on moving people rapidly to and from airports by this type of transportation.

Dr. STEVER. I think we are. I think technically we are prepared to do that. DOT has two good high-speed train developments which can compete with the Japanese and the French. I rode the Japanese train at 125 miles an hour, but these two developments in this country could beat that if they were given express runs. I believe that at that particular airport that you are talking about which clearly will be one of the principal airports of the entire world, you are going to have to solve the local transportation by all three methods, high-speed rail lines to certain centers, excellent highway access, and also the feeder airlines. I think you are going to be relying on all of them to take the passengers to and from your airport.

Mr. HUNT. We have the embryo portion of the highway system in the New Jersey Turnpike and Interstate 95 Highway.

We also have a fine military road into the airport. How can we say we have no developments?

Dr. STEVER. I think you ought to talk to the people in the high-speed train business. They are going through their teething troubles as all developments do whether it is a supersonic aircraft or what have you.

Mr. HUNT. We are going through that. The problem involves two companies making compatible equipment but with different circuits so you can't use one car with the other car.

Dr. STEVER. You should never give up your faith in technology.

Mr. HUNT. I haven't given up faith, Doctor, but you know there is an old saying, "the road to hell is paved with good intentions."

Dr. STEVER. In engineering of systems and large elements you are never in my estimation going to get over the period in which the thing is operated and busted. In other words, you have a period of debugging. I think that the high-speed train concepts that the Department of Transportation has underway are well conceived, but they are going to have to get some bugs out. There is no question there are bugs in them today, but if I were going to build a new airport I would certainly have high-speed lines to the major centers. Of course you can't depend solely on high speed trains because a lot of people don't want to go to the centers which they serve. A highway system is needed to spread people around; you have got to have both systems involved here.

Mr. HUNT. I agree with you completely. I think this is an absolute necessity and I wonder how far they have progressed in this area.

Dr. STEVER. I think you could do a superb job on that airport.

Mr. HUNT. So far as the military aspects are concerned, it would be of tremendous importance in an emergency.

Dr. STEVER. The New York authority that works on the ground transportation and the airports and so on, they are really remarkable people. They know an immense amount about airports but they have some of the most difficult political jurisdiction problems.

Mr. HUNT. Thank you.

Mr. HECHLER. When you bring forth this recommendation about transferring research on air traffic control to NASA, it sort of puzzles me. I can't quite understand why FAA—the agency that you yourself said didn't have enough support—couldn't do this job. I think they are adequately equipped and it is the lack of support rather than the lack of technical know-how, it seems to me, that is the limiting factor.

Dr. STEVER. I will certainly agree with you in part. They have not had the support, but they also do not have tremendous depth in research.

You heard this morning the fact that some space research was having an impact on aircaft equipment. It is a tremendous advantage to have that breadth of research that NASA has.

Also in NASA the whole orientation is toward research and I think that is pretty important.

I am not one, by the way, to give any researcher all the money he needs hoping that one of his ideas will apply to something you have. There is a happy medium between confinement into the area in which you want developments to come out and freedom for the researcher to think. Again, I think that the NASA, of the Government agencies, has the best chance to give you the proper combination. That is really the basis behind this recommendation.

In any case, NASA's capabilities are going to have to be used pretty widely on some parts of this. It is a systems problem. It is not simply a problem where you put one kind of equipment in the airplane and another kind of equipment on the ground. It is very important to get those three agencies (DOT, NASA and FAA) closer together than they are now.

Mr. HECHLER. Well, in further defense of the FAA, which I think has been very unfairly criticized in connection with the air traffic control crisis, the FAA has sounded the voice of warning in the wilderness for many years and nobody has done anything about it.

How can you anticipate some of these crises through the think tanks and publicizing what the predictable future crises are going to be? Evidently, you can look back and point to exactly when people in the FAA have pointed out that these crises are going to arise. We need a better mechanism for predicting and taking action to avert these crises.

What do you suggest?

Dr. STEVER. Mr. Chairman, I think that the FAA was forced, because of lack of funding to concentrate on the operational problem. I don't agree with you that they have enough research capability. I think that they were forced to treat the aircraft control problem on today's basis only. There has not been laid down for civil aviation the long pattern of ideas for 20 years from now, for 10 years from now, for 5 years from now. It is partly because of lack of support, partly because we do not have the right agencies working on the problem.

I would rather see the great capabilities for research in NASA used on this important problem than have them unused. I would rather see NASA have capability of looking over the entire research field rather than three-quarters of the research field. I think that is the wrong way to divide research.

I would like to see FAA strengthened. At the beginning of my talk I said I would give them full credit for what they have done. You remember they told us they would run into a problem of shortage of aircraft controllers.

I am not downplaying FAA at all, but I do not think they have the forward-looking research that produces long-range ideas.

Mr. HECHLER. We have a distinguished member of the full committee, who just coincidentally happens to be from Pittsburgh, with us, Mr. Fulton.

Mr. Fulton, do you have any observations or do you have any questions to raise?

Mr. FULTON. I have been very interested in Dr. Stever's approach. I would like to follow some of the lines that have already been developed a little. Speaking of an allied field, there will be the antiballistic missile development. Actually, much of the multiphase Army radar surveillance equipment and computer controls could well be beneficially modified for civilian aviation use in the future.

Dr. STEVER. I think there will be many developments from that. I think there will be developments from the civil space program, and the military space program, that will eventually be used in our civil air transport.

Mr. FULTON. In my estimation, air traffic control at the major transportation centers such as Kennedy, La Guardia, and O'Hara Airports are hindered by the lack of adequate computer utilization. Why isn't there an overall control, including a passenger and deposit system to reduce the number of flights and yet meet the peaks and the valleys of traffic needs.

One of the troubles is that traffic volume gets separated off into little hierarchies by companies. I have seen planes departing from busy

Kennedy airport carrying only 15 or 20 people. I have flown in there on a 707 with only eight people aboard. To me, this amounts to a misuse of time and equipment at Kennedy. I believe the same thing occurs at O'Hare as I noticed in flying there recently from the Southwest.

Dr. STEVER. I think that that temporary measure is going to have to be taken and is being taken now. Clearly there is some balance between absolute complete control or complete freedom of persons who want to be an air traveler with respect to when he can and can't go. There must be a balance between complete control and complete freedom, and it is obviously shifting right at this moment because of the air traffic control crisis.

Mr. FULTON. Within a peak time period, if it can be predicted that the passenger flight is going to be 2 hours late because of the traffic saturation, why aren't the schedules changed?

In flying from Boston to Kennedy, I was advised by the flight crew: "We are waiting an hour on the ground out of Boston, and we will be an hour and 15 minutes stacked at Kennedy." That, to me, seemed to be very poor scheduling.

Dr. STEVER. In most people's minds, they already have been changed. Most air travelers now keep their own schedules which don't agree with the airline schedules.

Mr. FULTON. Out of necessity.

In addition you spoke of the high-speed trains and high-speed ground transportation to the airports. Why isn't there more done on STOL or vertical takeoff and land (VTOL) development using small auxiliary fields to speed travel? Supposedly, the helicopters at various airports will accomplish this, but they are now so inconvenient that I have never used one although I am frequently in a hurry. Why isn't more done on that ancillary service?

Dr. STEVER. I hope that more is done, of course; there is growing pressure now from the people who have developed these to bring them into use. VTOL transportation is still more expensive. There are some problems. There are problems of noise. There is particularly one very large problem which is the location of VTOL and STOL ports.

For example, in the very area that you are talking about, if there were a better series of heliports in New York City, and Philadelphia and others you could handle lots of that terminal traffic. But those heliports have not been developed well enough, but I do think they will. I think we have to keep the pressure on and get them.

Mr. FULTON. We in Pittsburgh have quite a large airport. Being flown from the airport into the city take less time than waiting around Kennedy for a landing permit.

Dr. STEVER. That is right.

Mr. FULTON. Why aren't corollary airports of large size put into more use? I mean so that they are automatically used for flight connections? The intense and primary concentration in New York is self-defeating. It was the same for ships jamming New York Harbor with all the coastal traffic. Only now we find air traffic concentration has created air traffic ghettoes.

Dr. STEVER. I agree.

Mr. Fulton. I would propose a study of air travel preferences, including locations, time schedules, and types of service, be done at the Federal level. The problem deserves national attention. Shuttle service between the major cities should be rationalized as well as normal passenger service. We cannot continue to operate with local airport autonomy, because we cannot afford the chaotic result of mere space-available planning.

Dr. Stever. I would like to take a shot at that, as was earlier mentioned, that the Federal Government had an important role in the airport, the terminal problem which had to do with planning, and now you are talking about statistics.

I believe the FAA could give lots of statistics to help the operators come to more reasonable solutions and one of the improvements would be to use more international air terminals and although I don't like it controlling the times of departure on the schedules.

And I think again the Department of Transportation has to take that leadership getting the industries, the operators, and the local airport authorities together to show them the statistics of where people want to go and make schedules more rational. I agree we have aggravated our problem by a curious focusing on a few airports.

Mr. Fulton. Airport utilization of new technology varies over a very wide spectrum. Many airports although recently constructed just cannot keep pace with the technological innovations being made almost daily in our space age. And human factors are important, too. For instance, Pittsburgh constructed a modern new post office with up to the minute advances in computers, conveyors, and mail handling facilities. But it wasn't until the dedication of the facility approached that the builders realized someone had forgotten to include the letter drops in the main office. Technology itself and alone is not always the sole answer to our problems.

Dr. Stever. Let's not get the FAA or NASA involved in this one.

Mr. Fulton. Perhaps airports should have divided and distinct landing and departure strips stemming from a transfer circle. I served on the bridge of an aircraft carrier in World War II. Our planes could take off in an awful hurry because they were all going in one direction.

Why not handle every plane mechanically once it hits the runway? Taxiing is very awkward at best. It likewise perfumes the atmosphere. Pollution around our airports should be at an absolute minimum. I suggest that every bit of ground traffic be run by electricity.

We might have some of our runways underground instead of having two-way traffic on one runway at an airport. With electrical proplusion for maneuvering the aircraft until takeoff I think we might design boarding facilities underground. There would be no pollution or ventilation problems, and passengers could board the airplane without marching out into the rain and snow of wintry weather. By careful planning, the airport could provide parking facilities directly underground beneath the boarding area for each particular airline. Passengers now have to walk half a mile from the parking lot to the terminal and usually face another hike from there to the airplane itself. By stacking the facilities, runway on top, boarding area next, and parking facilities below you create an efficient system of transportation designed around the people using it.

On aircraft carriers our Navy has for years used a ground-based acceleration system to assist heavy airplanes in takeoff where space was limited to an extremely short runway. I think some serious study should be given to the feasibility of commercial use of such a ground-based hydraulic accelerator concept. In the Navy we used the term "catapults," but I hesitate to adopt a term which might frighten some people.

Noise continues to be a major problem in airport neighborhoods. I recall witnessing the effects of the first and only use of the atomic cannon at Frenchman's Flats. A pine forest had been targeted with trees at varying levels to demonstrate the effect of the blast. The pine trees bent under pressure and within a day after the blast were standing right up again. In a body, the pines had a breaking effect on the noise of the blast and absorbed a tremendous amount of the concussion. It might make good commonsense to line our runways with low pines. As you move away from the runway, the pines get bigger until near the edge of the field you have a substantial stand of fir trees. They would baffle the sound and, being flexible pines they would not endanger the aircraft even on a miscalculated landing.

An interesting concept advanced for cargo use is the prepackaged capsule. Perhaps planes should be hinged on one end and merely land to pick up or discharge whole capsules of passengers already buckled into their seats and ready to take off.

As a matter of Federal policy, military and civilian planes should be segregated into entirely separate landing and takeoff strips. Likewise, I would isolate the smaller planes using the large airports. They should have full access to the airport facility, but we shouldn't continue to mix the moths and butterflies with the behemoths and the dinosaurs.

It seems a good idea to separate airfreight from the passenger traffic as well. Passengers have close schedules to maintain, and freight can best be handled where the facilities are geared to the movement of cargo and not people. In Pittsburgh, we have concentrated freight at the Allegheny County Airport and passenger traffic at the Greater Pittsburgh Airport. The system works very well.

I think our airport technology should keep pace with the advances in the aircraft. Modern airports really don't need the runways aiming in every direction to avoid crosswinds and insure into-the-wind takeoffs. The big planes today have a new need—long runways and more of them, for both takeoff and landing. The airports of the past should be modernized.

My final point centers on the need for improved guidance and ground control systems for aircraft once they are off and away from the immediate vicinity of the major airports.

In 1966, I lost two good friends, the attorney general of Pennsylvania and Mrs. Alesandroni, when their small plane crashed into a mountainside near Uniontown, Pa. It amazed me to learn that the radar and radio of the Greater Pittsburgh Airport, less than 100 miles away, were ineffective for guiding this light plane beyond a range of 12 to 15 miles. Beyond that radius, the craft was in a zone of silence. When it crashed it took almost 36 hours in the cold of winter to find the scene of the accident.

Another friend was killed on a flight from Pittsburgh to Jamestown, N.Y., because of the lack of radar and radio guidance facilities. He was forced to fly visually and on the night before Christmas he headed through a valley and was caught on the hillside just beyond.

I think that radar tracking and radio guidance systems should be available for all pilots flying between cities. They should not enter a no man's land some 15 to 20 miles beyond a major airport with nobody paying any attention to where they are going.

I have finished.

Mr. HECHLER. The hearing will be open a week if you care to make any observations.

Mr. FULTON. You don't have to answer, Dr. Stever. These are ideas. This is the long-range speculation department.

Dr. STEVER. Some of the ideas are obviously good and take a tremendous economic investment of capital to do, and some of them are, in fact, improved tracking of all the aircraft, is, in fact, on FAA's list of eventual capabilities, but it is going to take a long time to get there.

Mr. FULTON. What do you think of the underground runways, and I will let you go?

Dr. STEVER. Well, I like the idea of being underground after we land and out of the weather, but I am not so sure I want to land underground.

Mr. HECHLER. This has been raised before.

Dr. STEVER. That extra, you know, if you came in at any high speed you would probably get quite a pressure shock from going through the tunnel.

Mr. FULTON. Not a tunnel. I picture a big, broad, open underground.

Dr. STEVER. I see. Well, I think it would be very expensive just as people find your proposal of parking underground. Lots of people would like it. We would like to have underground parking at Carnegie-Mellon University, but we discover the cost of parking a car on the surface is about $1,500, parking it in an aboveground structure about $3,000, and if we go underground, about $5,000 per car.

The parking cost always defeats the ideas of going underground, well, not always, but often.

Mr. FULTON. Maybe you should write to your Congressman, Bill Moorhead, and to me. We could look into it.

Dr. STEVER. I will see about it.

Mr. FULTON. That's all.

Mr. HECHLER. Do you have any final suggestions as to what is going to happen to this report, how it can better be implemented, and which agency or what means should or could be utilized?

Dr. STEVER. I personally think the most important recommendations we have made is to perform air transportation research in NASA in much better operating conjunction with FAA and DOT with respect to research and development.

Mr. HECHLER. Yes.

Dr. STEVER. This may take some legislation but a lot can be done without the legislation, but I do think that that is the first step.

I would like also to see additional study on the technical recommendations which came from a very broad base. We got an immense number of people into our study and our report represents the sifting out at several recommending layers. I would like to see the research organizations both in NASA and FAA look at these and try to come to some priority judgments on the recommendations.

Of course, I think the National Academy of Engineering would welcome further participation, too.

Mr. HECHLER. I think this might be a good subject for one of our science and astronautics panels to follow up on this.

Dr. STEVER. I think it would be very good.

Mr. HECHLER. We appreciate very much your appearing this morning. It has been very helpful.

The committee stands adjourned until 10 o'clock tomorrow morning.

(Whereupon, at 12:15 p.m., the committee stood adjourned until 10 a.m., Thursday, September 26, 1968.)

AERONAUTICAL RESEARCH AND DEVELOPMENT

THURSDAY, SEPTEMBER 26, 1968

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Advanced Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. Hechler. The committee will be in order.

The committee is pleased to welcome back David D. Thomas, Acting Administrator of the Federal Aviation Administration, who has compiled a remarkable record as a public servant in the FAA and its predecessor agencies over the past 30 years.

(The biography of David D. Thomas follows:)

David D. Thomas, Deputy Administrator, Federal Aviation Administration, Department of Transportation

David D. Thomas was sworn in as Deputy Administrator of the Federal Aviation Agency on July 1, 1965. He was selected for the position by President Lyndon B. Johnson on May 12 to succeed Lieutenant General Harold W. Grant, USAF, upon General Grant's resignation June 30.

When the agency was absorbed into the newly created Department of Transportation on April 1, 1967, Thomas continued in his post as Deputy Administrator of the renamed Federal Aviation Administration.

The recipient of many awards, his first major honor, in April 1963, was the Laura Barbour Award for Air Safety. The award, administered by the Flight Safety Foundation, cited Thomas as ". . . one of the outstanding experts in this country, if not in the world, on the management of air traffic control."

Two months later in a White House ceremony, he received the President's Award for Distinguished Federal Civilian Service, which is given for exceptional achievement in advancing important domestic and international programs.

In December 1966, he received Princeton University's 1966 Rockefeller Public Service Award in the Field of General Welfare or National Resources. He was cited for his services affecting the general welfare and the benefits realized individually by the public, and collectively by the nation, from a healthy, expanding air transportation system and also for his efficient management of the nation's airspace.

On April 21, 1967, he received the Career Service Award of the National Civil Service League which recognized Thomas as the leading authority in the highly specialized technical aviation field of air traffic control.

Less than a month later, on May 17, 1967, he received the Monsanto Aviation Safety Award for 1966. Sponsored by the Aviation/Space Writers Association, the award cited Thomas for ". . . his skillful and dedicated service to aviation safety as the principal architect of the U.S. air traffic control system. . . ."

Thomas has had a long and distinguished career in Federal service, having spent 27 of his 35 years in aviation with the FAA and its predecessor organizations. Following his first aviation job as an operations agent and assistant station manager at the age of 19 for American Airlines in Nashville, Tenn., he entered Federal service as an air traffic controller at the Pittsburgh Airways Control Center in 1938. He transferred to the new Cleveland Center shortly thereafter and the following year was made assistant chief at that facility. In 1941, he moved up to Chief of Air Traffic Control for the Fort Worth Regional Office of the Civil Aeronautics Administration.

After a number of field assignments he was transferred to Washington in January 1946 to serve as assistant chief of the Airways Traffic Control Section in the CAA. In June of the same year he became Deputy International Services Officer, holding this position for three and one-half years before taking the post of Planning Officer of CAA. In October 1953, Thomas was made Acting Chief of the Planning Staff, and less than a year later he was appointed Deputy Director of CAA's Office of Federal Airways.

In July 1956, he was promoted to the position of Director, Office of Air Traffic Control. He headed FAA's Air Traffic Service when the agency was formed in 1958.

In 1963 he was named Associate Administrator for Programs with responsibility in Washington headquarters for planning and coordinating the operating programs of the Air Traffic, Flight Standards, Airports, and Systems Maintenance Services. He held this position until his appointment as Deputy Administrator two years later.

Thomas was born in New Castle, Texas, February 19, 1913. He attended the School of Mechanical Engineering at the University of Tennessee and the School of Business Administration at George Washington University in Washington, D.C. He is a member of the Institute of Aerospace Sciences, the Air Traffic Control Association, and other aeronautical organizations. He is a Deacon in the Church of Christ, Falls Church, Va.

He holds a commercial pilot certificate with multi-engine and instrument ratings and piston, turboprop and jet aircraft type ratings, and is a graduate of USAF fighter/interceptor and bomber aircraft indoctrination training courses.

Thomas resides at 3909 Rose Lane, Annandale, Va., with his wife, the former Dorothy Clark of Murfreesboro, Tenn., a daughter, Frances, 24, and a son, David, 20.

We are glad to have you here this morning, Dave. Proceed with any prepared statement that you have, following which we will hear from General Maxwell on the supersonic transport.

STATEMENT OF DAVID D. THOMAS, ACTING ADMINISTRATOR, FAA, DEPARTMENT OF TRANSPORTATION, ACCOMPANIED BY JOHN WEBER, DIRECTOR OF RESEARCH AND DEVELOPMENT

Mr. Thomas. Thank you, Mr. Chairman. I am David D. Thomas, Acting Administrator of the Federal Aviation Administration. I am accompanied this morning by General Maxwell on my right, who is the Director of Supersonic Transport Development, and on my left, by Mr. John Weber, Director of our Research and Development.

We appreciate the privilege of appearing before you to discuss the future aeronautical research and development needs of the Nation.

First, I would like to discuss the reason that we face a challenge in aeronautical research and development, and that is the growth and prosperity of civil aviation.

Although our forecasts have shown that aviation was growing rapidly, the rate of growth has been somewhat steeper than anyone predicted. Right now, approximately 50,000 people inhabit the airspace over America (a number equal to the population of White Plains, N.Y.).

Mr. Hechler. Excuse me, sir. Does that include those who are waiting to land? [Laughter.]

Mr. THOMAS. No, sir. It would be more than 50,000 in that case. That is just a statistical average, Mr. Chairman.

Mr. HECHLER. Yes.

Mr. THOMAS. During 1968, the Nation's air carriers will transport more than 150 million people, and the public demand for air transportation grows at the rate of 16 to 17 percent a year. Air carrier enplanements have increased 115 percent over the last 5 years, and air cargo volume has tripled. The hours flown by general aviation aircraft have increased nearly 50 percent. Aircraft production in the United States has increased more than 100 percent in the last 5 years. The fact that air carriers now account for nearly 7 of every 10 common carrier passenger-miles demonstrates that today air travel is the favorite form of intercity common carrier service. In short, more people are flying, more often, for more reasons.

The industry has been responding to this demand by producing more and better planes, by promoting business and pleasure flying, and by catering to the commuter and tour-traveler as well. On the horizon are the second-generation "jumbo" jets, and an unfolding transpacific market. In the next 10 years, the number of air passengers in the United States will grow to more than 450 million annually. In that same time, the total aircraft operations at airports with FAA traffic control service will increase from 47.6 million—the 1967 figure—to an estimated 167 million operations—an increase of 250 percent. Between now and 1979, U.S. air carriers will expand the size of their fleets by about 1,500 aircraft, and many of these will be the large capacity jets. Despite this substantial increase in the size of the average air-carrier unit, the carriers do not anticipate fewer flights. Rather, to meet the constantly climbing passenger and cargo traffic demands, they expect to schedule about 140 percent more flights in 1979 than they had in 1967.

I think that all this present and future activity in aviation shows that we are going to be very busy in aviation research and development. Our immediate task is to match our R. & D. effort to aviation's growth and prosperity. This is a difficult task because the commodities that we need to do that job are money, time, and cooperation, and they are often hard things to get.

Short-term measures that only relieve the symptoms but don't get at the cause of the problem are no answer. For example, this week we are having public hearings on a proposed rule that would impose restrictions on the number, type, and equipment of aircraft using the high-density airports in New York, Washington, and Chicago. The proposed rule is a limiting and restrictive measure that does not contribute to economic growth or long-range progress in aviation. The restrictions should, and we hope will, be temporary. The long-range solutions to these challenges are what we require, and we must find them in our aeronautical research and development effort. Of course, I am not telling you anything new when I say that long-range solutions to operational problems are the immediate challenges in aeronautical research and development. For example, our efforts must give us more information about noise, about avoiding collisions in flight, about turbulence in the air and on the ground, and about basic aerodynamics.

In the field of aircraft noise and sonic boom research, we need to do more. Because of concentrated attention given the aircraft noise problem in recent years, considerable progress has been made in aircraft noise research and development programs. Both the Government and private industry have sponsored these programs. Even with that progress, however, a great deal of additional work and possibly some technical breakthroughs will be necessary before we have a true solution to the aircraft noise problem. Specifically, we should know more about the generation, propagation, and prediction of noise within turbine engines, with particular emphasis on compressor and fan noise. We should enlarge on the significant progress that the military has achieved in reducing certain kinds of V/STOL noise. We should build on the basic document recently compiled by the Department of Housing and Urban Development on the cost and effectiveness of acoustical treatment in residential construction. We must determine the physiological and psychological effect of noise on people with greater accuracy. This may require refining the yardstick used to measure noise, determining acceptable levels of noise for purposes of regulation, and developing guidelines for determining compatible land uses in the high-noise environment near airports. Beyond this initial effort, a large systems analysis is required to determine the most economically effective, achievable, and equitable "solution to the aircraft noise problem." As to sonic boom, we are collecting basic data now, but the initial program will not be completed for 2 years, or more. Of course, we need to focus on the critical area of human response to booms.

Short takeoff and landing aircraft (STOL) capable of operating on runways of approximately 1,500 feet length are becoming operational. We have increased the speed of helicopters from 80 to 180 knots in 20 years, and we need to find ways to achieve even higher speeds and more efficient lifting systems. We must improve the aerodynamic efficiency of rotor systems, decrease the weight of engines, and increase their thrust, leading to economically feasible VTOL aircraft. We have to solve the control problems associated with the different modes and systems of operating V/STOL aircraft. We should define the stability characteristics necessary for commercial operation of V/STOL vehicles. Specifically, we need to assure smooth transition from hovering flight to forward cruising flight to steep approach and landing so that all are within the pilot's control capability.

The development of simple pilot-warning instruments to prevent midair collisions requires an analysis of visual separation techniques, and development and testing of equipment, possibly using electro-optic infrared techniques. Learning more about storms and turbulences both in clear air and in the wake of jet aircraft will involve considerable research and development. We need to know about visible storms generally, and about how they develop and what they do. To develop a system that is capable of detecting and forecasting clear air turbulence, we must know more about clear air turbulence, its detection, and how the pilot and his aircraft respond to it. To develop and test equipment to sense and record wake turbulence, we must determine the characteristics of the vortex flow field behind aircraft and their effect on encountering aircraft.

These are some of the areas in which we need to increase the research and development effort, and they are by no means all of the areas. However, each of them represents an element of the national airspace system. This system must evolve in a way that insures the compatibility of each of its elements—aircraft, airports, air traffic control, airmen, and air navigation and communications. The system must be able to handle either a hovering helicopter or a mach 3 supersonic transport. It must be able to handle an airplane operated by a student pilot solo or with only his flight instructor aboard. And, at the same time, it must be able to handle a 500-passenger jumbo jet operated by a highly qualified, professional flightcrew. In many ways, the system is self-limiting—only one vehicle can occupy the same space in the air or on the ground. These facts don't change.

The national airspace system evolves. Both Government and industry must carefully consider each system change to be sure that a high degree of safety is maintained, and the great expense is justified. Each system change requires 10 years to complete, and we must be certain that we have decided carefully not casually or in reaction to immediate urgency.

In closing, I wish to say that aeronautical research and development needs all the help that it can get from industry, from NASA, from DOD, and from any other source. We will use what is learned from the space R. & D. program as to tracking aircraft and transmitting flight data. We will use what is learned from the military R. & D. program on V/STOL, on radar, and on navigational systems. We will use what is learned from private industry in computers, data processing, and communications technology. We will use that, and we need more. We need an expanded aeronautical R. & D. program that places emphasis on our evolving the national airspace system and that anticipates the technology that aviation growth and prosperity requires.

That concludes my prepared statement, Mr. Chairman. Now I will be happy to try and answer any questions you may have.

Mr. Hechler. Thank you, Mr. Thomas.

Before we proceed, I would like to welcome a number of GAO audit trainees I understand are in the hearing room.

I trust that this committee will measure up to the rigorous examination which every GAO audit entails.

Mr. Thomas, I was interested in your definition that we need money, time, and cooperation. I would think that we have a good measure of cooperation, but isn't leadership a far more important item that we need in this area of aeronautical R. & D.? It has been my impression in just listening to witnesses and looking into this problem casually, the key question which always comes up is: Who is in charge here? And in the case of aircraft noise, which you so well set forth as one of our big R. & D. problems, I think we made a great deal of progress in defining the necessary leadership as a result of some of the hearings of this committee starting in 1967.

But across the board in aeronautical R. & D., it disturbs me that this quality of incisive, precise, and imaginative leadership is not present. I wonder if you would care to make any observations on that, sir.

Mr. Thomas. Yes, sir.

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My statement was intended to deal with more than the research and development in solving some of these growth problems. And obviously, the question of leadership is there.

I intended rather to point out that we know we need more runways, we need more ground facilities. Here we do need a great deal of cooperation, a great deal of money, and obviously a great deal of leadership to see that we can tie together the things that are known and we can do, and go ahead and do them.

Specifically with the research and development, the question of leadership and who is carrying forward is particularly important. And I think that noise is a good example, and several things have been done, as I point out, by the Congress and by the agencies. It is clear that the FAA has been given the responsibility by the Congress to establish limits of noise through legislation just passed.

It is also clear that to establish those limits of noise, one must know what is possible. And at the moment NASA is about the only one that has the facilities and capability of making that determination, and we are working well together.

And then one must know the compatibility of people and noise and what could be used in the way of land planning and land use. And here we come with the HUD people.

I think we are working well together, and I do think that it is this type of cooperative effort that produces results.

Mr. Hechler. It may well be, then, that we could profit by some of this experience in other areas as we have in noise and hopefully stimulate a little bit more leadership in those other areas of aeronautical research and development.

I wonder if you could give me some of your impressions of our visit to Cambridge and the Electronics Research Center last Friday. What do you consider to be some of the most useful areas of advanced research which NASA is carrying on?

Mr. Thomas. Well, obviously we were very impressed by the visit. It is a fine laboratory, excellent people, and doing very effective work.

Our biggest problem——

Mr. Wydler. Excuse me, Mr. Chairman. Where is that located now? Is anything built there, or are they still in rented facilities?

Mr. Thomas. They are in rented quarters at the moment. Their building, as I am sure NASA will testify, is under construction. It is out of the ground, but they are actually operating in rented quarters.

One of our biggest problems is that often we do the exotic well and fail to do the more mundane which causes us more difficulty. I was very impressed with their power laboratory there. We have tended to think that electric power is old hat, we know all there is to know about it, and pay very little attention to it. I was excited to learn that they were beginning to look at just basic power, and we have found some difficulties we have had in switches. Other failures in equipment are traceable back to the prime power source that we had disregarded 20 years ago.

And so I am happy to see them looking into some old problems which people think were solved, as well as looking ahead to the new ones.

One of the activities up there that we are very interested in pushing is the possibility of electronically observing lights on an aircraft and enhancing those lights and bringing them to the pilot's attention to give warning of collision.

We have some developments going forward now using very expensive and large-scale computers and some almost atomic clocks in the sense of accurate timekeeping, and communications equipment that can warn large aircraft of the presence of other large aircraft and what to do about it.

Our big problem, however, is enhancing the capability of the human eye to see small aircraft which may not be known. I think there is a great potential in the electro-optics method of doing this, and this is one of their major projects.

We are very interested in this and are impressed with the results so far. Obviously they are now just breadboarding, in their infancy, but I think there is some hope of enhancing safety through this method.

Mr. HECHLER. Do you ever indicate to NASA: "Look, this is a problem, we hope you can do some research on this. This may well be an increasing problem in future years in aeronautics"?

Mr. THOMAS. Yes, sir; we do. We have a committee jointly between us where we do discuss not only current projects to make certain that the effort is properly divided, what the requirements are, and future needs. And they have been very responsive.

Mr. HECHLER. I have several other questions. I would like to yield to other members of the committee, however.

Mr. Pelly?

Mr. PELLY. Thank you, Mr. Chairman.

I would like to refer to your statement, Mr. Thomas. On page 6 you say that aeronautical research and development needs all the help they can get from industry, from NASA, DOD, and from other sources.

My question is: Is it getting all the help that it can get from NASA?

We have oversight for NASA aeronautical research and development; I think that we ought to get an opinion on it as to whether we could do more.

Mr. THOMAS. Mr. Pelly, yes; NASA is very responsive to us. I think our plea is that we need a great deal more effort in the aeronautical field.

From the bias that I have of airplanes rather than space, I obviously would like to see more work done on how you could stop airplanes quicker, how you could see other airplanes, how you could make steeper descents, and this sort of work.

Mr. PELLY. Are you satisfied with their progress? Do you think that it comes as a result of Congress not providing enough in the way of financial resources to match the growth of the air industry?

Mr. THOMAS. I think again from a biased viewpoint there has been somewhat preoccupation with space rather than aeronautical activity.

We are pleased with the progress on the projects and the resources that they have, and, of course, dividing national resources is a difficult problem. We would hope to see more in aviation, because we think we have not solved all the aviation problems, and as a matter of fact, we probably will never solve all the aviation problems.

Mr. Pelly. It seems to me that NASA has requested a little more money each year for aeronautical research and development. But when you consider inflation, I do not believe NASA is actually getting additional funding because it is being absorbed in higher cost.

Mr. Thomas. I think that is true.

Mr. Pelly. You mentioned earlier in your statement that in noise and sonic boom research, we need to do more. Is that a reflection on the effort that NASA is putting into it?

Mr. Thomas. It is not a reflection on the effort, the quality of the work, or the program, because we work with them very carefully on this. More money and more effort would bring earlier results, I would hope.

There is some balance here, because you could put an infinite amount of money in and not spend it wisely. But we were given the responsibility by the Congress very recently to establish noise standards for aircraft and to require a retrofit of aircraft for noise purposes, if economically feasible.

Now, if we just took some numbers out of the thin air and said in 1980 we want aircraft to be this quiet, I think it would be completely meaningless. I think it has to be demonstrated what can be done and at what price.

Hopefully you could develop a quieter engine that would be more efficient and would be economically feasible. But the airlines today are adding more than one jet aircraft to the fleet, and they are going to be around with us for the next 15 or 20 years, so even though new, quieter engines, which may be 5 years away coming on airplanes, at that time are quieter, we are still going to have many hundreds of airplanes making a great deal of noise that need the retrofit.

The only way we can get at that program is to demonstrate that one can be built. So I would like to see more work in that direction. They are pursuing quite a program as far as Government is concerned; I think the total is about $100 million. But it might be worth more to the total country to get a little peace and quietness from the jet engines to put more money in that program.

Mr. Pelly. Do you feel that the need to curb spending and the efforts made by Congress in any way has held back research and development and has had an adverse effect on safety and other factors involved?

Mr. Thomas. Mr. Pelly, one cannot reduce Government expenditures by $6 billion without having some adverse effect on all the programs, and it has had.

Mr. Pelly. We haven't done that, by the way, and I don't think we are going to do it. So, don't use that $6 billion figure as freely as we do on the floor of Congress.

[Laughter.]

Mr. Thomas. But it is bound to have some effect. The question of safety is more nebulous because if you didn't do something and didn't know about it, you really don't know whether you affected safety or not.

But just in general, yes, we achieve safety by learning how to do things better, get more reliable, and it is bound to have some effect.

Mr. PELLY. I don't think there is any amount of money that the public wouldn't support and want Congress to appropriate when it had to do with wise expenditures for safety in the air, and especially to suppress noise. And this committee, as I have observed it throughout the years, has never in any way wanted to curtail—in fact, I think in some years we actually ——

Mr. HECHLER. We have.

Mr. PELLY (continuing.) Have increased the funds for the effort in research in fields like noise abatement.

So I for one want to welcome you over here. I appreciate your statement very much; I think it is very helpful to the committee.

Thank you.

Mr. THOMAS. Thank you very much, sir.

Mr. HECHLER. Thank you, Mr. Pelly.

Mr. Wydler?

Mr. WYDLER. I always notice, for example, that the airlines and the aircraft manufacturers are very sensitive to the problems of flight safety when they talk about jet noise, and its solution. They are always indicating that we better be very careful that we don't do anything to the aircraft or the way it is operated that might endanger anybody in any way at all. And yet they don't seem very sensitive when it comes to loading up the skies with planes to such a degree that we are having near misses in the airspace near our airports and when the air traffic controllers can hardly handle the amount of aircraft that are coming in and going out.

There doesn't seem to be that same concern with the safety factors and margins. They appear to regard the jet noise problem as one which will involve expenditures of their funds. However, they tend to look favorably on the air traffic problem since it might permit them to generate larger revenues. The more planes they can fly with more people will be to their economic advantage.

I think there is a tendency on the part of those who really don't want to do anything about noise, because it is an economic problem for them, to hide behind the safety factor.

How much safety is really involved in the programs that you are now working on to reduce jet noise? How is the safety margin really going to be affected?

We constantly see this issue of safety raised. I wonder how much of a safety factor is really involved.

Mr. THOMAS. Yes, sir, I will try.

Our sole use for being, and the only reason Congress created us, was safety. Expedition and everything else is secondary. We have always said safety is first. But noise is second in our consideration to safety.

A lot of the——

Mr. WYDLER. That is a recent development, isn't it?

Mr. THOMAS. No, sir. No, we have said this for some years. Being able to get a handle on noise is fairly recent, and we don't have it yet. But I think we are approaching it.

In the past, most of the efforts on reducing noise—and there have been many millions spent by industry as well as Government—have not been too successful because they involved various sorts of devices on the back which added weight and complexity and in the end result reduced the thrust of the airplane, because it almost did the same thing as pulling the throttle back. That is an exaggeration, but almost.

But at any rate, it reduced the power that was available. And when you reduce the power that is available, there is a point where you would affect safety by either pulling the throttle back or reducing the thrust of the airplane. Our aim is not to reduce safety but to have quite acceptable performance out of the airplane and still significantly reduce noise, but we are approaching it quite differently through NASA: trying to do something with the whine in the fan. And NASA has contracts now for two four-engine planes that we think by the nacelle treatment can significantly reduce the noise. And if that is effective, and we think it will be, we might look at that as possible retrofit. It would not affect safety; it would affect the economics.

Some of our safety problems have been aimed at locations where there have been noise-measuring devices on the ground, the pilots knew there were noise-measuring devices there and they suddenly reduced power to coast over those noise-measuring devices and then applied power again. We don't like that sort of operation. But we had no problem with a computed reasonable thrust reduction and a proper reduction. We don't like a thrust reduction too low. And some of our noise abatement procedures have a thrust reduction almost immediately after leaving the ground. For instance, at Washington National Airport our noise abatement procedure is that we will maintain takeoff power to 1,500 feet, then reduce thrust to where we have a good grade of climb, at least 500 feet a minute, 500-up, and then hold a reduced thrust until we get 10 miles out from the airport and then continue the climb.

Mr. PELLY. I think you increase that power and noise right over Georgetown where I live. [Laughter.]

Mr. THOMAS. We try to increase it a little further out, but it is noisy in Georgetown.

But all the things we are doing is to try to make the airplane more efficient, reduce the minimum of thrust, and have no effect on safety We think we can have safety and noise reduction both.

Mr. WYDLER. You might compromise safety to some extent if you put certain devices on the engine to reduce the thrust power of the engine and thus make the plane less safe. However, the way to compensate for that is to make the plane lighter.

I am trying to bring this bugaboo of safety that is always thrown into these noise discussions into some perspective here. How much of a safety factor is really involved and how is it being used as something to hide behind whenever you talk about the solution to the jet noise problem? No one wants to compromise safety. But I have never understood how it becomes such a critical problem whenever we consider jet noise.

It apparently is not a critical problem to the airlines when they flood the skies and airports with traffic. There we apparently are willing to take a few risks and cut a few corners. But when it comes to doing something about jet noise, we are told it is not possible because we may endanger somebody's life.

Mr. THOMAS. I think maybe I could help on that.

We will not let the thrust go back where it will endanger anyone's life. We would simply not approve it. But let me give you an example right now that we are looking at.

Mr. WYDLER. You would have the alternative. You could tell them to make their plane lighter if they could build a reasonably quiet engine.

Mr. THOMAS. Congress just gave us that authority. We didn't have it until now.

Mr. WYDLER. But that would be a possible answer to the thrust problem, would it not? The alternative is not that since you can't get all the thrust you need and therefore, you can make all the noise you please. One alternative is that you will have to build an aircraft that won't need as much thrust and that will be the aircraft you'll have to live with.

Mr. THOMAS. That is the authority Congress gave us. I would like to point out one other example of safety versus noise, and at the moment we have decided on safety.

NASA has been experimenting and our pilots have performed a six-degree glide scope, a very steep descent. It is less noisy, you have less power, you are up higher. But one of the big problems is overshoot and undershoot and control of the airplane just as you flare to the runway. If you look where the accidents are, that's where they happen.

NASA pilots fly this and they tell us it is fine; our test pilots fly it and tell us it is fine. And I have flown it. But my problem is do we approve it for the everyday airline pilot, not the test pilot, with 100, 150, 200 passengers behind him in day-in and day-out operation? Ultimately we will, but I am not satisfied with it yet.

So from a safety viewpoint, we will not approve a six-degree glide scope with what we know today. I think that ultimately we will, with better display, more training and more experience with it. And this is the safety versus the noise.

Mr. WYDLER. I have been hearing that for years. It is something that is important to me. And naturally I have been following this question of landing at the six-degree angle for years. And I hear over and over again that everybody who has tried it says it can be done, it is a reasonable thing to do, and that pilots have landed aircraft under these conditions. You know it is possible, and that it works. And yet we still don't do it.

You say ultimately it will be done. What are we waiting for? Why are we afraid to go ahead with it? What's the problem here? What problem has to be solved to make it into something that we are going to put into practice?

Mr. THOMAS. The problem that has to be solved is the rapid change of power, attitude, and rate of descent of the airplane at its most critical point.

Mr. WYDLER. The planes do not do that now, or cannot do that now?

Mr. THOMAS. We are looking at all-weather instrument operation and—I have done it, a lot of pilots have done it.

Mr. WYDLER. I know; I have heard it over and over again, everybody has done it.

Mr. Thomas. Our accident record indicates that we get into the problems of rate of descent and the undershoot and overshoot right at the end of the runway and just before you get there.

Now, we need better display before we will approve it to carry you as a passenger.

I will take you out experimentally and I will do it with you today.

Mr. Wydler. Mr. Thomas, some Congressman suggested yesterday that the Federal Government become the airport landlord in the New York area and probably in other areas of our country. It probably reflects the frustrations of trying to come to grips with current problems. It is going to become a greater problem as the years go on and I suppose this idea has the advantage of giving power to the Government so they can condemn property it needs for proper airport development. What is your reaction to that kind of a proposal?

Mr. Thomas. I would be very much opposed to it. There is a frustration because you take a place like New York, there are several hundred individual communities which as some of our people pointed out, can prevent an airport being built, and you must almost get all of them together to get it built, because airports are so large and communities are so large now. Every community prefers to build an airport in somebody else's community.

Whether we need more authorities, regional authorities or State action, I am not real sure, in order to solve this local jurisdiction problem which seems almost insoluble in some places. However, I would not think that the Federal Government building, operating, and condemning the land would be the proper solution to our airport problem. I would much rather see some local regional authority—how combined, I don't know, whether it would be port authority activity, whether multistate or a regional area—to solve those problems.

In nearly every case now we are running into the problem of one community trying to build in some other community's backyard.

Mr. Wydler. I will be glad to yield to the chairman.

Mr. Hechler. In view of the fact that the people who use these airports come from every State in the Union, and also in view of the fact that the residents of the local community have a particular local interest which frequently runs counter to what the optimum regional, State, or National transportation needs are, it seems to me we are going to have to move more toward this kind of thing, whether it be regionally or nationally.

Also, in addition to that, you have kind of a conflict between what is desirable for the passengers or what is most acceptable for the airlines and the financing mechanism by bonding by the local community which tends to cause the people in the local community to have their feet encased in the concrete of the existing airport and they want to sell that extra pack of cigarettes tomorrow at that airport without looking toward what is going to be necessary in order to solve these critical airport problems in the Nation. What kind of research is necessary in this area?

I wonder if you would care to comment on this briefly, and then we will go back to Mr. Wydler.

Mr. Thomas. Yes, sir.

I think this all points to the need, and in my own personal view, I am not even sure that we have enough authority in the Department of Transportation view. So my own personal view is we do need regional authorities because of the need to get very large airspace. One proposal in New York, as you know, is some 25,000 acres. And this is larger than a lot of cities. And just finding that much space near New York is quite difficult.

I think we need to get regional airports and we need to get regional authorities which would look at more than just the one community.

Probably the most difficult place to get an agreement on airports is right here in this city. The Federal Government does operate two airports and is specifically authorized by two different acts to operate Dulles and Washington National. But there should be a system of airports around Washington. There should be some for general aviation, and they should be well tied together. But one must get Maryland, Virginia, the various counties in Virginia and Maryland, and each individually take their own action to come up with a system of airports around the Washington area. It simply doesn't exist, and it is very difficult to cause it to exist with Fairfax County on the one hand having to take its action, Prince Georges, Md., on the other having to take its action, and hope it comes out right.

We can encourage, we can advise. But I would very much like to see a regional authority just to take care of the problems here.

Mr. HECHLER. Well, the current system puts a premium on obstructionism by one party that feels that if they can hold out long enough, why, then they can get their way.

Mr. THOMAS. Or prevent anything from being done.

Mr. HECHLER. Exactly. Now the suggestion—if I could just expand on this a second, the suggestion was made yesterday by Dr. Stever that there ought to be a better system of providing a centralized source of factually researched information.

I think the FAA and the Department of Transportation both could well strengthen their information-supplying facilities on some of the basic facts that involve the crisis we face and what needs to be done in order to meet that crisis.

In your statement you didn't mention research on airports as one area that needs additional research and development.

Mr. THOMAS. Yes, sir. This is an omission. Probably the most effective single result of research and development in airports is reflected out here at Washington National where we have grooved the runways; that is, cut very minor trenches—they are about an eighth of an inch wide and about an eighth of an inch deep, so they are small grooves—across the runway for the purpose of letting the tires squeeze the water out through those grooves instead of riding on a thin film of water and hydroplaning, and for stopping in wet weather.

This is work that was done in England and we are taking advantage of the experience there. Work was done at Langley, with NASA, and I think some was done at Wallops Island as well. What looks to be ridiculously small grooves are very effective in the runway problem, and we could use more of this at many other airports.

We would like to see some more on surface traction. We have painted on available concrete some STOL runways at Washington National and Dulles. They happen to be just parts of taxiways, and we painted them to look like runways. We used a new paint with an abrasive in it that makes it easier to stop. And our normal runway marking paint that we have used with just the sole of a shoe is quite slick when you step on it. But this paint is quite rough even when it is wet. So there is a lot that could be done this way—signs, turnoffs. This is an omission.

Mr. Wydler. Is that the same as the highway problem?

Mr. Thomas. No, sir; you see, the highway groove is longitudinal, and for quite a different reason. The hydroplane problem at the same speed is the same, but they want you to stay straight on those roads so you will find longitudinal grooves on the highways.

We have learned a lot, but it isn't the same problem.

Mr. Hechler. I would just like to make one other observation.

You have mentioned some of the technical and engineering developments and research necessary. Perhaps we need a little human research also, which may not be either your or NASA's responsibility. But it is certainly necessary.

Mr. Thomas. Well, we would like to contribute to it as much as we can, because there is a great deal of work that should be done to get this congestion problem solved, and most of it is just plain hard work. There is a great deal of thought that we file it in a black box and all the airplanes go away. However, they are so big, they occupy a runway so much time, and we do need more airports. This is a political problem rather than an engineering problem.

Mr. Hechler. Mr Wydler, I interrupted you.

Mr. Wydler. Are the operations of National and Dulles Airports profitable to the Government?

Mr. Thomas. In terms of out-of-pocket cost they are profitable. In terms of interest, investment, and the other things that we put into our accounting system, they are not yet profitable, but will be.

There is nothing we can do at National to lose money. We make a profit on everything we do, and there is no way you could mismanage National and fail to make money. There is no way you can manage Dulles right now and make money. We put the two of them together and we make a profit as far as our annual appropriation versus what our income is.

Mr. Wydler. Don't all the airlines that use Dulles Airport pay for such use?

Mr. Thomas. Oh, yes, sir.

Mr. Hechler. Mr. Wydler, I would like to issue a mild reminder of the purpose of these hearings. We are concerned with advanced research and development, and not how airlines use airports.

Mr. Wydler. I get interested in these things.

Mr. Hechler. I know it is an extremely interesting subject, but we have two other sets of witnesses this morning, and I would like to indicate that we have a good deal of ground yet to cover, and within our jurisdiction.

Mr. Wydler. In another committee we were talking about this subject with the airlines who indicated they were willing to pay for an operation which might not be profitable for them. I was trying to find out how well they did that at Dulles, if they really were subsidizing the airport.

Mr. Thomas. No, sir. On the curves that we have on Dulles, it will be very profitable for the Government. You lose money at the outset of an airport and you make it hand over fist later on. And we are in the later on period at National; we will be at Dulles. We are not there yet.

Mr. WYDLER. Will you tell me as clearly as you can: Can we or can't we land an airplane today automatically? Could we take a pilot out of an aircraft today and land it?

Mr. THOMAS. Yes, and I have done it. But again, I wouldn't sell tickets on it. Five years from now we will be selling tickets on it. We've got over 300 landings on the C–141, both automatic and pilot controlled, with the pilot never seeing and coming to a complete stop.

Technically it is here. And the system we are working now is reasonably fail-safe. But this is one system, one airplane, and a few handfuls of pilots trained on it.

Mr. WYDLER. Now, what are you doing now in FAA on implementing the bill that was passed on the regulation of jet noise?

Mr. THOMAS. We are preparing a notice of proposed——

Mr. WYDLER. What is going on in the Government about this?

Mr. THOMAS. All right. There has been internally drafted a notice of proposed rulemaking which will be issued very shortly, I am not sure when, within a couple of weeks or so. We will get the comments on the values that we set forth. Then we make an actual rule as we do under the Administrative Procedure Act with an effective date I would suppose about July of next year. And that will deal only with the subsonic current jets.

The next step is the supersonic jets, because they are quite different vehicles, and then the next one is the light airplanes.

We are doing it in three phases, but our first is the current family of subsonic jets.

Now, the airplanes that are certificated will not be affected, the ones now in progress, until we come up with a notice of proposed rulemaking on retrofit. What we do on retrofit depends on the results of NASA's work. So you will not see any effect on today's jets until we know more about the retrofit.

Mr. WYDLER. Now, are there any privately owned companies that are working on air traffic control equipment? And by that I mean not under Government contract or paid for by the Government.

Mr. THOMAS. I don't know of any that are not under a contract because there are millions involved.

Mr. WYDLER. You don't know of any private enterprise action in this field at all?

Mr. THOMAS. That is a difficult question, because everyone who comes up with a slightly better navigation device makes the claim that yes, this is perfect. But when we are talking about say the ground system for example, we are spending about $400 million for computers and displays, and I don't know of any company that is large enough that just on its own would go into that type of expenditures.

On better displays, on better communication, better bits and pieces, yes, there is a great deal of work going on, particularly in the navigation field.

Mr. WYDLER. Solutions to these problems will come from the Government?

Mr. THOMAS. Well, it is a Government function. There is nobody in the private field for it. And there are such huge outlays I just don't know how someone would build a complete center and say I have something better. In the field of air navigation there is a lot of work going on.

Mr. Wydler. One last question, Mr. Chairman, if I might. And that is on the steeper descent question.

Can you define for me what is it that we need in the way of equipment that we don't currently have on aircraft. What is it that we would need to make this system come into being? As you say, ultimately it will, but what is the equipment problem that we have?

Mr. Thomas. Yes. I would like to see an airplane that could maintain a relatively stable attitude and change its rate of descent with some variable lift on the wings. We don't have that except experimentally.

Mr. Wydler. What does that mean to me as a layman?

Mr. Thomas. It means you are not diving and then suddenly pitching up to land. I would like to see the floor of the airplane stay relatively stable so that as it changes quite markedly the rate of descent—at the present time you come way back with power, you dive rather steeply and then when you hit another signal close to the ground you follow that signal. If you do it very expertly and you know all there is and you do it right, you can use the excess energy you have and excess speed in lieu of power, and bleed off to the landing speed as you change the attitude very rapidly.

Now, I don't think we are going to get this variable-lift wing very quickly. And what we must do then is give a good display to the pilot so he can do this maneuver on instruments and do it regularly with passengers.

So we think——

Mr. Wydler. Now what is the equipment therefor that we need? What is the piece of equipment we are after?

Mr. Thomas. A display that I haven't seen.

Mr. Wydler. It is a piece of display equipment?

Mr. Thomas. Yes.

Mr. Wydler. Are we working on that?

Mr. Thomas. Yes, sir.

Mr. Wydler. Who?

Mr. Thomas. As far as I know, NASA is, and we are working on—we have some in our own airplanes at Atlantic City.

Mr. Wydler. And this equipment is being developed now. Could you give the committee a progress report on what has been done on that piece of display equipment in the last year?

Mr. Thomas. Yes, sir. I can't right now, but I will be glad to furnish it.

Mr. Wydler. I mean for the record.

Mr. Thomas. Yes, sir.

(The information requested is as follows:)

During the past year, the FAA has continued to work on the development of this display equipment—an airborne computer designed to provide steep segment glide path information to the pilot down to normal ILS glide path intercept. The FAA has developed a low-cost prototype computer suitable for use with current aircraft. An operational evaluation of the equipment and procedures previously developed by FAA and NASA will commence this month (October 1968) and continue for approximately one year. The technique used provides let-down guidance information and thus eliminates the requirement for providing dual ground and airborne equipment for depicting the entire approach in the cockpit. Full noise abatement capability, however, cannot be realized at this stage of the program due to the programmed high altitude transition to the standard glide path. Further testing and refinement of hardware should bring the transition inside the three mile point.

In addition to this work, in July and August of this year, FAA, industry and NASA participated in a joint evaluation of several "tools" for assisting in the two-segment and curved steep ILS approach. Among these were direct lift control, stability augmentation, auto throttles, and a new electronic attitude director indicator (CRT flight director). This work was performed in a specially modified jet transport (Boeing 367–80) using descent rates at steep angles. In these tests operational pilots performed steep segment approaches to as low as 250 feet and found them generally acceptable. It should be emphasized that pilots were asked to overlook certain hardware limitations and shortcomings. Additional research is required to make the steep approach operationally acceptable under IFR conditions.

Mr. HECHLER. There are many other questions that we would like to pose for the record and in writing; for example, the question of air traffic control research came up yesterday. I very strongly indicated at that time that I felt there was no reason this should be transferred out of the existing agency, FAA. We would like to get your thoughts on this and many other subjects which I am sure that members of the committee will have questions on.

(Questions posed by the committee follow:)

QUESTIONS SUBMITTED TO DAVID D. THOMAS BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. Please specify the areas of research and development for which NASA has responsibility in response to DOT–FAA requirements.

Answer 1. The FAA statutory responsibility for aeronautical R&D is concerned with: (1) Development, modification, and evaluation of systems to meet the needs for safe and efficient navigation and air traffic control of all civil and military aviation, including procedures, facilities, equipments and devices; (2) Long-range planning for the orderly development and use of airspace and landing areas, including the airways, radar installations and other aids for navigation; and (3) Development and service testing for the improvement of aircraft, aircraft engines, propellers and appliances. Technical information concerning any R&D projects of the military agencies that have potential application to the needs of, or possibly conflict with, the common system are furnished to the FAA. The aeronautics portion of the NASA R&D program places emphasis on air breathing propeller systems, aircraft, aerodynamics, aircraft operation problems, and aircraft structures. In this context, FAA requirements for NASA R&D work has been largely in the areas of aircraft, aircraft engines, propellers and appliances. Of course, in carrying out its responsibilities, the FAA also uses the facilities and capabilities of the private sector and of Government agencies other than NASA, such as DOD and ESSA.

NASA's technical R&D capabilities have contributed to FAA's effort in the following areas:

(1) Development of a Pilot Warning Indicator to prevent midair collisions.

(2) Development of a clear air turbulence detection system and techniques for forecasting clear air turbulence.

(3) Development of new air-ground communications systems using satellites.

(4) Determining the characteristics of, and developing solutions for, aircraft wake turbulence.

(5) Development of improved runway surface materials to improve traction.

(6) Investigating use of an inertial platform for ILS landings.

(7) Development of a turbulence flight director for severe weather operations.

At present, FAA and NASA are cooperating in a program to develop a "quiet engine", and in the field of lightning ignition hazards to aircraft fuel systems.

In addition, at FAA request, NASA has undertaken the following programs:

(1) Measuring light aircraft loads.

(2) Testing noise on specific aircraft as related to takeoff and rate of flight performance.

(3) Doing fundamental research on jet engine noise generation.
(4) Evaluating stability control system for prevention of aircraft upset.
(5) Doing supersonic transport aerodynamic and performance data.
(6) Doing simulator program for preliminary check of flight dynamics in intense turbulence.
(7) Training FAA personnel on test of moving base simulators.
(8) Assisting the FAA in flight test of flying qualities of executive jets.
(9) Analyzing flying and handling qualities of light aircraft.
(10) Measuring sonic boom intensities.
(11) Investigating fundamentals of sonic boom generation.
(12) Checking of high speed propagation of flame front through fuel vents following lightning causing ignition.

Finally, NASA has under consideration several FAA requested programs:
(1) Examining L-band radio transmission to satellites.
(2) Determining flying and handling qualities of VTOL and STOL aircraft and recommending preliminary certification criteria.
(3) Examining and handling qualities of large commercial jet aircraft.
(4) Determining analytical techniques for predicting height velocity diagram for autorotation of helicopters.
(5) Examining use of Teflon for aircraft icing protection using the NASA icing tunnel.
(6) Demonstrating STOL aircraft characteristics using NASA Buffalo.
(7) Demonstrating steep approach capability for noise suppression using Boeing 707/80 experimental aircraft.
(8) Measuring noise profiles for various flight techniques under FAA Convair 880 aircraft during test flights at NAFEC.

Question 2. In what area of R&D do you believe NASA can be of greater assistance?

Answer 2. Based on our exchanges with NASA, we believe that NASA can be of greater assistance in the following R&D area:
(1) Development of quantitative standards for aircraft handling flight characteristics.
(2) Noise suppression and abatement, including engine and airframe R&D, operations, land use, airports, human response and systems analysis.
(3) Wake turbulence.
(4) Analysis of fatigue failures of older, pressurized propeller aircraft.
(5) Basic research, particularly concerning quantitative standards governing aircraft handling flight characteristics.
(6) Satellite communications for ATC functions.

Question 3. Failure to pursue R&D in which areas has resulted in the technology gaps we are now experiencing in our Air Transportation System?

Answer 3. The technology gaps we are now experiencing in the air transportation system result, in part, from failure to provide increased R&D efforts in the following areas:
(1) Unsolved noise problems.
(2) Unsolved quiet engine problems.
(3) Updated airport design and operation criteria.
(4) Surface access to and from airports.
(5) Improved civil aircraft technology.
(6) V/STOL technology and SST technology.
(7) Quantitative standards regarding aircraft handling flight characteristics.
(8) Wake turbulence.

Question 4. Since a significant portion of our National Aerospace System today includes international operations by our own and foreign carriers, what is being done to make sure that our future R&D programs in aeronautics will produce systems compatible to domestic and international needs?

Answer 4. The United States (through the Department of Transportation and the FAA) participates in international aviation organizations, and maintains liaison with foreign countries, on aviation research and development programs to ensure coordination of proposed systems that are capable of meeting both domestic and international requirements. Examples of these are: The International Civil Aviation Organization (ICAO), The Interagency Group of International Aviation (IGIA), The Radio Technical Commission for Aeronautics (RTCA), and The European Organization for Civil Aviation Electronics (EUROCAE).

Question 5. With regard to aircraft noise, the Subcommittee has been told that, within definite limits of economics versus efficiency, research to develop quieter engines cannot proceed at a faster rate than at present. Is this also your belief?

Answer 5. We agree primarily because sufficient pressure has been applied to manufacturers to force them to use all available practical technology to reduce the noise output of their new engine designs. The development of quieter engines is today limited almost solely by the availability of technology.

Question 6. With regard to the need for additional work, are the limiting factors of noise research related to money, numbers of qualified people, adequate leadership in Government?

Answer 6. We believe the primary limitation on development of noise reduction technology is availability of qualified people. Both Government and industry recognize the importance of work in noise reduction technology, and available resources are being used as fully as possible. We think it would be desirable for the Government to sponsor a large amount of basic noise research in universities, both because of the need for more fundamental knowledge about noise generation and propagation, and because it should result in interesting and developing qualified people in this area of technology.

Question 7. In recent years aviation's rate of growth has been more rapid than predicted. Current problems that were forecasted based on the lower predictions have been compounded by this steep rise in aviation. How much confidence do you have in current predictions for the level of activity in the next 10 or 20 years? What do we know in making these new predictions that we did not know before?

Answer 7. Within the past two years, we have expanded our activities in the area of forecasting in an effort to make them more reliable. We have examined each of the methodologies used, and we have made a substantial number of changes. Our new methods are much more responsive to the underlying factors behind the growth in aviation, and we believe our current forecasts will come much closer to predicting future activity levels than the old methods have. In addition to improving our forecasting techniques, we now review and report each month on the trends in a few significant activity measures. In this way, we are constantly up to date on what is taking place, and we can immediately call attention to changes that may need to be made.

Question 8. I believe that approximately 10 years is considered a fairly standard lead time for the introduction of a new concept into the system. Are your current predictions sufficiently long range that we know what will be needed for traffic control systems and support facilities?

Answer 8. The FAA's basic long range forecasts of aviation activity cover a 10-year period. In addition, special forecasts for 15–20 years are prepared to meet longer range planning needs. Examples would be terminal area forecasts prepared for use in airport and research and development planning. We believe these forecasts are sufficiently long range to provide the basis for National Airspace System planning. However, budgetary constraints have generally hampered FAA in pursuing long range technologies on a continuous basis.

Question 9. You emphasize the need for knowledge about compressor and fan noise. I know that we need this, but why do you consider it more important than other areas? Along these lines, do you anticipate a bigger noise problem with the larger C–5, B–747, and SST engines? If not, how is the greater power being generated without adding further to the noise level?

Answer 9. The new generation of highly efficiently high bypass ratio engines have noise characteristics dominated by compressor and fan noise. This noise, therefore, becomes the most important area to attack. However, significant reduction in these noises will someday result in another noise source becoming dominant, with a resulting change in our area of emphasis. The JT9D engine which powers the B–747 incorporates all of today's practical noise reduction technology (low fan tip speed, optimized fan-stator spacing and blade numbers, low fan discharge, and jet exhaust velocities), and therefore, will result in the B-747 being quieter than the long-range four-engine aircraft that it will replace. The C–5 military cargo aircraft will be noisier than today's aircraft because its engine was optimized for operational efficiency, and does not incorporate noise reduction features. The SST engines will be much noiser than today's aircraft in the immediate airport area during full power takeoff, but they should be quieter than today's long-range aircraft on approach and after thrust reduction on takeoff.

Question 10. You suggest the possibilities of surpassing 180 knots with helicopters. Some people consider this to be about an upper limit for the conventional variety. Do you have in mind other versions such as the compound or rigid rotor?

Answer 10. I foresee natural and early evolution of the compound helicopter, both with and without rigid rotors, extending the operating speed envelop to speeds of 250 knots.

Question 11. I've heard that vortex separation from wingtips is a serious hazard to following aircraft, especially small light types. Yet, I can't recall having read or heard of an accident actually having been caused by this. You mentioned in your statement "the wake behind jet aircraft." Is this what you were referring to?

Answer 11. Wake vortices ("prop wash") can be created by propeller and jet aircraft. The agency considers wake turbulence a present and future hazard to flight safety, particularly with the introduction of super jets. Numerous law suits have been filed against the U.S. for claims exceeding $4 million and alleging negligence in failing to provide adequate warning regarding turbulence.

Question 12. Previous witnesses have commented on the somewhat lagging interest of young people today in engineering and scientific careers with a consequent gradual increase in the age of professional staffs. Has this been recognized at all in the FAA?

Answer 12. The number of our engineering vacancies has not been large because of a low turnover and staffing emphasis on other occupations, such as air traffic controllers, and electronic technicians. As a result, the average age of our professional engineers has gradually increased.

However, with few exceptions, FAA's needs for young college graduate engineers have been met. We cannot say that we have noted any lagging interest on the part of young people to enter engineering careers. In fact, we encourage young engineers to recognize the advantage of employment in FAA, particularly in the research and development effort, where there is virtually no limit to the scope of their interest. However, in aerospace engineering, the high paying glamorous jobs all seem to be associated with the space activities and it is often difficult to interest them in lower paying less glamorous jobs in the field of aviation. This is particularly true in the highly specialized fields, such as noise and vibration.

Question 13. What measures are being taken to maintain or improve on the past safety record when the large subsonic and SST's are introduced into the world's airfleets?

Answer 13. We are working with industry to maintain and improve the existing safety record with the new, larger and faster aircraft being developed for air carrier use. We encourage aircraft manufacturers to make the fullest use of technical state-of-the-art in vehicle safety design. Where this state-of-the-art is limiting, we work to expand it through appropriate research in development, either within Government laboratories or in private industry. In air carrier training programs, we are incorporating training concepts that advanced educational institutions have developed and are using. Also, we are developing and using advanced training devices (such as simulators with sophisticated motion and visual systems) to provide better methods of training and evaluating crewmember performance in these training programs. In air carrier operations, we are developing and using operational data recording systems to provide a continuous and comprehensive monitoring capability of aircraft and flight crew everyday performance. Also, we are using total system design concepts of aircraft and developing automatic systems to provide better aircraft performance and flight characteristics, and to reduce pilot workload in the operating environment.

Question 14. Recently Eastern Airlines demonstrated a STOL aircraft here at Washington National Airport. The aircraft had aboard, I am told, very sophisticated navigation equipment which enabled it to fly off of airways with a *high degree of navigational accuracy. One feature was a traveling map, which enables a pilot to see his location at any time. It was advertised as a means to take the load off of the ATC system by removing the necessity of reporting it over radio facilities and through the utilization of usually unused airspace. Would you comment on this?*

Answer 14. Integrated airborne navigational capability, with a high order of accuracy, is available in many forms. With automatic data link transmission to ground stations in the ATC system, there would be a reduction in the voice reporting, and hence the radio communication traffic. However, the ATC system would still have to interpret the position information and provide adequate control and separation of traffic. When the aircraft and reliability standards were met, there would be more efficient use of airspace, particularly en route, and to a much lesser extent, in the terminal area.

Mr. HECHLER. But I know that your schedule is a busy one, and also we have several other witnesses before the committee. So we would like to thank you for your very helpful appearance this morning, Mr. Thomas. And we will proceed with General Maxwell, unless you had any further comment you would like to make?

Mr. THOMAS. No, sir.

We appreciate, again, very much the opportunity of appearing here. Thank you.

Mr. HECHLER. It has been very helpful, Mr. Thomas.

Mr. THOMAS. Thank you.

Mr. HECHLER. We will now hear from another old friend, Maj. Gen. Jewell C. Maxwell, Director of Supersonic Transport Development, FAA, Department of Transportation, who has appeared before this committee before.

Welcome, General Maxwell. Do you have a prepared statement?

General MAXWELL. Yes, sir, Mr. Chairman.

Mr. HECHLER. You may proceed.

(The biography of General Maxwell follows:)

MAJ. GEN. JEWELL C. MAXWELL, U.S. AIR FORCE, DIRECTOR OF SUPERSONIC TRANSPORT DEVELOPMENT

Jewell C. Maxwell is a native of Cockrum, Mississippi. He graduated from Whitehaven High School, Tennessee, in 1935, and attended the University of Tennessee from 1938 to 1941.

In 1941, he entered the U.S. Army Air Corps and received his pilot's wings and commission as a 2nd Lt. in January 1942. He was assigned as a bombardment pilot and became Squadron Commander of the 496th Bomb Squadron. While serving in the European Theater, he flew 44 combat missions as a B–26 pilot. He returned to the United States in May 1945 as Lt. Colonel.

He received a B.S. degree in Mechanical Engineering from the University of Tennessee in 1947 and received the Master's Degree in Aeronautical Engineering from Princeton University in 1949.

General Maxwell has been assigned to the research and development field since 1949, in various positions in Headquarters, USAF, Air Force Research and Development Command (ARDC) and its successor Air Force Systems Command. Between 1963 and 1965, he was stationed at Vandenberg Air Force Base where he was Commander of the 6595th Aerospace Test Wing and of the Air Force Space Test Center, now known as the Air Force Western Test Range. He was promoted Brigadier General in August 1963.

General Maxwell was assigned to his present position as Director of Supersonic Transport Development in the Federal Aviation Agency in October 1965 and was promoted Major General in August 1966.

His awards include the Legion of Merit, Distinguished Flying Cross, Air Medal with 7 Clusters, the Bronze Star, Air Force Commendation Medal, Army Commendation Ribbon, the Croix de Guerre avec Palm, and the 1967 Eugene M. Zuckert Trophy. He has logged more than 3600 hours of flying time.

General Maxwell is married to the former Harriett Caldwell of Knoxville, Tennessee. They have two sons: Jewell C. Maxwell, Jr., and George C. Maxwell.

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STATEMENT OF MAJ. GEN. JEWELL C. MAXWELL, DIRECTOR, SUPERSONIC TRANSPORT DEVELOPMENT, DEPARTMENT OF TRANSPORTATION

General MAXWELL. Mr. Chairman, I am pleased to have the opportunity to appear before this committee again to discuss the supersonic transport program. I have had the privilege of appearing before this committee twice before, as you mentioned.

The first occasion was in support of the fiscal year 1968 Authorization bill for the National Aeronautics and Space Administration and the next occasion was earlier this year to report on the status of the supersonic transport program as a part of the fiscal year 1969 authorization hearings for NASA.

I will cover two topics in my statement. First, a very brief description of the supersonic transport program and its management, and second, I will discuss more fully the nature of the technical difficulties we have encountered in the program and the progress in resolving them.

The supersonic transport program has as its objective the building of two prototype supersonic transport aircraft of a single design to demonstrate that a commercial supersonic transport can be produced that is safe for the passenger, profitable to the manufacturers and the airlines, who will operate it, and superior to any competitive aircraft.

The supersonic transport program is in the national interest because of the favorable impact a successful program would have on the the growth of the economy and the balance of payments. U.S. supremacy in the manufacture of commercial jet aircraft is being challenged by the British and the French with the development of their supersonic transport called the Concorde. In addition, the Soviets are developing a supersonic transport, the TU–144, which is planned for service with the Soviet airline Aeroflot. While the sale of the TU–144 is not considered a direct competitive threat in the markets of the free world, possible expansion and modernization of the Soviet civil aviation fleet is certainly a matter deserving consideration. Both the Concorde and TU–144 prototypes are already built and are expected to fly in the next several months. Production versions may be in airline service as early as 1972.

The reasons the Government is supporting the supersonic transport program is that the program is simply too large and too risky for the industry to undertake by private means. The development and first 100 hours of flight test are estimated to cost $1.5 billion. That is more than double the net worth of the Boeing Co. This tremendous cost, coupled with the high technical risk associated with tripling operating speeds of commercial aircraft from the present 600 miles per hour to 1,800 miles per hour and doubling operating altitudes from 30,000 to 60,000 feet, plus the long time period between investment in development and before any profits could be expected from sale of production aircraft are the reasons that the project is beyond the reach of private capital.

The management of the supersonic transport program is a partnership between the manufacturing industry, the airlines, and the Government. All partners are sharing in the costs and risks of the program and have a voice in the management. Through this unique partnership we seek to preserve the traditional relationships between the airplane manufacturer and his customer, the airline. The manufacturers are required to share in the cost of the development program to the extent of their ability to do so and their cost share increases if costs overrun. Thus we have a strong incentive for prudent management by the manufacturers.

I should emphasize that the Government's obligation to the supersonic transport program is limited to participation in the prototype phase. We have no obligation to pursue the program further. However, in event the program is successful and production is undertaken, either with or without the aid of the Government, our contract provides a means to get our money back and a share of the profits should the program prove to be an outstanding success.

The supersonic transport program is the largest aeronautical development program in the Nation today for civil aviation. It represents a unique way that the Government, the industry, the manufacturers, as well as the airlines, can contribute to a joint effort whose successful completion would benefit all.

I would like now to turn to the status of the supersonic transport program. On the 27th of February this year, I appeared before this committee and at that time reported that the supersonic transport program had been delayed for at least a year because the airplane design was deficient in range and payload, and left too large a gap between the prototype and production versions.

The SST design that was selected for prototype construction was a variable sweep, or swing-wing, design. Through the swing-wing design we had hoped to take full advantage of the extensive research in supersonic aerodynamics that has been accomplished over the past years by NASA. The swing-wing design was selected because it promised good low speed and subsonic efficiency as well as excellent supersonic performance. Subsonic performance is important to a supersonic transport because it means moderate takeoff and landing speeds which not only bear on safety, but relate to the amount of community noise.

Although incorporation of the swing-wing feature does entail a penalty in weight, it was believed that the aerodynamic advantages to be gained by the swing wing would more than offset its weight penalty. Unfortunately, that did not prove to be the case. At the first of this year when all efforts to resolve the weight problem were ineffective, a decision was made to return to the design boards until a solution could be found. We wanted to make very certain we had an adequate design in hand before we begin the very expensive job of hardware construction.

It was evident that the solution might require extensive redesign. For the past year, the Boeing Co. had been engaged in an intensive program to be sure that all available technology has been applied and that the best possible overall design is selected. Boeing undertook a program to reanalyze all designs that promised potential solutions, including both fixed-wing as well as swing-wing designs. I have been advised by the Boeing Co. that they are now placing their principal effort on a fixed-wing design with a conventional tail because it is the most promising of the candidate considerations that were studied.

This new design is intended to achieve the same balance between subsonic and supersonic efficiencies that was the feature of the swing-wing design. This fixed wing is not so sharply swept as previous delta wings. This gives a wider wing spread or span, improving the subsonic efficiency without a great sacrifice in supersonic drag. By the use of a conventional horizontal tail, flaps and other high-lift devices can be used to assist in takeoff and landing, much as today's transports use them. The cruise speed of the SST remains unchanged at mach 2.7 or about 1,800 miles per hour. It will be constructed of titanium; however, the new fixed-wing design will take advantage of recent technical developments in aircraft structural design.

At the present time we have received only preliminary information on the revised design. The Boeing Co. is required to submit an integrated design fully substantiated by wind tunnel tests and detailed engineering analyses not later than the 15th of January. The Government and the airlines will conduct a comprehensive evaluation of the Boeing design at that time. The contract performance objectives remain unchanged and will be the criteria against which the new design is to be judged.

NASA is an active partner in the supersonic transport program. Not only has NASA provided the research upon which the entire supersonic transport program was based, but they have participated in all our evaluations and have provided daily technical advice and assistance. NASA is responsible for the research effort that will assure the continued development of supersonic commercial aviation. The supersonic transport is not merely one airplane or one design, but the first aircraft that will usher in a new era of aviation.

Mr. Chairman, that concludes my statement. I am prepared to answer any questions you may have.

Mr. HECHLER. Thank you, General Maxwell.

I would like to recognize Mr. Pelly.

Mr. PELLY. Thank you, Mr. Chairman. Unfortunately, I am scheduled in a few minutes to be over in the Capitol, and I must leave.

As you know, there is one individual at least who is convinced that the financing and research work could be accomplished through private enterprise or through the formation of some corporation like the Satellite Corp.

I would like you to indicate to this committee as to whether or not you think that the only way is to have the Government put up a major share of the financing of the research work, which you have indicated will be about a billion and a half dollars.

General MAXWELL. Well, first, I certainly believe that the only way that you could raise that amount of money for a program of development with the risks involved of the nature of the supersonic transport program is through Government support. There simply isn't any other way. You cannot raise that amount of risk funds in the private sector.

Now, regarding the means by which funds are provided for the program, obviously we could use private funds or use appropriations in many ways. We are using appropriated funds in the development phase, and I happen personally to think that this is the correct way to go at this point in time.

The private funding solutions that have been proposed envision the creation of a Government corporation which would be empowered to sell bonds to raise money backed by Government guarantees. Such a corporation would then contract for the development of the aircraft with the manufacturers.

I see two or three basic problems with such an arrangement that I believe most people have overlooked. First, I don't think one goes into business to build one airplane; one airplane has a way of deriving a No. 2 and a No. 3 and a No. 4 because the very nature of the program is that way. Once we build the first aircraft we will automatically know how to build the next one that is even better. That has been the nature of the industry to date.

In effect I think what would occur would be the creation of a new Government corporation to compete with those who are already in the business.

Secondly, of course, the taxpayer underwrites all the risks anyway in such an arrangement. But he doesn't share in any of the return. If it is a successful program the taxpayer would share the benefits of an expanded industry, but not in the profits, nor would there be any returns to the Government.

Mr. WYDLER. Aren't we in effect going to give the Boeing Co. under the present arrangement complete domination in this field? Isn't that going to be the result of what we are doing now?

General MAXWELL. Mr. Wydler, we have included in our contract provisions to protect the public against the exploitation of a monopoly by the Boeing Co. in this instance. There are provisions on ownership of design rights, there is also the right, if we choose at a later date, to institute price controls and other devices to assure that such a monopoly cannot be exploited to the public detriment.

Now we have an alternative——

Mr. WYDLER. That is the company who designs the planes and who is also going to build them.

General MAXWELL. We can license other companies to build the plane. And the know-how can be transferred. That is done today.

Mr. PELLY. There is nothing new about that.

General MAXWELL. Nothing new about that. The last point I wish to make, Mr. Pelly, is that the costs of the program, I think, would increase, first because we would have to start paying interest immediately upon borrowing the money. The interest rate in the private sector is higher, I believe, than we pay—assuming that the entire Government expenditures are a part of the national debt, which is not necessarily a valid assumption but one which is ordinarily made.

Mr. PELLY. Well, it seems to me that because there is a school of thought that it could be done privately, that we ought to spell out for the public what the differences in cost would be and what the alternatives would be likewise under various plans.

I will simply conclude by saying I am sorry you weren't here yesterday. The witnesses from NASA did indicate great confidence in the team that is working on the SST and expressed their belief that the problems will be successfully resolved. I know you would have liked to have heard those witnesses because I think you share that feeling.

General MAXWELL. Yes, sir; I think I do. I would like to add one further thing about the subject of financing, and the use of such a corporation.

We are considering that device for the production phase. We would prefer to do otherwise. But if we cannot raise the money, then here is a way to do it, and it is definitely being considered. We believe the production phase of the program is where the application of that idea is more appropriate than it is in the development phase.

Mr. PELLY. That is for the financing after the first two prototypes?

General MAXWELL. Yes, sir; after successful development.

Mr. PELLY. Well, thank you very much. And thank you, Mr. Chairman. I am sorry I have to leave.

Mr. HECHLER. All right, Mr. Pelly.

Mr. Wydler?

Mr. WYDLER. Yes.

Part of the decisions that you made to slow down the SST program have been generated by the problems the administration is having in getting the budget in balance. The way I understand your statement, General, there are a lot of complicated problems in building an SST. I am sure that didn't come as any surprise to anybody. As a result of the fact that you have some problems that have to be solved, you are just going to delay the construction of the plane.

We must have known that these problems existed when we started building the aircraft and that it was going to involve a great many research problems. Is this decision being made for economy reasons although you say the delay is caused by design problems?

General MAXWELL. Mr. Wydler, I would like to believe it was made for those reasons, but unfortunately, that is not the case. We wouldn't be redesigning the airplane, obviously, if this were the problem.

I should say we have never lacked for support in this program, and every year that I have been present in the program we have had in fact a carryover in our funding. The Congress has supported us—until this year we have received virtually every dollar we have ever asked for to support the program, and at no point in time has my request been reduced by the Bureau.

So it hasn't been a lack of support, it hasn't been a lack of funding. They were plain and simple technical problems. And they were associated with our ability to design and build an airplane having the swing-wing feature of this particular variety. Two years ago we thought we could do it. Other such aircraft had been built, but we had never built a commercial transport aircraft of this nature. The simple truth is we have now found out we don't know how to build an airplane like that, and we just simply can't put it together. And perhaps the product of this research is a textbook on what you can or cannot do with a swing-wing design, but at least I think we are much wiser today.

Mr. HECHLER. Would the gentleman yield for just a brief question?

Mr. WYDLER. Yes.

Mr. HECHLER. What is the comparison with the original cost and time estimate as a result of this change in design?

General MAXWELL. Mr. Chairman, we have not revised our estimates of the program cost at this point in time. We probably will revise them when we receive new cost estimates in January. But as to cost—the expenditures of this year have been very minimal. We have spent in Government money at the Boeing Co. this year through the 31st of August some $35 million. So we have been proceeding at a very low rate of expenditure.

There will be a revision upward in the cost, but there will not be a change in the cost overrun point. I would not expect that the increase in cost would be a great deal. We were fortunate because we stopped before the point we started cutting metal and we were able thus to control our costs.

Mr. HECHLER. What about time now?

General MAXWELL. Time, we are going to slip about 18 months as a result of these problems.

Mr. WYDLER. What have you spent to date on this project?

General MAXWELL. Total funds to date on this program, including all the previous phases, have been $411 million. There were $290 million on previous phases.

Mr. WYDLER. What do we have to show for that?

General MAXWELL. Well, I will tell you one. I think we've got a tremendous amount of technical data. We are running an engine, for example, the largest that has ever been built.

Mr. WYDLER. You know what we can't do?

General MAXWELL. Yes, at least we know that.

And we made far more progress in other areas, I think, than perhaps the record might show in such a discussion. We have done a great deal of work, for example, in titanium technology, in engines, in the field of aerodynamics. So in the whole field we have accomplished a great deal.

Mr. WYDLER. I have a great deal of respect for my colleague, Mr. Pelly. I understand his feelings toward the Boeing Co. But I wonder what Lockheed must be thinking about this change.

You had a competition between the Boeing Co. and the Lockheed Co.; the Lockheed Co. came in with a design for a fixed-wing aircraft. You looked at their plane, and you said, no, we don't want your plane, we want a swing plane and we're going to give the contract to Boeing. About a year later you decide that the swing-wing design is not what you want and you tell Boeing to build a Lockheed plane. Isn't that what is happening?

General MAXWELL. No, sir, we are not building a Lockheed plane. I would like to add, the Government does own the rights to the Lockheed plane, so we could if we chose. But that is not the case. I would like to make the record very clear on that point.

Let me say what must be going through their minds might be that "We are really the winners" because they have taken their team and are now building a commercial subsonic aircraft, competing with other Boeing products, I might add, if one looks at it that way.

I am not sure what their feelings are. I would not think that as a company they would be upset. This is not an unusual occurrence in the aviation business. And as a matter of fact, almost all programs that I have been associated with over the 20 years in the business have gone through an extensive redesign at some point in their development. As a matter of fact, they hardly resemble what was the initial proposal in most instances.

So it is not an unusual thing to encounter such difficulties. I don't think we have had one where the physical redesign shows quite as clearly as it does in this case, although I can recall some. The original proposal for the B–52 was a straight-wing turboprop, but it wound up to be a swept-wing jet. There are many examples in the industry where such redesign has occurred. I don't consider it abnormal.

Mr. WYDLER. I don't understand. What happened really was that you had a competition between these two companies.

General MAXWELL. Yes.

Mr. WYDLER. They went through a period where they drew up plans and designs and submitted them to you. You examined their proposals and you decided you liked the Boeing proposal, the swept-wing proposal.

General MAXWELL. We thought we could build it. And by the way, I had a lot of company who sat by my side and agreed with that decision at the point in time, including the airlines.

Now we found later that the problems were far more severe than we thought. Some of these problems do not show up until one gets into the process of detailed design of the aircraft, which would not show up in a competition.

Mr. WYDLER. Is there a connection between the design problems you had and the problems they are having with the F–111?

General MAXWELL. No; not to my knowledge, Congressman. But I cannot say in the latest accident or two whether that is the case. We do keep fully informed on the F–111, and we have had an exchange of technical information to make sure that we are aware of all their difficulties.

Mr. WYDLER. Thank you, Mr. Chairman.

Mr. HECHLER. Thank you, Mr. Wydler. And thank you also, General Maxwell. We have quite a number of other questions we would like to submit for the record.

(Questions posed by the committee follow:)

QUESTIONS SUBMITTED TO GEN. JEWELL C. MAXWELL BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. What do you perceive to be the spectrum of new research and development needs that will be created by the insertion of SST aircraft in our national and international air space system?

Answer 1. As with the subsonic jet transports and any new advanced aircraft the first vehicles introduced into service can meet their economic requirements but are restrained by the necessity to be relatively conservative in design to insure a viable vehicle is produced. The SST represents a greater step forward in terms of performance and technical sophistication than any civil aircraft introduced into service in the past. It took the subsonic jets about seven years to realize the productivity they have today and their full potential has not been realized yet. The SST will begin commercial operation with the capability to compete economically with the subsonic jet transport on transatlantic routes but much greater technological advances are required to extend its growth beyond the 4000 statute mile initial goal than were required to extend the range of first generation large subsonic jets.

The insertion of SST aircraft in our national and international air space system is not expected to create a spectrum of *new* research and development needs beyond those areas which are already quite well identified. One area, that of the operating environment, may permit the isolation of some potential problems all of which are being studied at the present time; e.g., engine noise, clear air turbulence at SST cruise altitudes, improved altimetry and the effects of abrupt temperature changes at altitude on SST engine performance. The research and development needs to improve range and payload for future SST's are numerous but requirements have been identified such as:

(*a*) A better understanding of aeroelastic effects.

(*b*) New materials and structural concepts to reduce structural weight, particularly fibre technology and composites.

(*c*) New control systems which can be used with the most optimum aerodynamic configurations.

(*d*) Improved engines, propulsion efficiency and noise reduction.

(*e*) New air traffic control and distance and altitude separation instrumentation, procedures and systems, and weather radar.

(*f*) Improved knowledge of handling qualities requirements for aircraft which will probably be heavier than even the jumbo jets.

As a corollary to the growth of SST aircraft in size and range, continued and expanded research efforts are necessary in regard to noise and sonic booms. All of these above mentioned problem areas are being intensively investigated now and the research will continue for the next several fiscal years in order to provide the technological lead time for second generation SST's.

Question 2. In comparing the TU–144 and the Anglo-French Concorde with our own SST it is obvious that in performance, economics, and payload we will have a superior aircraft with built-in future growth capabilities. Yet, theirs will be operational up to 3 years before ours will. Will this not possibly have a serious effect upon our own status as the leading aircraft producer?

Answer 2. There is no doubt that the Anglo-French Concorde and Soviet TU–144 will have effect upon our status as an aircraft producer. This is one of the major reasons that the U.S. Government has been supporting the program since 1962. The extent of the impact of their production on our position as the world's major aircraft producer will not be finally known until the Concorde and TU–144 are actually flown and evaluated by the airlines. An important fact, however, is that the French and British governments have made available production money for the Concorde even though the prototype program is experiencing technical difficulties. This means that they are willing to overlap development and production efforts in an attempt to hold their lead over the U.S. SST and increase their market.

A situation could develop where the Concorde program is firmly established and an improved version larger and economically more attractive than the first version might be offered for sale to compete with the U.S. SST. Under such circumstances this would have a serious adverse impact on the U.S. entry into the market.

Question 3. Research with the B–70 has done much to assist the SST programs. Do you see a continuing need for such research?

Answer 3. The flight test program that has been and is being pursued on the XB–70 in support of the SST has been the result of mutual planning between NASA and the SST Office. The completion of the currently scheduled series of tests will mark the completion of all of the priority test programs requiring the XB–70 as a test vehicle. Other programs of lesser interest could be accomplished by the XB–70. However the great cost of operating the aircraft with the relatively infrequent flights make it an uneconomical way to obtain such test data. There are and will continue to be needs for testing in supersonic aircraft. However, these may be fulfilled by flight tests of other supersonic aircraft such as the SR–71, B–58, F–111, etc., that can be operated at much less cost per flying hour.

Question 4. The National Academy of Sciences in a series of reports recommended that additional research be conducted regarding sonic booms. What programs are currently underway and what is planned for the future?

Answer 4. The Sonic Boom Research Program shown below has been developed jointly by the FAA and DOT as guidelines for implementation in FY–1969. This plan has been formulated in light of the broader recommendations made by the Panels of the Interagency Aircraft Noise Abatement Program and the SST-Sonic Boom Committee of the National Academy of Sciences. The FAA is initiating necessary action to implement the Sonic Boom Research Program stipulated by these guidelines.

This program draws particular attention to the aspects pertaining to the development of new simulator facilities and imaginative theoretical work on sonic boom alleviation. As the recommendations of the Interagency Aircraft Noise Abatement Program Panels and the National Academy of Sciences SST-Sonic Boom Committee stress the simulator requirement, cooperation with the groups of experts will be continued regarding the development, construction and utilization of these needed facilities.

In regard to propagation, studies will be conducted investigating topographical, atmospheric and focusing effects of sonic boom. In addition, funds have been programmed to ESSA for further study of the meteorological effects of sonic boom in a program currently underway.

In the area of sonic boom response, continued simulator programs are underway on human and animal response to sonic boom. Of primary interest, is the continuation of the NASA sonic boom startle and sleep experiments.

Sonic boom recorders have been placed in four national parks and will monitor and record sonic boom events in these areas.

SONIC BOOM RESEARCH PROGRAM FISCAL YEAR 1969 AND 1970—PROGRAM CONTENT

A. Generation and Propagation:
  1. Sonic Boom Reduction and Control:
    (*a*) NASA in-house work to continue.
    (*b*) Industry Research: Initiate research in industry to investigate new theoretical concepts, prediction techniques and unconventional configurations aimed at reducing boom generation and/or suppressing its effects.
    (*c*) University Research Program: Initiate University Research Program with additional participants and research activities not included in current NASA program.
  2. Propagation and Meteorological Research: Theoretical investigations conducted by ESSA in addition to the collection, analysis, and processing of data currently being obtained.

B. Response:
  1. Human Response:
    (*a*) Simulator studies to determine the parameter or combination parameters which most influence subjective response.
    (*b*) Sonic boom assessment and evaluation to develop technical and social criteria for sonic boom "acceptability."
    (*c*) Development and installation of promising new simulator (operations to be funded by FY 1970).
  2. Structural Response:
    (*a*) Simulator and analytical studies to correlate sonic boom induced structural response with damage criteria for glass and plaster.
    (*b*) Development and installation of promising new simulator (operations to be funded in FY 1970).
    (*c*) Analysis of seismological and topographical effects of sonic booms.
  3. Animal Response: Simulator studies of animal behavioral and reproductive response, if any, to sonic boom.

Question 5. Titanium technology has been questionable at times. Is this technology completely satisfactory for the proposed U.S. SST as of now?

Answer 5. Titanium technology has progressed rapidly over the past few years due to the research and development programs that have been conducted by DOD, NASA, FAA, the aerospace industry and titanium producers. This is reflected in the increased use of titanium in military systems, the space program, and commercial aviation. On the basis of the research and development programs that have been conducted and the service usage that has been accumulated, it is believed that the present titanium technology will be satisfactory for the proposed U.S. SST. Continuing improvements can be expected in the technology as additional use of titanium is made. This is similar to what has happened, and is continuing to happen, for the other metals that are in common usage.

Mr. HECHLER. I just like to ask one final question. What specific further aeronautical research yet has to be done before the SST becomes a working aircraft?

General MAXWELL. Well, I think we can build the SST from the current state of knowledge. The principal problem I think we will face as a result of the change in design is a renewed emphasis on use of advanced structures, because the success or failure of a fixed-wing design is very closely related to how light one can build the aircraft. And I do think we need and will require additional emphasis in that area.

I have discussed this matter at least informally with the people in NASA. They understand it. They understand the nature of our problem.

Second, I think we need to know more about flexible structures and aerodynamics of flexible structures than we know at present. I think we are well advanced on aerodynamics of supersonic rigid bodies, but we need more work on the interaction of these flexible structures, and particularly also related to stability and control.

I think it would be helpful if we had more aircraft design studies so we might recognize somewhat sooner in time some of the physical limitations of trying to apply new techniques to a design, because while we were attempting to use the best in theoretical aerodynamics, we found ourselves unable to do so, because of physical limitations we simply didn't understand at the outset. I believe work of that nature and study of new configurations or system studies would be most useful to future generations of SST's.

I suppose finally, to fully exploit supersonic transport, sooner or later we ought to learn to fly them over land. This implies knowing more about airplane designs having low boom characteristics, because if we are going to open the era completely, we should then make an effort to design an airplane or attempt to design an airplane that can operate over land without having the population severely upset by its presence.

I think the present one could fall in that category.

Mr. HECHLER. Now these things that you have mentioned, have you had any conversations with NASA as to which portion of these items NASA could well contribute toward?

General MAXWELL. We have had only preliminary discussions, Mr. Chairman. As you can understand, at this point in time we are applying our hindsight to determine where we were wrong and what we should do in the future.

I would expect before next year that there would be some more definitive programs suggested. I am certain that NASA is going through the same soul searching that I am going through and that our program is going through, on what we should have done and what we should do now. But I think it is too early for me to give you specific recommendations.

Mr. HECHLER. These hearings are attempting to insure that there isn't an isolated series of research efforts going on in different areas and directions that isn't pulled together with some sense of priority, as to future needs. This is the purpose of my question.

General MAXWELL. Yes, sir. We do work—and I might say we work very closely with NASA. They have a man in my office. They have people at the Boeing Co. who are working with us on versions of the SCAT–15. We are continuing to work that design to find out how to build that airplane, because it looks so good if only we could find a practical way to construct it. And we do exchange information on a day-to-day basis, and we suggest to them through our regular coordination exercises what we think should be done as a part of that program

Mr. HECHLER. Thank you, General Maxwell.

We will have a 1-minute recess before hearing the next witnesses.

(A short recess was taken.)

Mr. HECHLER. The committee will be in order.

The next witness will be Mr. Ben Alexander, chairman of the board and technical director of the General Research Corp., accompanied by Dr. Lawrence Goldmuntz, executive secretary to the Advisory Committee on Air Traffic Control.

Mr. Alexander has had an outstanding career in research and development, primarily in industry, and he is presently Chairman of the Advisory Committee on Air Traffic Control for the Department of Transportation. Mr. Alexander's background makes him especially qualified to undertake the heavy responsibility of assisting the Department of Transportation in its efforts to achieve solutions to the serious problems of air traffic control, both today and in the future. His background and experience with the International Telephone & Telegraph Co., the Institute for Defense Analyses, and the General Research Corp., will be a valuable asset to such achievements of the Advisory Committee and to the Department of Transportation.

Welcome, Mr. Alexander.

Mr. ALEXANDER. Thank you, Mr. Chairman.

Mr. HECHLER. Do you have a prepared statement you would like to present?

Mr. ALEXANDER. Yes, I do. I would like to read it, if you don't mind. It shouldn't take long.

Mr. HECHLER. You may proceed.

(The biography of Ben Alexander follows:)

BEN ALEXANDER, CHAIRMAN, ADVISORY COMMITTEE ON AIR TRAFFIC CONTROL (CHAIRMAN OF THE BOARD, GENERAL RESEARCH CORPORATION)

Education

Studied physics, economics, electrical engineering and mathematics at Cornell University, U.S. Navy Academy Post-Graduate School, Brooklyn Polytechnic Institute and Stevens Institute, receiving B.A. (1940) and M.S. (1957) degrees. Served in the U.S. Navy as an electronics and communications officer from 1941 to 1945.

Professional Experience

1945–1959—International Telephone and Telegraph Company.—Joined the research division and remained with ITT in various engineering and management positions until 1959. Initially engaged in the design of electronic switching systems for telephony. This project led to the demonstration of one of the first all-electronic automatic exchanges. In 1947, assigned to ITT's navigation department, and worked in air navigation, guidance, and related areas until 1959. As Department Head (1950), Associate Laboratory Director (1955) and Laboratory Director (1955) was associated with programs of engineering, development, and research.

1959–1961—Institute for Defense Analyses, Arlington, Va.—Member of the Technical Staff of the Advanced Research Projects Agency Project DEFENDER. Participated primarily in the analysis and synthesis of terminal and midcourse ballistic missile defense systems, and collaterally in areas of radar, radio propagation, and missile guidance. In addition, served as member of task group assigned to assess the national Ballistic Missile Defense effort for the Secretary of Defense.

1961– —*General Research Corporation, Santa Barbara, California.*—Chairman of the Board of Directors and Technical Director. Involved in problems of ballistic missile defense and penetration aids. Participated in development of BAG series of digital simulations of ballistic missile attacks on defended targets. Specialized in radar, guidance and control, discrimination, and simulation. Participated in limited war studies, including reconnaissance and communications technology and operations research. Beginning in 1966, involved in urban studies, with emphasis on urban transportation and problems of the core city.

Other Professional Activities

1946–1947: Member, Research and Development Board (working group on missile guidance).

1949–1959: Member, Radio Technical Committee for Aeronautics, Special Committees, 49, 50, 62 and 63.

1957–1958: Lecturer, Stevens Institute, Computer Technology.

1960: Vice-Chairman, Woods Hole Summer Study, AICBM System Concepts.

1960–1965: Member, AMRAC Program Committee.

1961: Chairman, Weapons Panel, Paris meeting of Von Karman Committee on Long-Range Scientific Studies for NATO.

1961– : Consultant, Institute for Defense Analyses.

1961– : Consultant, Advanced Research Projects Agency.

1962–1963: Director, INTERCEPT X Study.

1963–1965: Member, BMD Advisory Committee (ARPA).

1964–1965: Director PEN X Study.

1965–1967: Chairman, BMD Advisory Committee (ARPA).

1966–1968: Member, Scientific Advisory Group, Rural Security (Thailand).

1966: Chairman, Transportation Panel, Summer Study on Science and Urban Development (HUD–OST).

1966– : Consultant, HUD.

1966–1967: Member, President's Task Force on Cities.

Memberships

Fellow, IEEE.

Patents

Pulse Code Communication System, No. 2,510,054, June 6, 1950 (with E. M. Deloraine).

Pulse Spacing Modulated Communication System, No. 2,557,950, June 26, 1951 (with E. M. Deloraine).

Airborne Pictorial Navigation Computer, No. 2,836,816, May 27, 1958 (with J. L. Allison).

Pulse Pair Detector, No. 2,861,184, November 18, 1958 (with J. F. Sullivan).

Aerial Navigation Indicator, No. 2,938,204, May 24, 1960 (with P. R. Adams and R. I. Colin).

Velocity and Position Indicator, No. 2,194,948, July 13, 1965 (with G. A. Deschamps).

Magnetic Switch with Infinite Rejection Ratio, No. 2,881,331, May 23, 1957.

Long-Range Radio Navigation System, No. 2,975,417, March 14, 1961 (with M. Rogoff and M. Vosburgh).

Storage Device, No. 3,104,377, September 17, 1963 (with J. F. Sullivan).

Collision Avoidance System, No. 3,025,514, 1962 (with M. Press and J. Murgio).

Publications

"Inverse Celestial Navigation," presented at MIT Navigation Symposium, 1947 (Unclassified).

"Instrumentation of Long-Range Navigation Systems," presented at National Aeronautical and Navigational Conference, IRE, Dayton, Ohio, May 1951 (Unclassified).

"Radio Position Fixing by Low-Frequency Composite Wave Measurements" (with S. Hyman), presented at National Aeronautical and Navigational Conference, IRE, Dayton, Ohio, May 1957 (Unclassified).

"Background and Principles of TACAN Data Link" (with R. C. Renick and J. F. Sullivan), IRE Transactions on Aeronautical and Navigational Electronics, March 1959 (Unclassified).

Intercept X Report (U), (editor), Institute for Defense Analyses, 1965 (Secret).

PEN X Report (U), (editor), Institute for Defense Analyses, 1963 (Secret).

"Representations of Missile Phenomenology for Use in AICBM Engagement Models" (U), (with L. R. Ford), Vol. VI, Part I, AMRAC Proceedings, Meeting of 30 April, 1–2 May, 1962 (Secret).

"Highlights of the Intercept X Study" (U), Vol. VIII, Part I, AMRAC Proceeding, Meeting of 15–17 April 1963 (Secret).

"PEN X Summary" (U) Vol. XIII, Part II, AMRAC Proceedings, Meeting of 15–17 November 1965 (Secret).

General Research Corporation Reports

Methods of Representing Radar Errors (U), IMR–1/1, July 1963 (Confidential).

Radar Discrimination Based on Wake Velocity (U), (with W. Short), IMR–5, July 1963 (Confidential).

On Precursor Jammers (U), IMR–65/1, January 1964 (Secret).

The Use of Beta Variation as A Discriminant (U), IMR–87, February 1964 (Secret).

Hypothetical Soviet Missile Defenses (U), (with J. Boys), IMR–90/1, February 1964 (Secret).

Novel Defense Systems (U), IMR–121, July 1964 (Secret-Restricted Data).

A Simplified Analysis of Radar Performance in Ground Clutter, IM–173, October 1964 (Unclassified).

STATEMENT OF BEN ALEXANDER, CHAIRMAN, ADVISORY COMMITTEE ON AIR TRAFFIC CONTROL (CHAIRMAN OF THE BOARD, GENERAL RESEARCH CORP.), ACCOMPANIED BY DR. LAWRENCE GOLDMUNTZ, EXECUTIVE SECRETARY TO ADVISORY COMMITTEE ON AIR TRAFFIC CONTROL

Mr. Alexander. Mr. Chairman and members of the subcommittee, the Secretary of Transportation established the Air Traffic Control Advisory Committee and directed it to present to him, by July 1, 1969, a design for the next generation air traffic control system. The committee has just begun working, having held its first meeting early in September.

The committee members were selected from the fundamental disciplines involved in air traffic control, including systems engineering, transportation economics, computer science, communication, navigation, and electrical and aeronautical engineering. The men who were invited to serve on the committee have distinguished themselves in the practice, as well as in the theory, of their specialties. They all have experience which bears directly on air traffic control problems. They will each devote 4 or 5 days per month to the committee's activities.

The committee's staff, of which Dr. Goldmuntz serves as Executive Director as well as being Executive Secretary of the committee, is composed of specialists from the FAA, NASA, and USAF, supplemented by consultants from the aviation industry, from research organizations, and from universities. The staff will consist of about 30 individuals who, on the average, will work about half-time.

Secretary Boyd wrote, I quote:

> The principal objective of the committee is to define the requirements for, and propose an air traffic control system adequate for the 1980's and beyond. Specifically, the committee should plan to:
>
> (*a*) Utilizing estimates of demand for air transportaton in the 1980's and beyond which are agreed upon by the Department and by the Committee,

identify the essential design and design and performance characteristcs required of an air traffic control system capable of meeting this demand safely and economically.

(*b*) Assess the potential of current and projected technology in relation to these system characteristics and propose a next generation air traffic control system.

(*c*) Identify research and development programs which should be undertaken by this Department in order to ensure the timely introduction of the technology required for the next generation system.

Not only must the committee's work be technically, operationally, and economically sound, but the committee must help create a climate conducive to acceptance and implementation of its recommendations. We are fully aware that studies such as this too often are ineffective; their results, however excellent, are noted when they appear and then forgotten. To help avoid this, we are involving representatives of the entire aviation community through their service on our technical staff. As such, they will participate with the committee in debates on the implications, as well as on the validity, of their work. We believe that the allegiances so created are an essential product of the committee's efforts.

As you know, we have just begun our work. We appreciate this opportunity to tell you about our plans and to solicit your views. Our approach is to start by identifying and trying to understand the critical problems, while at the same time assembling all of the many concepts that have been proposed for air traffic control. Subsequently, we will study these solutions and others in light of the critical problems that have been identified.

Four questions were raised in the committee's initial deliberations which appear to be fairly fundamental. Others of comparable impact may arise. How, and to what precision, they are answered will profoundly influence both our system designs and our recommendations for research and development. The committee's staff is now concentrating on these questions which may be briefly stated as follows:

First, we are concerned about the accuracy and reliability with which one can predict the air traffic demands for the decade of the 1980's. Our tools do not seem very potent for dealing with conventional aircraft and seem to be inadequate for predicting STOL and VTOL traffic. Is it possible to place bounds on the 1980–90 traffic which usefully guide the range of system performance needed?

Second, what is the upper limit to the rate of safe movement of aircraft into and out of airports? How is it affected by the number of runways, their spacing, the electronic equipment used, the effects of turbulence produced by one aircraft on another, the procedures imposed by aircraft noise, the influence of mixed aircraft types and varying pilot skills and many other factors?

Third, the evaluation of improvements that might be realized by complete automation depends on understanding the degree to which pilot and controller reaction time, attention, and capability actually limit performance. To what extent can relatively simple incremental improvements in instrumentation, computer use, and communications enhance pilot and controller performance? In what respects and by how much is this inferior to the performance of fully automated systems?

Finally, there is the problem of the interface between controlled and uncontrolled aircraft. Ideally, the air traffic control system of the 1980's would impose a minimum of interference to free use of the airspace. In any case, the system must provide for the many private fliers who cannot afford the cost of sophisticated equipment or the time to become proficient in its use. To what extent can regulatory policy plus carefully selected technological innovations provide safety at traffic densities of the 1980's with a minimum of regimentation?

In addition to addressing these problems, the committee's staff will shortly begin to define alternative system concepts. We are inviting all of the very many individuals and groups who have been studying the air traffic control problem to present their views and to work with us in defining a set of perhaps half-a-dozen, significantly different, innovative approaches to the ATC system of the 1980's.

How these two preliminary tasks fit into the overall program can be seen from the committee's initial schedule.

During September and October, we are investigating key problems and identifying alternative broad system concepts.

From November through February we plan to continue to study the key problems and to analyze the technical feasibility and comparative costs and benefits of alternative concepts.

On the basis of the work that is done during that period, from February through May we will select one or two "preferred" systems. For these we will undertake system design, implementation studies, performance and cost estimates, sensitivity studies, consideration of their impact on air traffic, on the aviation industry, on airport design, on urban transportation needs, and so forth. Also we will plan a research and development program commensurate with the needs of the systems that we identify as best.

Finally, in May and June we will prepare our final report.

Naturally, we hope that there will be "fallouts" of this program that will contribute to ATC improvements well before 1980. We think, in fact, this quite likely, and will make a point of promptly informing the Secretary and the FAA Administrator whenever the findings of the committee seem applicable to current problems.

We feel the Department of Defense participation in the committee activities is assured by full-time representation on the staff of the committee as well as by DOD briefings on current and projected systems. It is, of course, most important for the committee to understand the extent to which the civil air traffic control system can depend on military surveillance of the airspace.

The National Aeronautics and Space Administration has had a traditional role in aeronautics research and development. The NASA-sponsored study conducted by the Aeronautics and Space Engineering Board of the National Academy of Engineering on civil aviation research and development has been distributed to committee members. NASA is fully aware of the committee's plans and will be represented on the technical staff. In addition, the committee will certainly call on NASA personnel as consultants in their various areas of expertise.

I would like to tell you about the members of the committee. We tried to have a fair representation of the social and the physical. We include men whose careers have been in transportation, economics and air operations. Among the scientists and engineers, some are specialized in highly advanced technologies that have not yet been applied to air traffic control, and some have worked on air traffic problems for a good many years and bring to the committee not only their expertise, but the leavening effect of their wisdom.

The composition of the committee is as follows:

Chairman: Ben Alexander, chairman of the board and technical director, General Research Corp.

Executive secretary: Lawrence A. Goldmuntz, Office of the Assistant Secretary for Research and Technology, Department of Transportation.

Thomas A. Amlie, Technical Director, Naval Weapons Center, China Lake, Calif.

Robert R. Everett, vice president, technical operations, MITRE Corp.

Edward L. Glaser, director, Jennings Computing Center, Case Western Reserve University.

Richard R. Hough, vice president, Long Line Department, American Telephone & Telegraph Co.

John R. Meyer, professor of economics, Yale University, and president National Bureau of Economic Research.

Courtland D. Perkins, chairman, Department of Aerospace and Mechanical Sciences, Princeton University.

Jack P. Ruina, vice president for special laboratories, Massachusetts Institute of Technology.

Gen. J. Francis Taylor, senior vice president, planning, Aeronautical Radio, Inc.

Ex officio member: James E. Densmore, Deputy Assistant Secretary for Research and Technology, Department of Transportation.

Mr. Chairman, this concludes my statement.

Mr. HECHLER. Mr. Alexander, I would like to congratulate you, and, through you, Secretary Boyd for the appointment of this committee and the way in which they are going about their work. As all these current crises are overtaking us and causing us to exert a lot of frantic effort to avert them, it is very heartening and refreshing to see that there is a committee like yours that is looking forward, trying to peer into the 1980's and see what steps we can take to avert these crises. And certainly the caliber of this committee is really outstanding.

I want to ask you about the scope of the charter of this committee. Inasmuch as the problems of air traffic control are related to and in some cases determined by such things as airport development and your ground links to the airport, your aircraft and pilot capability, do you have the authority to broaden out and cover these things, which have a direct effect on what you have your focus on?

Mr. ALEXANDER. We worry just about the problem you raised, sir. As a manager of studies, it is always my hope to define the problem as narrowly as I can. The narrower you can define your problem, the more chance you have of making a contribution.

I am afraid that this one is one which can't be defined too narrowly. We clearly have to look at each of the points you mentioned, the institutional problems, for example, of pilot acceptance as well as the human engineering aspects of pilot capability. We have to look at the airport problem from the point of view of its economic and social impact on the locality and to some extent look at the airport access problem. We hope we can spend relatively small amounts of our time on that.

You often don't know at the beginning of a study how far afield you have to go. We would like, to the extent possible, to treat these problems by clearly defining sets of assumptions which people perhaps like yourselves, certainly like the Pilot's Association and specialists in community problems, are willing to accept as a reasonable set, and then identify the extent to which the systems that look reasonable are able to match those needs.

Mr. HECHLER. Mr. Wydler?

Mr. WYDLER. The fact is that all you really know now is that you have a lot of problems and that you are going to try to define what they are between now and next February.

Mr. ALEXANDER. Yes, sir.

Mr. WYDLER. I don't see that there is very much light you can possibly shed on what we can do with the problems that exist at the present time in this area.

Are the studies that you are undertaking really directed toward a nationwide problem? Or are they much more specific? I mean by that; do these problems of air-traffic control that we worry about exist as a national problem or aren't they really just in a very few places where we have tremendous congestion of the air space?

If I understand correctly what is happening today in most of the airports of our country, there is no problem whatsoever because the traffic is reasonably light. It can easily be handled and planes can land and take off with complete safety. It is only in a few airports such as Washington, New York, Chicago, and possibly Los Angeles, where the systems aren't big enough in capacity to handle this traffic, that is why we have this so-called air-traffic control problem.

It seems to me it is a very localized kind of a problem, not really a national problem at all.

Mr. ALEXANDER. Well, sir, first of all, I agree, we don't know much more than that we've got a problem from the committee's point of view.

I will make a comment on your second point.

Mr. WYDLER. That is not your fault; that is the nature of what you have been assigned to do.

Mr. ALEXANDER. Yes, sir.

Mr. WYDLER (continuing). And the point of time in which you appear before us. I am saying you can really add much for the future because as you say, you don't know very much about the problems today.

Mr. ALEXANDER. I think most people guess that there will be perhaps three times as many areas, instead five airports, perhaps 15 that will face problems in the eighties comparable to what we are facing now. Maybe the number will be larger, and, perhaps smaller.

Whether this is a national problem I think depends a lot on your point of view. It is clear that the degree of regimentation that may have to be imposed on the airways will go beyond the areas where the congestion lies. Furthermore, the problem of kinds of equipment that are necessary to solve these problems raise other problems of compatibility with private flyers and other parts of general aviation.

So my feeling is that while you could look at them as local problems with perhaps local fixes, that sooner or later they are going to spread throughout aviation.

Mr. WYDLER. But right now, at some of these airports, planes are landing or taking off about every minute. You can't really improve on that, can you? Are we going to be able to take off or land a plane every half a minute or 20 seconds or 10 seconds? How much further can we go in that connection? No matter how much you put into the problem of controlling the traffic, you really can't handle it much faster than that, can you?

Mr. ALEXANDER. I don't think we are prepared to agree with you. I think that——

Mr. WYDLER. You mean you really conceive that you might have a takeoff every 10 seconds?

Mr. ALEXANDER. I don't want to put numbers on it, and we recognize some but not all of the constraints on airport movement rate. But it wouldn't surprise me if doubling or perhaps tripling present rates turns out to be safely possible in the decade of the eighties.

Mr. WYDLER. You mean using the same number of runways you think it is possible to land aircraft 20 seconds apart?

Mr. ALEXANDER. No, I think that that is more difficult. I think it more likely that there would be closer spaced runways than we can now have so in the same amount of real estate you can have more simultaneous takeoffs and landings.

Mr. WYDLER. No matter how we theorize about it, no matter what kind of equipment we decide to build to get the planes in the proper order and bring them down quickly and safely without colliding with other aircraft—no matter how much we do in that regard, when the airplane lands, you must get it off the runway before you let the next plane come down as a matter of safety.

Mr. ALEXANDER. Supposing you could put independent runways a thousand feet apart.

Mr. WYDLER. I think they have done that too, haven't they?

Mr. ALEXANDER. Not for instrument conditions. For instrument conditions we run our independent runways 5,000 feet apart. If we could have runways operating a thousand feet apart safely with the spacing on any individual runway just the same as now, then we might achieve something like two or three or more times improvement over present rate for the same real estate.

Now of course there are lots of complicated questions in both the technical feasibility of doing this and in the general advisability of increasing air traffic, for example, to Kennedy by a factor of two or three while at the same time the average aircraft's passengers may increase by a factor of two or three. To handle this flow you would have to expand its passenger handling capacity by as much as a factor of 10.

Mr. WYDLER. That is true. Incredible problems are going to be created on the ground in handling the numbers of people that are being talked about.

It seems to me that the airports we have today couldn't possibly handle it. Kennedy as a practical matter today cannot. It has reached its limit, as far as I can see as a functioning airport. They have traffic jams where cars cannot move around the airport. To talk about doubling the number of people the airlines will bring in does not make sense. There may be a way of handling such large numbers of passengers, but I don't know what it is.

They are building large passenger terminals to process debarking passengers from one aircraft and embarking passengers on another plane. But how the people are going to get from the passenger terminal out to where they want to go in the city is going to be one of the amazing things of the age as far as I can see. There are days when the traffic stops on the airport property. They just can't move the cars. I don't know what the answer is.

I am trying to point out that all the designs to build a better system may not be of any importance because as a practical matter we may not be able to use it. In other words, I think there is a limit as to how many planes you can land and take off, no matter how great a system you might design and operate automatically, there are other problems that limit the number of aircraft that can be handled quite apart from the technical problems that you are going into.

Well, thank you, Mr. Chairman.

Mr. HECHLER. Thank you, Mr. Wydler.

Mr. Hunt?

Mr. HUNT. Thank you, Mr. Chairman.

Mr. Alexander, with previous witnesses I have been pursuing questions in this same vein with regard to airport construction and the transportation problems that will face us in the feeder situation.

I assume you are familiar with one of the latest studies that was completed and presented to the New Jersey delegation about 10 days ago on the projected jet port in New Jersey. Are you familiar with that?

Mr. ALEXANDER. No, sir, I am not. I have heard about it, but don't know it.

Mr. HUNT. We have had an exhaustive study made in the State of New Jersey for a projected airport, of prime importance to the eastern seaboard. This is one of the most critical questions now confronting air transportation and surface transportation.

There is a plan, a copy of which I am going to make available to Dr. Bain. What worries me is not only location, because, as you know, New Jersey is the most heavily populated State per square mile in the entire Union. We now have more than 925 people per square mile. It is not only a matter of locating the airport but how people are going to get to and from the airport.

We have studied seven locations in New Jersey and in New York. Of course we now know the one in north Jersey in Morris County is unrealistic in location because we compromise the entire north Jersey watershed as well as two of our major reservoirs, Round Top and Spruce Run, which we have just completed several years ago.

I realize your committee is in the embryo stages, but these are problems that are facing us.

The latest projection is that it be located in the Pine Barrens of south Jersey, in the immediate proximity of McGuire Air Force Base.

The plans would extend one runway of the McGuire Air Force Base to accommodate military and supersonic transports arriving there.

Now this plan, of course, is radical in design and includes five separate terminals connected by subways. There will be at least 10 runways—five sets of dual runways—that will permit the takeoff and landing of at least three, and perhaps four, planes simultaneously.

My question is: How can large numbers of people get to and from this airport or from other airports of similar design that must be located far away from metropolitan centers? Do they intend to solve this problem together with the complications of V/STOL operations and ground transportation insofar as automobiles are concerned?

What is the thinking on using rail transportation? Railroads at the present time are trying to divest themselves of passenger service by giving the poorest service the Nation has even seen. They have even taken off the dining car on the Congressional Limited. They are doing everything possible to have people believe that this is a lost cause. I don't believe this. I don't care how many planes you fly or how many you land; we have to get the people in and out of that airport.

The trucking concerns are here to stay. You can fly all the cargo you want into an airport, but you must get trucks in there to take it to the people. What is the thinking insofar as rapid transportation for the city of New York and the metropolitan area, if the airport should be located in the Pine Barrens of New Jersey? We know that population is moving toward Wilmington and Philadelphia, because there is no other place for housing.

These are the things that bother me.

I am thinking along the same lines as Mr. Wydler. What are they doing to provide rapid transit to and from the cities? Will it be by monorail, or by the present system of rail lines?

I can drive from here to New Jersey to where I live in less time than by air, considering the delays involved in landing at National Airport. I have abandoned the airlines in getting to and from my home for that reason.

Is any consideration being given to this knotty problem of how to get people in and out of airports?

Mr. Hechler. Mr. Alexander, now you can understand why I asked you how broad the scope of your committee was.

Mr. Alexander. Yes, sir.

Let me answer Mr. Hunt's question.

Mr. Hunt. I will say this for you, Mr. Alexander: That this plan that we saw was projected to 1985 with expansion to the year 2000. So the committee that did study this—and I urge you to get a copy of it from them—did project into the future and may save you considerable research on that line.

If you will contact Mr. Frelinghuysen, a Member of this House, I am quite sure he can furnish you with duplicate copies of the committee study. It may help you considerably in your field of endeavor.

Mr. Alexander. Thank you, Mr. Hunt.

I don't have an answer to your question. And it really is in general outside of our committee's purview.

However, one part of it, the problem of use of the shortrange aircraft, either STOL or V/STOL, or even conventional at high densities does pose a special air traffic control problem which we are going to pay attention to and hopefully integrate with the total air traffic control system.

Mr. HUNT. The Department of Transportation is likewise charged, Mr. Alexander, with ground transportation.

Mr. ALEXANDER. Yes, sir.

Mr. HUNT. This is another aspect that must be considered.

I know your problems are very complex, and I again say to you I compliment you and Mr. Boyd on getting this committee together.

I realize that you have just started on your study. But if at any time I can be of any assistance to you on prior explorations that we have made in this field—and believe me, if you have spent as long as I have, 8 years, on this jet airport problem in New Jersey, please call on me.

The present road structure is totally inadequate and we cannot use the same rail lines currently in operation by transferring passengers from here to there and hither and yon to expedite the movement. It will take you longer to get to the airport than it will to fly from here to California.

Mr. ALEXANDER. Yes, sir; I think we all are very concerned.

Mr. HUNT. I took the liberty of riding on the Paris to Avallon high-speed line. I don't know why we are waiting in this country to put in operation what has already been tried, tested, and found true on the Continent for the past 25 years.

Mr. HECHLER. Mr. Hunt, you have hit a very sympathetic note with the chairman, even though this isn't within the purview of Mr. Alexander's committee. We want to thank you again, Mr. Alexander and Dr. Goldmuntz, for appearing before the committee.

We wish you well in this very, very important work that your committee is doing, and your testimony has been helpful and we will look forward perhaps to hearing you after your final report is submitted.

Mr. ALEXANDER. Thank you, Mr. Chairman.

Mr. HECHLER. The committee will stand adjourned until Monday at 10 a.m.

(Whereupon, at 12:04 p.m., the committee was adjourned, to reconvene at 10 a.m., Monday, September 30, 1968.)

AERONAUTICAL RESEARCH AND DEVELOPMENT

MONDAY, SEPTEMBER 30, 1968

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Advanced Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. Hechler. The committee will be in order.

We open the second week of these hearings on the Nation's future needs for aeronautical research with testimony by the Secretary of Transportation, the Honorable Alan S. Boyd.

Mr. Secretary, the first time you appeared before this committee was 3 days after the establishment of the Department of Transportation in April of 1967. I guess the problems haven't gotten any easier since that time, have they?

Secretary Boyd. Mr. Chairman, they have gotten worse, because we are beginning to understand them now. [Laughter.]

Mr. Hechler. We appreciate very much your appearance before this committee, and if you have a prepared statement, you may proceed.

(The biography of Alan S. Boyd follows:)

Hon. Alan S. Boyd, Secretary, Department of Transportation

Alan Stephenson Boyd, first Secretary of the Department of Transportation, was sworn in by President Johnson on January 16, 1967.

A public official with extensive and varied experience in transportation, Secretary Boyd was nominated to head the Nation's twelfth Cabinet-level Department on November 6, 1966. His nomination was confirmed by the Senate on January 12, 1967.

Before becoming the Nation's newest cabinet member, Boyd served as Under Secretary of Commerce for Transportation. He was appointed to that post by President Johnson in 1965. As the Under Secretary, his priority assignment was to persuade industry and the Congress that the country needed a Department of Transportation.

His background combines law, flying, politics, government, and regulation of several forms of transportation. In announcing Secretary Boyd's appointment, President Johnson said:

"Mr. Boyd has broader experience in the field of transportation than any other individual that I have been able to observe within or without the Federal Government."

Boyd was born July 20, 1922, in Jacksonville, Florida. He was raised in the town of Macclenny, population 2,500, in a cotton and tobacco farming area of northern Florida.

After attending schools in Macclenny and Jacksonville, he entered the University of Florida at Gainesville in 1939.

Boyd left the university before graduation to begin aviation cadet training in the Army Air Corps in 1942. Assigned to the Troop Carrier Command, he flew C–47's during World War II, both in the United States and during a 19-month tour in the European Theater of Operations. In 1945, he was released from the active duty with the rank of Captain.

He returned home to complete his formal education under the GI Bill and received a law degree from the University of Virginia in 1948.

Following graduation, he returned to Florida and entered general law practice. In 1951, he was called back into service by the Air Force and was in uniform during the Korean War for two years, flying C–46's and C–119's. When he was released, he had more than 3,000 hours flying time and held the rank of Major. He holds the Air Medal, with three oak leaf clusters, and two Presidential Unit citations.

He resumed his Florida law practice in 1953 and, in 1954, received his first appointment to public office. Governor Leroy Collins asked him to chair a committee established to develop aviation in the State.

The next year, he was appointed general counsel of the Florida Turnpike Authority.

Later in 1955, he was appointed to the Florida Railroad and Public Utilities Commission. In 1956 he was elected to a full term on the Commission.

He was Chairman of the Railroad and Utilities Commission in 1959 when President Dwight D. Eisenhower appointed him to the Civil Aeronautics Board in Washington. President John F. Kennedy named him Chairman of the CAB in 1961 and appointed him to another six-year term in 1963.

In 1966, President Johnson appointed him Under Secretary of Commerce for Transportation.

For relaxation, the Secretary cooks, camps and plays golf.

He and his wife, Flavil, live in an apartment overlooking the Potomac River in suburban Arlington, Virginia. A son, Mark, is a recent graduate of Washington and Lee University.

STATEMENT OF HON. ALAN S. BOYD, SECRETARY, DEPARTMENT OF TRANSPORTATION

Secretary Boyd. Thank you, Mr. Chairman.

I welcome the opportunity to discuss with you the need for an expanded research and development effort in aviation.

Additional research and development is absolutely essential to the future of all modes of transportation. This research and development cannot be confined solely to "hardware." It is essential that we carefully examine the impact of transportation on other aspects of life. The Department has already begun some of this research and we hope to do more in the future.

Much of the research and development in the aviation safety field has been of an ad hoc or crisis nature. For too long a time, R. & D. in aviation safety was almost solely an Armed Forces effort—motivated by the generally short-range requirements of the military.

The tragic collision over the Grand Canyon in 1956 resulted in a sudden surge of development funds for air safety along with an even larger increase in funds for the procurement of air safety equipment and facilities.

A substantial portion of research and development that was undertaken with this new money was short range in scope. The public, through the Congress, demanded immediate action to help prevent other accidents like the Grand Canyon disaster.

The response of the scientific and engineering communities was laudable. The work done in the laboratories and test facilities of the country has substantially improved the safety factor in air travel, and made it possible to expand airways system capacity.

But this kind of applied research alone will not produce the best results over a longer period of time. There is a great necessity for what the scientists call basic research in aviation—to expand the capacity of our air space to meet air transportation demand and at the same time maintain or improve our national levels of air safety. I believe that some of our scientists and engineers ought to be put to work, without any specific goals before them, to investigate the widest possible range of solutions to the variety of present and future problems in aviation.

Debate over the adequacy and safety of our airways system will be better informed, and future decisions will be more soundly based only if the results of current and future research and development efforts are adequate to our needs.

Our concern in aviation research and development extends beyond questions of air space capacity and safety. Under the new noise abatement law we will be expected to reduce the impact of modern aircraft noise on communities. There has been substantial research in this field. There will have to be a great deal more before we can produce significant results.

Probably the most productive of this research is presently underway at NASA. This work and other research will form the basis for what I anticipate will be ever-increasing performance standards issued by the Federal Government. But engine design and construction may still provide only a partial solution. We believe that fruitful efforts can also be undertaken in building construction and land use, even though such action cannot be described as research.

There is little question that a full realization of the potential of supersonic air travel must be preceded by additional research in sonic boom. Conceivably the solution to this problem may rest in a field of technology which has not yet been explored. There have been some probes that may eventually assist us in finding a solution to this problem. We are doing some research but more will have to be undertaken.

As we enter the last third of this century, it is clear that congestion of both the airports and airways threatens the mobility that we expect to achieve through the air. There are many possible solutions to this problem. VTOL and STOL flights may offer a major form of relief. I am convinced that far less research is being done than should be done.

The bulk of research on this type of craft to date has been done by Department of Defense or non-U.S. firms. Much more remains to be done. Additional research needs to be done on the noise problems created by such craft, on the best manner of moving them through the air, and on the facilities on which they will land and take off.

We believe that the Department of Transportation is well suited to conduct the intermodal research that will be necessary to fully solve the congestion problem. We need to explore what kind of ground access is best suited to relieve the congestion that now hampers our getting to and from the airport. We need additional research regarding terminal facilities that can best handle future air passenger volume.

These comments of mine have been intended to be only illustrative of some of the major problems we need to solve if we are to insure that we have an efficient air transportation segment of a national transportation system. The solutions will depend on the soundness and adequacy of our research effort. I hope that the work of this committee will advance that effort.

I have limited my remarks to a general discussion of some of the major problems requiring additional research and development. You have already heard more specific comment from the Acting FAA Administrator, Mr. Thomas, and from the Chairman of the ATC Advisory Committee, Mr. Ben Alexander. You have also heard from Maj. Gen. J. C. Maxwell on the current status of the SST. Following my remarks you will hear even more detailed discussion on aviation research and development needs from our Assistant Secretary for Research and Technology, Mr. Frank Lehan. I shall, nevertheless, be happy to answer whatever questions you might have and I thank you again for this opportunity to be with you.

Mr. HECHLER. Thank you very much, Mr. Secretary.

The roll-out of the Boeing 747 today will certainly accentuate the airport crisis which the Nation faces. Has any special research or anticipation been carried out by the Department of Transportation in order to solve the future problems in the airport crisis which this tremendous plane will cause?

Secretary BOYD. Nothing related expressly to the 747, Mr. Chairman.

In one sense, the 747 is going to be a benefit rather than liability in terms of congestion. We anticipate that when the 747's go into operation, that at our busiest airports, in the New York area, for example, there will be a plateau of the aircraft traffic volume for maybe as long as 6 months. And to that extent, it will be a benefit.

The airlines, I am advised, have done quite a bit of work on this, as has Boeing, trying to deal primarily with the ground congestion problem. But our work on air traffic control as such is not related to particular types of aircraft except to the extent that consideration is being given, as it must, to what happens due to the mix of aircraft in a particular landing pattern.

Mr. HECHLER. I was particularly interested in your remarks on page 3 concerning the development of VTOL and STOL, since this committee has placed additional funds into NASA research to improve these planes.

There are many people who are puzzled as to why you should need billions of dollars for additional airports if STOL planes are going to come into operational use within the next few years. I just wonder what the official position of the Department of Transportation is concerning the specific economic use of STOL planes, both in the way that they are used and in their relation to the development of airports in the future.

Secretary BOYD. The Department does not, to my knowledge, have an official position on this. I think that our collective intuition, if you will, comes down about like this:

Assuming the development at a reasonable pace of VTOL/STOL type aircraft, we would anticipate that as these are developed, they will take more and more of the shorthaul fixed-wing air traffic and they will operate not only between airports, but between airports and city centers.

"City center" is not really a good phrase. To take a local example, I would visualize that STOL aircraft or VTOL ultimately would be operating to and from locations such as one near the Capitol, one probably somewhere in the Bethesda-Chevy Chase area, possibly one somewhere in the Georgetown area and one in the Arlington area, possibly somewhere along Glebe Road. To permit this, however, we envision that these aircraft would have to be considerably quieter.

So it would be a completely different type of operation in one sense, a dispersal-distribution operation, but it would operate between airports.

Now certainly if some of these compound machines which have been visualized and on which considerable work has been done are able to get developed, I would expect them to take the bulk of the traffic moving between Washington, Baltimore, Philadelphia, and New York.

Mr. HECHLER. Is anyone carrying on any advanced research as to how STOL planes will be utilized in the 1980's? For example, the development of satellite airports as has been talked about around Los Angeles and is actually in operation to some extent in Minneapolis-St. Paul area?

Secretary BOYD. No; no research of that nature to my knowledge. Now the Minneapolis-St. Paul airport development is an example of what one might call hardheaded vision on the part of local government, the State of Minnesota and the civic officials in the Minneapolis-St. Paul area, with the full support of the FAA. But this was a local operation. And to a very large extent, the seven-county study in the Los Angeles area is a local operation. And this, of course, is one of the—I guess one might say the philosophical problems with which we are concerned, and that is, Who has what responsibility for the total system?

As it turns out, nobody has full responsibility nor full control for the total system. We have Federal control of the airways and of the control towers. We have local control of the terminals. And we have State control in effect of ground access, assuming the ground access is essentially the highway in most places. And then, of course, you have the airlines, the private sector operating the moving units plus general aviation. So you have a mix of different interests and different elements of control within each element of the system.

Mr. HECHLER. Doesn't this disturb you, Mr. Secretary, in term of the crises that are going to be accentuated in the future? Aren't we going to need some national leadership in order to develop an intelligent system in the light of the fact that we have all these competing local interests?

Secretary BOYD. I would say, Mr. Chairman, that certainly the Federal Government, to my mind, has a major role in research, development, and probably demonstration of the vehicle. I think it has the complete role in terms of air traffic control. I am not sure that I would go beyond that.

Now from a standpoint of problem solving, certainly it would perhaps be more efficient to have a complete authoritarian establishment, but that is not our system, and as someone who has to deal with a problem, I don't think that it would be preferable to have a dictatorship. I don't believe the system we have is so weak or frail that we ought to do it that way. I think there are a lot of drawbacks to doing it that way.

Mr. HECHLER. You referred to hardheaded local vision as exhibited in two areas, Minneapolis-St. Paul and Los Angeles. I think the problem is how do you instill more of that in local areas where the very nature and structure is to inhibit against the development of the kind of hardheaded local vision which will solve these problems which are national in nature. Isn't there something the Department of Transportation could do to at least set a standard?

One of the individuals testifying before this committee said that both the Department of Transportation and FAA perhaps ought to issue more factually researched information for the benefit of the local communities.

Secretary BOYD. Oh, I think we can do a great deal more in an educational role and that we should. But ultimately it comes down, it seems to me, to the question of how the local community values various activities. I think the great example of this is the so-called search for a fourth jetport in New York.

Mr. HECHLER. Yes.

Secretary BOYD. There has been considerable expression of view that the Federal Government ought to go in and say, "Well, you people can't decide what you want to do, but big brother knows what's best for you so we're going to build you an airport here." And it seems to me that if the citizens of the community—and I don't use that in a political jurisdictional sense, but the greater New York area—don't want a fourth New York airport, it would be a little presumptuous of the Federal Government to say, "We know what's best for you, so we're going to build an airport whether you want it or not."

Mr. HECHLER. What I am getting at here is I think the large majority of research that has been done has been of a technical or technological nature, and the nature of the problem is governmental and financial as well as technical and technological. And this is why I am raising the question whether the Department of Transportation should interest itself in doing a different type of research.

Secretary BOYD. Well, I think that we should expand our educational role. I am very hopeful that to the extent there is a future Federal aid-to-airports program that we will use Federal aid for participation in the construction of STOL ports and heliports. I think that would be a step in the right direction.

I think, too, that as we improve through research on the technical side, we can do a better job pointing out to the communities the economic benefits of having landing areas available. But we have to get an economic machine in the first place, because we cannot make a case today. All we can do is talk on the basis of hope. And that is a pretty slim reed at the moment.

Also I think that the Federal Government has to do a tremendous amount of research, and it is going to be very expensive in the area of noise. I really think that noise is our critical problem. I am absolutely confident that on the technical side, rigid-rotor compound helicopters and machines of that nature, larger STOL craft, better engine performance, better thrust-to-weight ratios, for example, can be accomplished. I don't think any of that is beyond expectations. But the noise is going to be the greatest problem, in my own personal conviction. And this is going to cost an awful lot of money, and it is going to take time. Even though we are able to obtain substantial funds from the Congress, we cannot buy quiet overnight.

Mr. HECHLER. You partially answered my next question with the last phrase of your last sentence. But is there anything further that we could do in noise control if we had more substantial funds available?

Secretary BOYD. I will have to refer that question to Frank Lehan, here, as I am not competent to go into that.

Mr. HECHLER. We are going to hear from Assistant Secretary Lehan later, and perhaps we can save that question till later.

Secretary BOYD. Yes.

Mr. HECHLER. Are you satisfied generally with the administrative responsibilities that have been conferred on the Department of Transportation and research responsibilities that are now available to NASA for noise control?

Secretary BOYD. I think the two organizations certainly have the necessary legal authority to conduct the kinds of research we are talking about. I also think that we undoubtedly will need the assistance, and expect to get it, of the Department of Defense activities and the National Academy of Sciences, and probably others.

I wouldn't want to limit this to just our two agencies, because I think there are other agencies within the Government as well as outside public or semipublic concerns who can make contributions in this area.

But I think to answer you specifically, the Department has the authority it needs in the existing law to conduct the research and to participate with NASA in various research activities conducted by NASA.

Mr. HECHLER. You mentioned on page 2 that scientists and engineers ought to be put to work without any specific goals before them. I wonder if you would like to expand on that a little bit since there are so many specific problems that we know are going to come up in the next 10 or 15 years.

Secretary BOYD. I am talking basically about the difference between short-range research to try to solve a problem which we see and basic research just to scan the whole field and see what might be done through possibly radical changes in our whole philosophy of regulation, air traffic control, power sources, and things of that nature.

Mr. HECHLER. Yes.

Secretary BOYD. I think we have skimped on that basic research far more than we should have.

Mr. HECHLER. I agree, Mr. Secretary.

I yield to Mr. Pelly.

Mr. PELLY. Thank you, Mr. Chairman.

Secretary Boyd, you said, and I certainly agree with you, in answer to one of Mr. Hechler's questions that the Federal Government should play the major role in traffic control and research and regulation.

I think you have already indicated that the level of funding is not adequate. Is that your opinion?

Secretary Boyd. Yes, sir.

Mr. Pelly. The purpose of these hearings now, is to try to ascertain whether the Congress is doing enough. Now I think that is a forthright statement. That is what we want to hear.

Mr. Hechler referred to the Boeing 747. Now it is my understanding that the Boeing 747 will give special attention to containerization as well as passengers. In other words, if there aren't sufficient passengers to fill the plane, they will have containers that can be automatically loaded, interlocked with each other, into the plane. This seems to be a field where much can be done in the way of research.

Secretary Boyd. There is no doubt in my mind that containerization is the wave of the future insofar as airfreight is concerned. And I have long thought that a mixed configuration aircraft on some routes was a very good idea.

It has been extremely difficult in the past to operate with both cargo and passengers. But in recent models, both the Boeing and Douglas aircraft, the designation "QC," for "quick change," has been developed. And this originally contemplated, as I understand it, a complete shift where the plane would operate, for example, during the day with passengers and during the night with cargo.

It should be possible to have sort of a sliding scale operation when you know how many passengers you have, if there is space for three or four containers they ought to be able to put them on. I think it is certainly the most economic approach to utilization of the aircraft one could develop.

Mr. Pelly. Is the Federal Government doing any research on containerization?

Secretary Boyd. I have no knowledge of anything we are doing in the Federal Government in the way of technical research on containerization. We are doing a great deal in the area of regulation, trying to simplify the movement of goods by container, particularly internationally, but not limited to that.

Mr. Pelly. One of the great features of the Department of Transportation is the tie between container transportation in trucks, airlines and rail. I presume that that is another field where more study should be given.

Secretary Boyd. Well, we have been working on a number of different areas, for example, trying to get standards for attachments. We have been working trying to develop standards for size of containers so that they are truly intermodal.

Mr. Pelly. I trust you don't have the same problems that the steamship companies have with the sizes of various containers.

Secretary Boyd. Yes. In fact, that is what started the whole effort, because of the maritime problem where they've got 35-foot, 27-foot, 25-foot, 20-foot containers, and then some 10-foot units.

I don't believe that we should have a single standard any more than I think a supermarket should be required to sell only No. 2 size cans of peas. But I think we should have a range of standards which hopefully would mesh.

Mr. Pelly. Would they mesh as far as railroads, buses, trucks, and airlines go?

Secretary Boyd. Yes, sir. Well, I don't think buses——

Mr. Pelly. I used that word. I meant to use the word "truck."

Secretary Boyd. Yes, sir.

Mr. Pelly. Are we taking advantage of the research that the Defense Department is doing in the whole transportation field? Is there a fallout to the civilian sector?

Secretary Boyd. I would say the bulk of the research on vertical lift has come from the Department of Defense. A substantial part of the research on supersonic flight has come from the Department of Defense.

The answer is yes, I believe that we are in full communication with the Department of Defense, both our Department of Transportation and NASA.

Mr. Pelly. It is a two-way street, in other words?

Secretary Boyd. Yes.

Mr. Pelly. The military gets the advantage of the ideas that are developed in NASA and the Department of Transportation and vice versa?

Secretary Boyd. Yes, sir.

Mr. Pelly. That is good to hear.

Thank you, Mr. Chairman.

Mr. Hechler. Mr. Secretary, we had quite a go round last year on noise. The President's Science Adviser, Dr. Hornig, issued some general instructions in this area. And I think the developments administratively have been very good as a result of this.

What disturbs me is that in the other areas of research aside from noise, I question whether there has been sufficient leadership exercised in order to pull together this research and make sure that it is going in the proper direction. For example, in the Senate committee hearings last year, Senator Smith asked you the question whether it was your responsibility to coordinate R. & D. throughout the Government, and you responded "In the area of transportation research, yes."

Now, NASA has been carrying on research in aeronautics for some years in various areas. And in the year-and-a-half since the Department of Transportation has been active, has the Department of Transportation given NASA any particular direction as to what they ought to emphasize in aeronautical research, and what they ought to develop in that area?

Secretary Boyd. No. There has been a very close liaison between the Federal Aviation Administration and NASA covering various areas which the FAA felt should be looked into. And I think NASA has been most cooperative in that area, as it has in all others in our relations.

Insofar as the Department itself is concerned, we have not done this. We are now prepared to do it. One of the reasons we haven't done it—in fact, the sole reason is that we did not obtain the services of an Assistant Secretary for Research and Technology until the middle of December, and to be perfectly honest about it, none of the rest of us knew what we were talking about in this area. NASA offered its assistance the day we were set up, but it was one of those things. Jim Webb introduced me to a whole bunch of very great engineers and once we got through saying "hello," I couldn't understand them. [Laughter.]

We just had to wait until we had someone who was technically competent. And Frank Lehan here has worked out an agreement with NASA which has been executed, through an exchange of letters and several meetings. That is the start of the effort which you mentioned a moment ago.

Mr. HECHLER. In the area of noise, after a great public flap and very keen interest at the presidential level and also legislation enacted by Congress, apparently this area is getting pretty well coordinated.

Do you think there is any additional legislation that is needed in the other areas of research aside from noise in order to give firmer support or additional legal authority to the Department of Transportation?

Secretary BOYD. No, I don't think so, Mr. Chairman. I think we have all of the authority we need; that what we need now is money and people, and time.

Mr. HECHLER. Let's start with the money. What areas would you think need additional financial support?

Secretary BOYD. Well, noise, unquestionably.

Mr. HECHLER. Yes.

Secretary BOYD. Some of the items that I mentioned in connection with vertical lift devices: compound helicopters, improved performance of STOL aircraft, particularly in the engine area. Additional research on steeper descents of aircraft into the runway for landing. Research on the question of how do you decrease the spacing between landing aircraft to get better utilization of the runway and maintain your safety level in the process.

We need increased research on—or demonstration, I guess—I am not sure that I understand where the line breaks, although Frank gave me a glossary of terms the other day, but I forgot to bring it—on the so-called blind landing activities. We need to know a great deal more about the weather and how it affects flying. We need to know a great deal more about the interaction between the pilot and the air traffic control system.

These are just a few that I can think of offhand.

Mr. HECHLER. What about research on airports themselves. Or is this mainly an action problem which grows out of the recommendation that you make?

Secretary BOYD. Well, I don't think there is a great need for research on airport design as such. I think we have a pretty good concept of airport design today.

I don't mean to imply that we know everything there is to know about airports, and obviously, as we get different types of aircraft the design requirements will change. But I don't think that airport design is a basic problem in today's operation of the air system.

Mr. HECHLER. One final question, Mr. Secretary. Have you been able to make any progress in the Department of Transportation in coordinating air travel with other forms of transportation?

Secretary BOYD. Yes, sir.

Mr. HECHLER. Is there any need for additional research in that area?

Secretary BOYD. Oh, we have a need for—we have a great need for additional research. As everybody who travels knows, we've got tremendous problems in the relationship between access to the airport and air travel.

Mr. HECHLER. Mr. Pelly and I happen to be very strong advocates of the passenger train.

Mr. PELLY. We are breathing down the neck of the ICC and looking with great interest into their study on the need for passenger trains.

Secretary BOYD. Of course we have this Northeast Corridor demonstration, and everything is ready to go on that demonstration except the trains. [Laughter.]

But we remain optimistic that we will get the trains running in the fairly near future.

There we thought we were just seeking some fine adjustments to improve existing equipment, and we found out that in fact, we had required an advance in the state of the art which few, if anyone, associated with the project realized at the time. So we got a lot of problems which we are gradually working our way through.

And it has been a disappointment that we haven't gotten trains running before now, but we will.

Mr. HECHLER. Are there any other aspects of the use of the passenger train in the transportation system as they relate to airports that you think merit additional research?

Secretary BOYD. Yes, but I think this is more in the economic study area than in technical research. There are a number of major airports in this country served by railroads, and I would like to see some work done in utilizing the passenger service on the railroad as a means of access to the airports.

Mr. HECHLER. You passed this phrase "economic study" off as though that is something the Department of Transportation really oughtn't get into.

Secretary BOYD. Oh, no.

Mr. HECHLER. I see.

Secretary BOYD. No. I was just trying to distinguish that from technical research.

Mr. HECHLER. Yes, sir.

Secretary BOYD. No, we are deeply involved. In fact, our greatest efforts are in this whole area of economic studies, or economic research, whatever you want to call it.

Mr. PELLY. I think the rapid transit developments in the Chicago area indicate that there are ways and means of providing transportation to people from airfields into the cities on an economical basis. The Chicago & North Western has automated their rapid transit system. They pay taxes and make a profit. It is possible to do it.

Secretary BOYD. It is possible, but it is not possible to generalize.

Mr. PELLY. I agree.

Secretary BOYD. Now they are not, to my knowledge, serving airports at the present time. The city is extending its rapid transit line out the Kennedy Expressway. It is going to be about 4 miles short of the airport, of O'Hare. But I think ultimately it will be extended to the airport as they get the money.

Mr. PELLY. There again you have two competing systems; one of them is able to serve a need where the other one couldn't do it. I know both benefit from the results of automation, research, and economics.

Secretary Boyd. No question about it. And they have a very healthy attitude in Chicago. The transit authority and the Chicago-North Western as well as the Illinois Central work together cooperatively instead of trying to shoot each other down.

Now, later this year the extension of the subway in Cleveland to the airport will be opened and all of us interested in transportation are going to be watching that operation with a great deal of interest and hope.

Mr. Pelly. I think this is very encouraging, and I want to say, Mr. Chairman, I think the Secretary has made a very valuable contribution to the understanding that our committee needs to have in order to have jurisdiction over some of the problems we have been facing. I want to compliment him.

Secretary Boyd. Thank you, sir.

Mr. Hechler. I certainly share that.

Mr. Gerardi, did you have any questions?

Mr. Gerardi. I have one question.

It appears that we are in some sort of a period of transition insofar as getting the type of fallout from military aeronautical R. & D. today as compared with what we used to get, 5 or 10 years ago. Do you have any idea as to how we could best stimulate increasing involvement by the aerospace industry in meeting our aeronautical R. & D. fund requirements or do you foresee the type of risk-sharing arrangement you had under SST?

Secretary Boyd. I doubt that we will utilize the pattern of the SST as a normal approach. I would think that is probably, as I see it today, a sort of outer limit. And my hope is that we can develop some sort of incentive so that the private industry will participate in the research efforts on a cooperative basis. And we have been quite successful in our own efforts in the Department so far in getting industry to support our research efforts and demonstration efforts on a basis of several dollars to one of the Government's.

Now whether we can make a pattern out of this, I don't know. I would hope so.

Mr. Pelly. Have you ever thought of accelerated depreciation and write-offs as an incentive to private industry to step up their effort?

Secretary Boyd. Not seriously. This is something that has been considered in various parts of the Government, and it is an area that we approach in a very gingerly fashion, particularly in view of the current fiscal situation.

Mr. Pelly. The Ways and Means Committee has announced that it will study the whole tax structure next year, and it seems to me that this could be one aspect of the problem to be considered.

Secretary Boyd. That is certainly a possibility. Certainly.

Mr. Hechler. Mr. Hines, do you have a question?

Mr. Hines. Yes, sir.

Mr. Secretary, with the advent of the large jet, the Boeing 747, we find ourselves confronted with quite a large number of problems. The decision to use it was not made by the Government. Is that correct?

Secretary Boyd. 747?

Mr. Hines. Yes.

Secretary Boyd. It burst on our consciousness as a surprise. We had nothing to do with it.

Mr. HINES. Well, to get right to the point, then, of my question: In the future, when a new aircraft is to be inserted into our air traffic system, do you think that the Government should play a larger role in the decision to build it and to use it?

Secretary BOYD. I think I would have to ask you to define what you mean by "larger role," Mr. Hines.

The whole philosophy of air traffic control up to the present has been that any airplane that can receive certification from the FAA is free to operate in the system. Up to the present, nothing has been developed that would strain the resources of the system in and of itself. The strain has come from volume, not from types of aircraft.

We have, of course, participated very heavily in the SST development. I would guess, however, that there would be less need to participate in the development of succeeding generations of supersonic transports. I think we would need to be deeply involved in the development of a hypersonic transport, because that would obviously create great changes in the requirements for air traffic control.

Mr. HINES. Well, you have been right to the point of my question, which is we shouldn't let future generations of aircraft have such a traumatic effect immediately without planning for those effects.

Secretary BOYD. Quite agreed.

Mr. HINES. This is the point.

Secretary BOYD. Yes, sir; quite agreed.

(Additional information for the record submitted by Secretary Boyd.)

EXCERPTS FROM REMARKS DELIVERED BY SECRETARY OF TRANSPORTATION, ALAN S. BOYD, BEFORE THE SOCIETY OF EXPERIMENTAL TEST PILOTS, LOS ANGELES, CALIF., SEPTEMBER 26, 1968.

We believe we have made a good start in the past year and a half on the job that President Johnson and the 89th Congress asked us to do: To try to pull together the various subsystems of American transportation into a better coordinated, total system; to make it safer to travel, easier to ship cargo, and less frustrating to get from here to there.

Let me be absolutely clear about one thing. We have made no more than a start.

Our system of transportation is, by any standard, mammoth. It represents an investment of some $500 billion. It meets the needs, with varying degrees of effectiveness, of 200 million people. It accounts for one of every six dollars in the economy; provides jobs for 9 million people; and unites a continent.

Yet the increasing demands on this system already strain its capacity in some areas and the growth to come—compounded by concentration of that growth—could bring it near collapse. Take the year 1975 as a yardstick of growth—a good year because it is so close you can almost reach out and touch it.

By then, the number of private aircraft will have nearly doubled. Commercial air travel will have tripled. Automobile traffic will be up by 40 percent. Railroads, which now haul 750-billion ton miles a year, will be hauling one-trillion ton miles. Trucks, now carrying 400-million ton miles, will carry 50 percent more. In fact, if the demand for transportation continues to match America's economic growth, we will have to double in less than two decades the capacity of a system that has taken the lifetime of a nation to build.

President Johnson and the 89th Congress read the danger signals of increased delay, congestion and cost two years ago. They called for more intelligent planning, more research and development and more prudent investment of transportation funds. And they created the Department of Transportation and gave it responsibility for leading the effort to make this country's transportation system conform to the needs of the people rather than forcing the people to continue to conform to the system.

To do this has required starting virtually from scratch on the most complicated analysis of a system ever undertaken by anyone. We are involved in jobs never before attempted—trying to measure not only the efficiency of the railroads, for example, but to relate them to air and to set some criteria for future investment of transportation funds.

We are trying to establish a perspective that cuts across the various modes; the kind of perspective that says, for example: if we really want to reduce the hazards in experimental flying we should concentrate on the most dangerous phase of your work—the drive to the airport.

The growth in transportation demand is exerting great pressures today on aviation.

This country's airlines carried 70 million passengers in 1963 and will carry 150 million this year. Five years ago, everyone predicted a 28 percent growth for the period. It was actually 114 percent.

The number of scheduled passengers is doubling every five years, and by 1977 one million people will board commercial airliners every day. General aviation will grow even faster—from 100,000 aircraft today to an estimated 150,000 by 1973. Traffic control centers, which last year handled 15 million flights, will have to manage 30 million within five years.

This rate of growth severely challenges the Federal Government as operator of the airway system, and state and local governments as operators of the airports.

Clearly, we need more airports, better traffic control and more efficient terminals, and we need them yesterday.

In the next few years we must achieve better integration of surface and air travel.

We must improve the control of traffic and the precision of navigation. And this will mean computer control of landings and takeoffs at high-density airports; automatic detection and avoidance devices; and advance processing of flight plans in digital form.

But I think parts of the air transportation system will need radical redesign to take into account diminishing air and ground space and the increasing psychological and economic value of time in our industrial society.

And one element of this redesign will certainly be STOL and VTOL aircraft. Straight thinking in a few years may not be nearly as important as thinking straight up.

Nearly 80 percent of all commercial flights are made between cities less than 500 miles apart. This is not really an efficient distance for the use of many of today's jetliners; not to speak of tomorrow's so-called "elephant" planes. What we need are mid-range aircraft that can land where the action is and eliminate the long trips between the runway and the business district.

Today's 25-passenger helicopters—the ones used in Los Angeles and New York City and San Francisco—have proven a real need for this kind of service, even with relatively high seat mile costs and without precision landing aids at the stops away from airports.

There are also a few 10-20 place STOL craft available. These vehicles—such as the DeHavilland Otter, the Dornier Skyservant and the Helio Courier are characterized by low wing loading and high lift and drag devices. They have been employed for years by the military; in the bush; by entrepreneurs; and for special industrial purposes. Recently, high density passenger configurations have been marketed. The Skyservant is now flying a run between Dulles, National and Friendship Airports in the Washington area.

But what can we expect beyond STOL air cabs and the helicopters which have been hauling people commercially since the early 50s?

The question is complex. Other than the helicopter, there is no VTOL aircraft to build systems around. We only have a check list of interesting possibilities to be developed or tested.

But working with this check list government and industry are already starting to block out the components of a VTOL aviation system. Various aircraft concepts are being developed by industry, the military and NASA.

Eastern Air Lines and McDonnell Douglas, with the help of local governments and the FAA, are experimenting with a STOL aircraft, the Breguet 941, in the Northeast Corridor to help work out STOL and VTOL operational problems.

The CAB is initiating a hearing on the usefulness of V/STOL in the Northeast Corridor and the result may be an authorized route in this heavily traveled region.

The FAA is studying the air traffic control problems and navaids required for these aircraft. Industry and FAA are developing requirements for V/STOL airports. Local governments are trying to find good sites for V/STOL ports.

As these systems components are clarified, we will be able to see where action by the Department of Transportation can expedite one piece of the system or demonstrate the feasibility of complete systems.

The industry has had long experience with the helicopter, which has followed a steady curve of improvements. Adequate operational concepts and design standards, including FAA certification requirements, have been developed, so that we can now move toward more sophisticated V/STOL aircraft.

The designer of STOLs has now the proposed civil certification criteria for these aircraft. We hope to be able to define certification criteria for VTOLs in the near future. What they will look like; how fast they will travel; how many people they will carry; all of these are questions that only time, design and testing can answer. All we can say for such at this point is that it appears that STOLs and VTOLs will utilize similar airspace and operating procedures up to the point of touchdown.

One thing we do know—the popular concept of VTOL aircraft wheeling in the skyscraper canyons of our cities, maneuvering like flying bicycles, is valid mostly for comic books. True, these aircraft are more maneuverable than conventional aircraft and will approach at slower speeds, but they probably will operate into small airports or pads with clearly prescribed approach zones free of obstacles. Glide slopes of 6° to 9° will be utilized even for VTOLs that touch down vertically from a few feet above the pad.

The most serious problem, inherent in any technology on the horizon, is noise. The whole point of STOL/VTOL is to get in close for convenience. Yet the roar of jets and blades might very well be unacceptable in many downtown areas, where there is enough noise already.

Maximum noise tolerances will have to be established; VTOLS will have to operate in such a way as to minimize the nuisance; and the miniports themselves will have to be situated with great care—perhaps as aquadromes on bodies of water adjacent to business districts where feasible.

The full potential of vertical landing and take-off will not be realized until the total environment is acknowledged in system planning. If ignored, the noise factor could stunt the growth of an infant service that has already had a long gestation and a difficult delivery.

Finally, the price of the ticket will have to be acceptable if VTOLS are to be more than a silk stocking service. It costs up to 25 cents per seat-mile to operate transport helicopters but this is an intracity taxi operation. Studies indicate that an intracity VTOL bus service may cost only 3 to 4 cents per seat-mile. Such costs would permit fares to drop low enough to attract a large percentage of medium distance passengers.

Our interest in STOLS and VTOLS stems from one of our basic responsibilities under the law that created the Department. It directs us to promote technological development with the objective of improving the nation's transportation system. During the past 16 months, our work has defined a number of gaps in the existing transportation complex. One of these is in what very generally can be called the corridor situation.

What we find in the U.S. is a trend to urbanization—but *not* the sort of urbanization that, in years past, congregated people in densely populated central cities. The new form of urban development is characterized by a wide dispersal of population within vast metropolitan regions. This is not simply a process of suburbanization. It is a process that leads to a pattern of many medium-sized communities, scattered about a large geographical area. The most famous of these is the Northeast Corridor, stretching from Richmond to Boston. Another is the band stretching from Chicago-Milwaukee east to Detroit, Cleveland, Pittsburgh and Buffalo. Still another is along the West Coast. And a fourth, within special properties, is the Southeast, with its center at Atlanta.

In all of these areas there is intense urbanization, but the most rapidly growing centers of population and industrial development are not the big cities, they are the medium cities.

Translate these trends into transportation demands and it is apparent that we need better links among these dispersed corridor cities. The automobile has a role, of course, but it has limitations for trips of more than 150 miles. The present fleet of aircraft also has its advantages, but it does other jobs better than serving points that may be only 150 to 300 miles apart. Trains may have a much larger role to play than is commonly recognized, but their fixed roadbed inhibits their utility.

There, then, is where the STOL and VTOL aircraft may have a vital part to play in our future national transportation system. As I have indicated here today, the STOL is flexible and efficient; it can link up the scattered points that make up the sort of metropolitan region which is likely to be the distinguishing feature of the U.S. in the next decade. Recognizing this, we are prepared to do our part in working with industry to build STOL and VTOL in our transportation system.

The VTOL problem is one of the problems that come with growth and progress. They are actually opportunities in a society that is rapidly moving beyond affluence.

The story of VTOL and of aviation in general, to which your efforts have contributed so much, is paralleled by the progress we have made as a whole in this country during the last seven years.

Naturally, dramatic change can produce uncertainty, disorder, and even resentment. Some people cry and caterwaul for the good old days. They demand that the world be stopped so they can get off.

They forget the historic lesson that a society without growth and diversity and dissent is either a sick society or a dead one, and certainly not worth living in. They need moral courage as dauntless as the physical courage of a man who steps into an untested airplane and lifts it toward the sky with confidence in himself and his destiny.

Mr. HECHLER. Mr. Secretary, your testimony this morning has been extremely helpful. We appreciate your coming. And Assistant Secretary Lehan will be testifying next, and the committee realizes that you have an extremely busy schedule. We will excuse you if you care to leave.

Secretary BOYD. Thank you. I will go try the air traffic control system now.

Thank you, gentlemen.

(Questions, with answers, submitted to Secretary Boyd by the subcommittee follow:)

QUESTIONS SUBMITTED TO ALAN S. BOYD BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. What are your current thoughts of presenting to Congress a total package for aeronautical R&D efforts within the Executive Departments, regardless of the separate justifications and submissions performed by each participating agency? Would not this permit the Congress to more effectively review the needs of the Nation on an overall basis?

Answer 1. Such a unified package is perhaps desirable from a conceptual standpoint, however, the practicality of such a package would undoubtedly reduce the visibility of the programs on which each committee or subcommittee of Congress is structured to review and to make recommendations. It would appear to be more advisable to ensure that adequate detailed coordination mechanisms are established and fully utilized by the personnel in the Executive most intimately involved in the programs. The present coordination process, for example, utilized by FAA and NASA, goes into considerably greater detail than time would permit in your authorization hearings. Furthermore, the project coordination and review of all projects and tasks down to the smallest scale provides an excellent means for the personnel involved in project direction to garner ideas developed in the other agencies that may enhance the value of their planned work.

The present arrangements of testimony by representatives of various agencies, such as at these hearings, provides an overview of needs and brief descriptions of the coordination of research and development activities. Continued emphasis must be placed on the maintenance of meaningful interagency coordination and communications. This latter point is clearly the responsibility of both the Legislative and Executive branches.

Question 2. What programs or measures do you contemplate for carrying out "proof of concept" programs so that hardware can be developed from basic research results without the need for specific mission requirements or commercial orders for final products?

Answer 2. First, the meaning of "proof of concept" as the Department of Transportation sees it must be stated. Proof of concept is a technology demonstration phase in order that the feasibility of certain research concepts may be explored in a real-world situation as opposed to the laboratory or wind tunnel environment in which the concepts were initially developed. If the government is to be the user of the product, the term "proof of concept" is not generally used to describe this work, but rather terms such as development, advanced development or preprototype engineering are used.

The justification for government sponsored proof of concept technology demonstration projects lies in the need to enable industry (the user) to envision the applicability of research results in operation, to perform such preliminary development work as is necessary to reduce the final industry sponsored development risk, and to permit reliable determinations of the acceptability of the concept both technically and economically should it reach the operational stage under industry cognizance. Proof of concept is the measure needed when mission requirements are not strong enough or when the risks are too great to force basic research results directly into hardware.

From another point of view, proof of concept demonstrations may well point the way to new mission capabilities which are in advance of mission requirements—as recognized by the user.

It is too early to project just what aeronautical projects of the proof of concept type will be directed or undertaken by the Department of Transportation. As was pointed out in the testimony, however, a great deal more work will be needed in V/STOL, in all weather landing systems, in noise, in collision avoidance, and in longer range solutions to terminal congestion; these are a few areas which may prompt proof of concept projects.

Question 3. What role does your agency play in the evaluation of the tradeoffs between increased payloads, improved safety, decreased noise and improved handling qualities? What is the priority of emphasis between these factors in making any evaluations?

Answer 3. First, it must be said that insofar as the Department of Transportation and the Federal Aviation Administration are concerned, there can be no tradeoff involving the decrease of safety. This is number one priority. As you know, aircraft are certificated by the FAA for safety. This involves such things as handling qualities and maximum gross weights. Whatever tradeoffs the manufacturer desires to make in terms of the aircraft performance or handling parameters is essentially beyond the concern of the FAA so long as the final aircraft meets federal safety levels.

In the area of noise, however, I believe we may become somewhat more involved in tradeoffs simply because our regulatory authority is new in this area. It is possible, for example, to off-load an aircraft and thereby significantly reduce the takeoff noise to which the airport community would be exposed. This is to say the lighter airplane can climb faster than the heavily laden plane. This would separate the lighter plane farther from anyone in the community and hence reduce the noise in the community. It must be pointed out, however, that payload has very little effect on landing noise.

In general the certification for safety and the future certification for noise prescribe standards which must be met. If the manufacturer cannot meet these standards he must perform tradeoffs that will then prescribe operational limits which will meet the FAA standards. The aircraft can then be certificated under those operational limits.

Mr. HECHLER. We are glad to welcome back Mr. Frank W. Lehan, Assistant Secretary for Research and Technology of the Department of Transportation.

Mr. Lehan, you first testified before this committee in February, I guess it was, about 2 months after your appointment. Is that correct?

Mr. LEHAN. Correct, sir.

Mr. HECHLER. Now that you have been onboard for several months and know all the problems, and I think have done a great job in identifying those problems, we appreciate hearing your analysis of the future needs for aeronautical research and development.

(The biography of Frank W. Lehan follows:)

FRANK W. LEHAN, ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY DEPARTMENT OF TRANSPORTATION

Mr. Frank W. Lehan was appointed Assistant Secretary for Research and Technology in the Department of Transportation on December 18, 1967.

Mr. Lehan has had a distinguished career in systems technology. He was born in Los Angeles on January 26, 1923, and attended the California Institute of Technology, where he received his B.E.E. Degree with highest honors in 1944. He was elected to Sigma Xi and Tau Beta Pi honorary fraternities.

Mr. Lehan joined the Jet Propulsion Laboratory of Caltech upon graduation and served from 1944–49 as Chief of the Telemetry Section. From 1949–51 he was Chief of the Telecommunications Section, and in 1952 he was advanced to Chief of Electronics Research. He served in that capacity until 1954, when he joined Space Technology Laboratory of the Ramo-Wooldridge Corporation, as Associate Director of the Electronics Laboratory.

Mr. Lehan then founded his own company, Space-Electronics Corporation, and served as its Executive Vice President from 1958–61. In 1961 he and his partner sold the company to Aerojet-General, and it became known as Space General Corporation. He served as Executive Vice President of Space General in 1961 and 1962, and as its President from 1962–66. Since leaving Space General, Mr. Lehan has been a consultant on a variety of scientific and engineering projects, including serving as a panel member of the President's Science Advisory Committee.

Mr. Lehan is a Fellow of the Institute of Electrical and Electronic Engineers, a member of the American Institute of Aeronautics and Astronautics, and the American Association for the Advancement of Science. He is an Associate of the California Institute of Technology.

Mr. Lehan is married and has one daughter. He resides with his family in Washington, D.C.

STATEMENT OF FRANK W. LEHAN, ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY, DEPARTMENT OF TRANSPORTATION, ACCOMPANIED BY CHARLES R. FOSTER, DIRECTOR OF THE OFFICE OF NOISE ABATEMENT, DOT; BERNARD J. VIERLING, DEPUTY DIRECTOR OF SUPERSONIC TRANSPORT DEVELOPMENT, DOT; AND JOHN A. WEBER, DIRECTOR OF SYSTEMS RESEARCH AND DEVELOPMENT SERVICE, FAA

Mr. LEHAN. Thank you, Mr. Chairman.

With me today, I would like to introduce Mr. Charles R. Foster, on my left, who is Director of the Office of Noise Abatement. On my right is Mr. Bernard J. Vierling, Deputy Director of the Supersonic Transport Development. At the end of the table on my right is Mr. John A. Weber, of the FAA, Director of Systems Research and Development Service.

It is a pleasure, after having a chance to get somewhat familiar with the problems, to once again appear before your committee, and to discuss the question of aeronautical research and development, which is of great interest to all of us present today.

That the question we are discussing today is a complex one can be readily verified when one considers the composition, in terms of practice, of the word "aeronautics." Today, in our systems approach we look at aeronautics through the matrix of technical disciplines which constitute the whole of the system, including applied fluid mechanics, which we call aerodynamics; propulsion technology; airframe structures; guidance, control, and instrumentation; communication and navigation systems; the atmosphere (or the aeronautical operating environment); human factors directly and indirectly related to aeronautics; airways and terminal operations; mission operations, marketing, and economics. The products of these diverse disciplines are the numerous types of aircraft and the vast array of ground-based support systems for navigation, communications, et cetera. The mix of users of these aircraft varieties and supporting ground facilities is equally diverse—including the military, commercial, and the general aviation sectors.

Roles in this aeronautical system have been relatively consistent over the years. The military, of course, has been heavily involved to meet its mission through activities in research, development, and operations. NASA and its predecessor agency, the National Advisory Committee for Aeronautics, have been the cornerstone of the basic research activities undergirding the development of all aircraft systems. The Weather Bureau, of course, has been heavily involved in the research and operational aspects of the atmospheric parameters affecting the operations of our aeronautical systems. The Federal Aviation Agency and now the Department of Transportation/Federal Aviation Administration have broad roles in the research, development, operations, and regulations of the civil aeronautical system. Other Federal agencies have research, development, operational, or regulatory roles to play within the broad spectrum of impact the national aeronautical activities have in our domestic and international affairs. Industry, in the final analysis has, of course, provided the capacity to produce the hardware called for by the Government and the market demands. The contributions of industry to our research knowledge must also be highly regarded.

The rapid growth of the aeronautical systems in the commercial field and in the military field has been predominantly tied to the development of new technology. Historically, actual or threatened military conflict has created demands for new technology to meet the military challenge. The technology developed by war applied to peaceful purposes has demonstrated a capacity and a convenience which has generally been in advance of public demand and has formed the foundation for the economic viability of the commercial aviation industry. Only in the national space system can we see a demonstration of a closed-loop system more closely coupled in time to the production of new technology. In no way am I inferring that research and development should be played down as it pertains to the other modes of transportation or indeed to any other aspect of our national life; however, I am attempting to make somewhat more visible the fact that the aeronautics field is critically dependent not on just the highly sophisticated technology presently incorporated within the system, but more importantly it is dependent upon the rate of production and introduction into service of new methods, of new thinking, and of new technology to meet the ever-growing demand.

In the military this has always been understood in terms of a need to continue to improve weapons systems to keep an advantage over potential enemies rather than be complacent about the superiority of past technology. The threat of a potential aggressor development of superior aeronautical systems has always been a keen incentive to sustain American capabilities for national security. Perhaps a comparable incentive in the field of civil aviation is our international competitive position for the export of American aeronautical products.

In years past, American aircraft products have dominated the commercial air transport industry throughout the world. Today, this dominance has reached alltime high levels, but technologically is being seriously challenged by European countries, Japan, and potentially by the Russian productivity. In 1967, exports of U.S. aeronautical products totaled more than $2 billion or in excess of 7 percent of the total U.S. exports and accounted for 44 percent of our favorable merchandise balance of trade. This accomplishment is further enhanced by the fact that aeronautical products represent less than 2 percent of our gross national product in the year 1967.

The implications of falling behind on the technologic curve in this international competition are, therefore, I believe, quite obvious. If we do not continue to aggressively pursue new technology we may find ourselves with first one "Volkswagen of the air" and then another interjecting itself markedly into not only the international competition for sales, but indeed, our domestic market as well.

Mr. HECHLER. They are more like Cadillacs now; aren't they?

Mr. LEHAN. Yes, sir.

Notwithstanding the massive military implications of aeronautical research and technology development, which are beyond the purview of my discussion today, or of the competitive international position to be gained or lost as a function of our production of technology, of primary concern must be the impact of new technology on the aeronautical system's capability to serve the needs at home. As I said, we have benefited greatly from past military technology which has been applied to increase the civil aviation capabilities. The civil capacities have now reached a critical mass, so to speak, and have created a driving force of consumer demand which has become self-sustaining and ever increasing. In both commercial and general aviation fields, the proven military engine and airframe technology has created a capability which has been exploited to its fullest in an attempt to keep up with the demand, but the consumer continues to "vote" more dollars into use of the system. The demand has at least temporarily outstripped our capability to produce an environment within which the aviation system can grow to meet a free marketplace demand, and the technology in operation is now becoming a restraint to the continued growth of the industry.

Aircraft noise, for example, has reached a proportion that has made the building of new airports or the expansion of existing facilities very difficult and is, therefore, blocking one obvious solution to the congestion problem. Noise will also be a substantial hurdle that must be overcome by research if VTOL and STOL aircraft are to ever achieve the effectiveness that many envision for these vehicles. Improved landing aids and techniques for more rapid execution of landing approach are other areas which need increased research in regards to the congestion problem. Efforts to continually upgrade the air traffic control system and to plan for the long-range requirements have been previously discussed by Mr. Thomas and Mr. Alexander. The critical operational needs of today and preparation for the future must be met by the FAA in performance of their statutory functions. Application of space technology spin-offs, basic research findings, and military systems developments must all be factored into the continuing evolution of the national airspace system.

Other areas of need include development of a low-cost collision avoidance system and research into the handling qualities of V/STOL aircraft to help establish criteria for certification of this new class of vehicles. Techniques or configurations to ameliorate sonic boom must continue to receive research attention despite the opinions by many that a dramatic breakthrough in this area is highly unlikely. By way of contrast to the problem-motivated research, we should continue some research into long-range areas such as hypersonic aircraft technology to provide a base for the future and hopefully reduce the need then for so much problem-solving research.

The problem is greater, however, than just adequacy of research—as this committee is well aware. Your colleagues in the Senate have also pointed out these facts in their reports, S. 90 and S. 957. A need is evidenced for adequate and properly directed short- and long-range research and development activities conducted within an environment which stimulates the rapid application of research results into the operational system. This, of course, involves the issues brought up by the NASA-sponsored study by the National Academy of Engineering, the additional questions of Government policy addressed by the Senate and others on Federal support of the system including regulation and even perhaps tax policies. I will not address the tax issue, but I do believe one must consider all the other factors before a rational and reliable position can be formed regarding the optimum level of research and development, the Federal share of R. & D. support and the institutional arrangements for the accomplishment of the Federal R. & D.

The Department of Transportation is charged by its enabling legislation "* * * to stimulate technological advances in transportation; to provide general leadership in the identification and solution of transportation problems; and to develop and recommend to the President and the Congress for approval national transportation policies and programs to accomplish these objectives with full and appropriate consideration of the needs of the public, users, carriers, industry, labor, and the national defense."

We are charged to lead—to lead the coordination of effective administration of Federal Government programs, to facilitate development and improvement of coordinated transportation services provided by private enterprise, and to encourage cooperation of government at all levels and all other interested parties. This kind of responsibility makes us keenly aware of the problem you are addressing in these hearings.

In consonance with our authority, as stipulated in the enabling DOT legislation and at the request of the Vice President and the National Aeronautics and Space Council, we have begun to work with NASA personnel, particularly Dr. Paine, Mr. Beggs, and Mr. Harper, on the formulation of a joint study on aeronautical research and development level of effort. We anticipate this study will involve other agencies beside NASA and DOT and will draw upon many able minds beyond the direct Government agencies involved, with particular emphasis on the academic community. While this activity is in the earliest embryonic state and without prejudging the final results, I can say that we may anticipate certain results to be forthcoming from our efforts. One item directly bearing on the subject of these hearings may well be that a larger investment of Federal facilities, personnel, and funds will be required to sustain the aeronautics system at a level approaching its potential. This will involve, I believe, increased research and a greater participation of the Government in demonstration and development activities related to civilian aviation than has been the case heretofore. If this is the case, new institutional relationships will have to be established to assure the proper direction, application, and coordination of such increased Government activities. It is, I believe, appropriate that the National Aeronautics and Space Council has requested the Department of Transportation to take the lead in this activity and to broaden it to involve other Government agencies, as appropriate, which will contribute to any such undertaking.

It is perhaps paradoxical that the Department of Transportation at this time, because of our recent formation, is not represented as an active member of the National Aeronautics and Space Council nor of the Aeronautics and Astronautics Coordinating Board, both of which have been viable mechanisms for coordinating NASA and DOD activities, including aeronautics.

Mr. HECHLER. Let me interrupt to ask, should it?

Mr. LEHAN. I think it should be considered, sir.

I think there are mechanisms for establishing coordination, and this should be considered as one of the possible mechanisms.

Mr. HECHLER. Well, I want to interrupt your testimony since we are pinpointing this issue.

What are some of the shortcomings you suffer by not being represented?

Mr. LEHAN. I wouldn't want to identify not being represented on these Boards as being a shortcoming. We are invited guests at the hearings.

I think that perhaps a proper solution may be the creation of a new coordinating council which involves other agencies and which is transportation oriented completely. This is one of the problems we are addressing in the study.

Mr. HECHLER. Yes.

Mr. LEHAN. On the other hand, we all recognize the undesirability of creating a lot of partially overlapping groups. And that is obviously another problem that needs to be addressed in the study.

So at this time I merely want to identify the fact that we are not fully represented, and we and NASA and others are studying the problem. We will be making recommendations.

Mr. HECHLER. Yes; you may proceed.

Mr. LEHAN. Thank you.

On the other hand, the Federal Aviation Administration and NASA have a formal agreement by which R. & D. and facilities programs are coordinated between these two agencies. The NASA and FAA agreement regarding the SST R. & D. activities also has been drawn to appropriately interleave the development activities within the DOT and the needed research activities to be supplied by NASA. In a similar vein the DOT has a memorandum of understanding with NASA regarding aeronautical research and facilities assistance from NASA pertinent to the planning and development activities of the Office of High Speed Ground Transportation in tracked air cushion vehicles. While I single out these particular NASA activities because of the formal agreements that exist, I must hasten to point out that the vast amount of NASA/FAA cooperative efforts derive from longstanding informal working relationships between these two organizations.

In virtually all of these working relationships I have been describing, between the DOT and NASA, the unique capabilities of NASA have been recognized and applied to the problems of the Department through the cooperation of NASA, and with the expenditure of NASA funds to perform the bulk of the research requested. I hope that in the years to come we can continue to look forward to support from NASA in the research area and that the aggressive policy of this subcommittee to aid the programs of civil aviation will be a continuing assistance in this regard.

There is, in my mind, however, a gap between the research result and the application of technology in the operating transportation system. I know this subject has been extensively discussed in the authorization hearings before this subcommittee in the past as well as in numerous other forums. Our study with NASA must include an examination of the effect of proof-of-concept demonstrations and Federal regulatory policies on the introduction of new technology.

We feel that in the area of noise abatement with our new legislative authority that we will begin to exercise such regulatory policies and demonstrations as a stimulant.

The FAA has established a schedule for implementation of this new authority first as it is applicable to the certification of new subsonic transport aircraft such as the Boeing 747, the DC–10, and the Lockheed L–1011 and all subsequent subsonic transports. On approximately November 1 of this year, notice of proposed rulemaking will be formally issued. Public hearings, debate, and establishment of final rules is anticipated to be completed and formal issuance of noise certification rules are anticipated by June 1, 1969. The noise standards which are anticipated to be established for the subsonic transport certification will require a diminution of the noise generated by this class of aircraft as compared to the present fleet of jet transports despite the increase in size, weight, and power of these new planes.

In order of succession, the proposed rulemaking will progress next to the airport noise generated by supersonic transports, light aircraft, and V/STOL aircraft. Finally, in the spring of 1969, following the demonstration tests of the NASA acoustically treated nacelles, regulatory proposals may be issued for retrofit of the existing jet fleet.

Thus, with this legislative authority concomitantly exercised with research advancing the state of the art, airport neighbors can now have a much higher degree of assurance that future generations of aircraft will not generate noise in excess of what is being experienced today and, indeed, if the research and technology demonstration programs are successful, that the noise environment connected with each aircraft noise event will decrease.

Mr. HECHLER. That is a happy and optimistic prediction.

Mr. LEHAN. Yes, sir. I hope it comes true.

Therefore, the land-use planner can focus primarily on the number of noise-generating events, which is amenable to analysis and projection into the future, to forecast the total airport noise environment. While the exercise of this authority will not immediately diminish the noise pollution around airports, it is now a tool with which the FAA and DOT will be able to arrest the heretofore increasing noise environment and the means by which new technology, as it is proven technically feasible and economically viable for the industry, can be ordered into operation. Without such legislation, it is not obvious that the market forces would command manufacturers and airlines to pay the price to achieve noise reduction in the very shortest segment of their flight operations, the airport vicinity.

On the other side of the coin, obviously, such legislative authority is of no value if the technology and the demonstration of the technology is not performed competently to demonstrate what is feasible and to determine what is economically viable to permit rational decisions regarding the general welfare of the public. It would not be feasible in the noise-abatement arena to simply establish criteria on the basis of small-scale laboratory tests. Such laboratory research is critical, however, to establish fundamental techniques which show promise for application and which can thereafter be demonstrated in full scale such as NASA is directing on acoustically treated nacelles. Only through such demonstrations can technology be reliably infused into the industry and only with such demonstrations can the Government take a position requiring the application of this state of the art.

It is in this area of demonstration and development that the NASA–DOT studies will, I believe, focus heavily in an effort to determine a balance of Federal aeronautics activity. This proof-of-concept demonstration and development function has traditionally been supported by the broad-based R. & D. activities of the military. However, the present environment of diminished numbers of military development programs and the divergence of military and civilian requirements appears to be demanding a new look at policy in terms of Federal support.

Until such time as our studies indicate the direction in which the Government should go and central decision can be made, we are planning to support in every fashion possible the research activities of the NASA, and the research and development and operational activities of the FAA and the DOD. The DOT, within the purview of its broad charter, intends to analyze the transportation system, determine priorities for R. & D. activities, to solicit Federal funds for the support of these activities, and to enlist the capabilities for research, demonstration, development, and operation where applicable throughout the total national aeronautics complex. We intend to support research wherever the best work can be done, whether it be NASA, DOD, AEC, the Weather Bureau, or industry, or the universities.

This concludes my presentation, Mr. Chairman. The staff and I will be happy to respond to any questions that you may have.

Mr. HECHLER. Thank you very much, Mr. Lehan.

When you look at the future of aeronautical research and development can you foresee any changes in the relationship between the aerospace industry, the universities, nonprofit research institutions, and Government in-house laboratories in meeting the aeronautical needs of the Nation? In other words, is there any change that you foresee in the nature of the related participation of these various units, and what you feel would be desirable in the future?

Mr. LEHAN. I don't think I can foresee any change at this time. However, I would expect that after the study is complete, that some change might be recommended.

Mr. HECHLER. Now, you mentioned here toward the close of your testimony the need of a new look at policy in terms of Federal support of demonstration and development.

I realize you can't pinpoint cost here, but this will be a tremendous investment by the Federal Government, will it not?

Mr. LEHAN. Yes, sir, it will be.

Mr. HECHLER. Can you give us any just general idea of what you had in mind in terms of the extent of the investment?

Mr. LEHAN. No, sir, I don't believe I can at this time.

Mr. HECHLER. Millions, billions?

Mr. LEHAN. I would reflect that the—well, at the present time the expenditures, which I am sure you gentlemen are all aware of, are in—in NASA are over $100 million a year in supporting aeronautical research and development.

Last year, in the FAA I believe the research and developments expenditures were $27 million. The DOD in its transportation research—this includes other than the aeronautical, but it is aeronautically oriented—is around $600 million a year if my memory serves me correctly.

Our airline industry, our air passenger industry I believe has sales of around $5.4 billion a year.

So I think all these numbers would put the answer in perspective. I don't think at this time we know enough to give an exact answer.

Mr. HECHLER. Well, I am just trying to get a general idea. Doubled, trebled? What do you feel generally it would be?

Mr. LEHAN. Let me identify some things that would influence it and influence the answer.

Mr. HECHLER. Yes.

Mr. LEHAN. I think if the NASA should move ahead on a communication and navigation satellite for ocean use, that would be a large expenditure that would have a strong effect to go or not go on that type of an operational system which I am not prepared to judge at this time. In any event it would have a large effect on the number.

I think I would like to see the research in VTOL and STOL's stepped up significantly with particular emphasis on being able to design those aircraft to have acceptable noise characteristics.

I think that although Mr. Alexander's committee looking at air traffic control post-1980 won't be coming out with its final report until next June, that it is to be expected that research and development are going to be required for implementing whatever final conclusions come out of the recommendations of that committee.

Mr. HECHLER. In any of these areas do you foresee the same type and nature of expenditure as we are doing on SST? Are any of these areas of such a nature as would require a tremendous taxpayer investment?

Mr. LEHAN. I don't foresee any at this time. I think that the hypersonic transport which the Secretary and I mentioned in our testimony may be another area but no one now knows whether that transport is a system that should be developed.

On the other hand, if it is a system that is to be developed, then expenditures certainly the level of the SST would be required from somewhere.

I think that our focus has been more on air traffic control and on noise abatement and on the VTOL and STOL aircraft. I feel that the VTOL aircraft and the STOL aircraft probably represent an important domestic market and perhaps an important international market as well.

Mr. HECHLER. I want to follow up and expand on some of the questions I was asking the Secretary on the economic application of STOL, particularly as it related to the airport problem. I wonder if you had given any thought to the economic relationship or the precise way in which STOL's are going to be used, or has FAA defined that?

Mr. LEHAN. John, would you like to comment on that?

Mr. HECHLER. Mr. Weber, would you like to comment on that?

Mr. WEBER. Well, our thinking so far as STOL's has been the short-haul, point-to-point, inside the metropolitan area from adjacent metropolitan areas. The main advantage, as we see it, of the STOL is that it can help us relieve the congestion of the regular fixed-wing aircraft operations.

But to this extent, we do not want them operating on the same runways and in the same traffic patterns that we would be using for the fixed-wing aircraft. And in this respect, it may require more concrete—certainly not of the magnitude of runways required for fixed-wing aircraft, but where we do not have it existing now we would need some additional concrete to make such an operation feasible, independent of the regular fixed-wing aircraft.

Mr. HECHLER. Then the development of VTOL and STOL would not in any way minimize the necessity for the multibillion dollar airport development program the Secretary has recommended?

Mr. LEHAN. I think that is the case, Mr. Chairman. I would anticipate that development of VTOL and STOL aircraft would enable us to cope with future transportation demands more economically than let's say the use of large jets for short-haul operations.

I think they may have another important influence in that if we look way downstream, the ability to use STOL with quite inexpensive airports and VTOL with quite inexpensive landing pads may well enable communities and regions which wouldn't be able to otherwise economically afford airports, to have good air service. I think that may be a very important advantage.

Mr. HECHLER. Do you foresee that this might also be a case where the Government would have to engage in investment for proof of concept?

Mr. LEHAN. I think that is a likely possibility, sir. I am not prepared to say definitely yet. We are beginning to work out a study. It is a likely possibility.

Mr. HECHLER. Is there any danger, then, that STOL may be uneconomic for anything over a short-haul run?

Mr. LEHAN. I am tempted to say yes, but the airplane manufacturers have in the past always managed to get a good deal more out of the airplane than anyone originally conceived, so I think my answer would be initially yes, but I would suspect that as time goes on, that short haul will get longer and longer.

Mr. HECHLER. What do you and Mr. Weber mean by short haul?

Mr. LEHAN. Maybe we should both answer it separately.

I think that short haul is 200 to 300 miles, John. Maybe up to 500.

Mr. WEBER. In that order of magnitude, yes.

Mr. HECHLER. Has NASA's role in aeronautical research changed any since the Department of Transportation was established or since you came aboard as Assistant Secretary?

Mr. LEHAN. I think that I can't really make observations. Perhaps, John, I should say simply that I found NASA, since I came aboard, to be extremely interested and extremely responsive to suggestions from the Department. I won't say formal direction we have given NASA, but general guidance has been given in meetings and conferences and so on.

Mr. HECHLER. What kind of general guidance have you tried to utilize?

Mr. LEHAN. We have been very interested in landing systems for VTOL aircraft, to improve their handling characteristics and bring them down safely in adverse weather. And NASA has been active in that area in the past, and I think is becoming increasingly active.

We are interested, as the Secretary mentioned, in steep descent. I believe there is some activity in that area. Is that right, John?

Mr. WEBER. Yes.

Mr. LEHAN. Would you like to elaborate on that?

Mr. WEBER. We are working together with them on that. NASA is particularly interested in the aircraft handling characteristics for steep descent. And we have been working closely with them in providing ways and means of providing the electronic guidance. As Mr. Thomas said, we have to do a lot more work on the display for the pilot to translate the electronic guidance into meaningful, usable instrumentation so that the pilot can properly control the aircraft during his steep descent and transition onto the runway.

Mr. HECHLER. One of the purposes of these hearings is to focus a little more public attention on how critical our needs are for additional aeronautical research and development. Wouldn't you be in a far better position in the Department of Transportation to say that the Space Council would exert leadership in areas other than noise? And I say other than noise because I believe the record would show that the Space Council has indeed taken the initiative in providing leadership in this field.

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Isn't it pretty difficult for the Department of Transportation in dealing with other departments that are on the same general level, such as the Department of Defense or the National Aeronautics and Space Administration, to exert the kind of leadership which the Nation is going to need to meet these crises which we foresee in the future?

Mr. LEHAN. The Space Council has been extremely cooperative, and I would like to read, if I may, into the record a letter which the Secretary received from Dr. Welsh, Executive Secretary of the Space Council.

Would you like me to read the letter here?

Mr. HECHLER. Yes, put the date on it.

Mr. LEHAN. The date is September 24. This is a recent letter that is confirming arrangements which were previously made. Your hearings have had a decided effect, sir.

DEAR MR. SECRETARY: The National Aeronautics and Space Council has a continuing interest and a legislated responsibility in the progress of aeronautical research and development.

As you know, the Senate Committee on Aeronautical and Space Sciences issued a report on January 31, 1968, in which some specific recommendations were made regarding aeronautical policy. One of these Committee recommendations was that a study should be made to analyze the relation between the benefits that accrue to the nation from aviation and the level of aeronautical research and development effort. The Committee went on to propose that such a study be accomplished by NASA and the Department of Transportation and that the results of the study should be transmitted to the National Aeronautics and Space Council. This recommendation went further and urged that the Council, after appropriate consultation, should determine the level of Federal government involvement and the relative effort of participating agencies. In actual fact, the National Aeronautics and Space Council's function would not be one of determining but rather one of proposing to the President and then carrying out needed coordination after a decision had been made.

At the May 22, 1968, meeting of the National Aeronautics and Space Council, the Vice President asked for progress reports on the study recommended by the Senate Committee. Administrator Webb of NASA proposed at that time that the Department of Transportation take leadership in the study because of its direct relationship to transportation policy. Mr. Densmore, representing your Department, reported that high level attention and interest were being devoted to this problem and that NASA–DOT meetings had already been held with the purpose of formulating an outline for the project.

The Vice President requested prompt action on the study and agreed that the expertise of the Defense Department should be coordinated with that of DOT and NASA in this matter. He also asked that interim reports be made to the Council. It would be in the interest of efficiency if such reports would be made to me so that they could be brought directly and promptly to the attention of the Vice President.

Sincerely,

E. C. WELSH.

Mr. HECHLER. Well, I think this is very, very valuable, and I am very pleased to hear this letter which, of course, is going to be incorporated as part of the record.

Have you given any thought as to followup on this letter?

Mr. LEHAN. Yes, sir. The followup is already underway between NASA and ourselves in the study, and I would suspect that within the next month or two we would be briefing Mr. Welsh on the status of the study.

Mr. HECHLER. I was very impressed by the study which Mr. Alexander is making at the request of the Department of Transportation, and I wondered if there are any other areas aside from air traffic control where you are giving this type of intensive look at the 1980's by any similar group?

Mr. LEHAN. No, sir; not at this time. We have discussed several areas, but none have been firmed up and formulated at this time.

Mr. HECHLER. I would think that would be a very useful technique, because we know these problems are going to be on us and it is absolutely necessary that we get the best thought in the industry and the scientific community, in the Government and in the Nation, to anticipate and prepare to meet these problems.

Mr. LEHAN. Yes, sir, I completely agree.

Mr. HECHLER. Do you have any suggestions? You have mentioned nothing had been firmed up, but that you had given some thought to other areas.

Mr. LEHAN. I can give you some examples of other areas.

Mr. HECHLER. Yes.

Mr. LEHAN. I think an obvious area is let's say the interaction of the highway system and the ground transportation system in the future; 1980 may be a little too short to look into the crystal ball on that system. What do we see for the future in that area? I think it would be a very, very useful study.

Another study that I think would be very useful is really a technical study, in a sense, but performed by nontechnical people. I think that very properly the technical person is inclined to not always bring in the citizen user of transportation at the appropriate time in the appropriate way in designing a transportation system, whether it is a highway or aircraft or airport system. I think it would be quite valuable to have a committee of intelligent and informed citizens simply to kibitz the technical people on how they react to the various transportation problems that they face and how they react to the environment in which they live, which to considerable extent is influenced by transportation solutions.

Mr. HECHLER. Well, the committee certainly wants to encourage this kind of thought and action by the Department of Transportation. I think it is extremely useful.

I brought this question up several times and I can't seem to get a very positive reaction on what I feel is a very great need for some advanced research on how to solve our airport problems in the future.

And I am rather amazed at the timidity at the Federal level.

Secretary Boyd indicated the—I think he called it—hardheaded local vision in Minneapolis and St. Paul. Must we just hope that this will happen in certain areas? Must we throw all these problems onto the local community which is hemmed in by the desire to do something for the people within a 5- or 10-mile radius without any relationship to the national transportation system? Why can't some thought be given to just exactly how we are going to resolve this very, very serious problem in the 1980's in the national interest?

Mr. LEHAN. I think your point on research is very well taken, sir. I think that your suggestion of the—I think you intended it as a suggestion, that possibly some kind of a committee be considered to look at airport problems and terminal problems and airport access problems and so on is an excellent one. I would not be surprised if the

Department of Transportation would take up your suggestion this coming year. I think that as a new department we are just getting organized and we are very conscious of some of these things, but very simply have not had the manpower available at the present time to sponsor such a committee as you suggest.

This is going to be changing, however.

John, do you have anything you would like to add to that?

Mr. WEBER. No.

Mr. HECHLER. Well, I want to thank you also for characterizing this subcommittee as being aggressive. We appreciate the compliment and we hope we don't create too many aggressions in the process.

Mr. LEHAN. No, sir; I consider you are constructively aggressive.

Mr. HECHLER. Would you care to amplify the comments that you made on pages 9 and 10 on planned noise certification rules anticipated by the 1st of June, 1969?

Mr. LEHAN. I would like to ask Mr. Foster to comment on that, sir.

Mr. FOSTER. We have been working with the industry for several years in anticipation of certificating aircraft for noise so that when the legislation was passed and signed this July we were in a pretty good position to move right into the notice of proposed rulemaking and follow the Administrative Procedure Act to actually get the rules out and in being. And the schedule that is indicated there, we hope we will be able to follow starting first with the subsonic jet aircraft. And hopefully this notice will be out within the next month, and by next summer, by July of next summer we hope we will actually have a rule that will be issued.

Mr. HECHLER. To what extent will this apply to flight operations and to what extent the engines themselves?

Mr. FOSTER. This rule would apply to flight operations only in the specification of measuring points where the noise would be measured and the altitudes that would be involved. It would not specify unique flight operations that have to be followed so far as certificating the aircraft itself is concerned.

We call the concept a three-point measuring concept where we would measure noise on approach, on the runway side line, and on takeoff. We would have prescribed noise levels that would be established at those three points. But the airplane would be flying in a normal, safe manner.

Mr. HECHLER. Any questions by staff on the area of noise?

Mr. HINES. Yes, sir.

Mr. GERARDI. I have one question.

The recent National Academy of Engineering Report indicated that there was a serious shortage of qualified scientists in the area of noise research, per se. Do you feel that is true?

Mr. FOSTER. Yes.

Mr. GERARDI. Would you comment on it?

Mr. FOSTER. Last year of several thousand Ph. D's, there were six in the United States who actually got their degrees in noise—or areas immediately related to accoustics. And the major work that has been going on, of course, in the Government, as far as the scientists are concerned, has been in NASA and in the FAA. And once you get out of the areas of the major engine and airframe manufacturers there is a very limited number of research personnel available in noise.

In fact, you will find in our industry quite a large number of scientists who have been educated abroad and not educated in this country. I think this is an area in which our educational system needs to be encouraged, and this we are doing in several ways, too.

Mr. HECHLER. What ways?

Mr. FOSTER. We are working with the universities with grants for programs. NASA, Langley, has a program with North Carolina State to encourage additional research there for example. We have research programs in noise and in sonic boom with the university staffs to encourage this kind of work, bringing in graduate students and calling attention to it.

Mr. HECHLER. Have you been in touch with the National Science Foundation to see whether any of their grants could be utilized in this area?

Mr. FOSTER. I have not been in touch with them. But we will get in touch with them.

Mr. HECHLER. Any questions on noise?

Mr. HINES. Yes, sir.

Your present attack on the noise problem is an engineering approach, is it not? It is an engineering attack, actually, rather than basic research?

Mr. LEHAN. Yes. That is correct.

Mr. HINES. This subcommittee has been told in the past that more money and more people just cannot advance the state-of-the-art any faster than it is going. Is this still true?

Mr. LEHAN. Let me say we are trying in the sonic boom area, to reemphasize basic research. But until very recently, until we got this reorientation, your statement was quite correct in that area also.

In the engine noise area, I think the orientation is still to a considerable degree engineering, wouldn't you say?

Mr. FOSTER. Yes.

Mr. HECHLER. I sometimes think that the answer of whether additional money will help is conditioned by the nature of the committee or, in the case of the executive branch, the nature of the budget. And this is what I observed at the outset. I would hope that we can approach these problems in terms of what the problems are and what needs to be done to solve them rather than in terms of the context of the $6 billion reduction.

Mr. LEHAN. Yes, sir.

Mr. HECHLER. Would that change your answer any?

Mr. LEHAN. I think, and I believe NASA would concur, that there is also a need to increase the basic research in the engine noise arena.

Exactly how much should be spent in that area, I think we are not ready to say at this time. We will be saying it, obviously, as we are going through the budgetary process.

Mr. HINES. One last question, sir.

Mr. HECHLER. Yes, Mr. Hines.

Mr. HINES. Do you believe that a real prudent program of insulating people from noise by other areas of the Government, such as urban development, this sort of thing, should be undertaken, or is it undertaken to any great extent at this moment? I know in England the Government does support the builders to insulate the homes from the noise. Is this a practical program for our country?

Mr. LEHAN. Chuck, do you want to comment on that?

Mr. FOSTER. We have some studies underway to determine what you can really accomplish by this. There is some joint work with HUD. They have some homes that have been built in Los Angeles, New York, and Boston where they are actually going into these houses and seeing what you can put in them, how much it is going to cost and what kind of insulation you would install and what you would get for it.

Simultaneously, we are looking also at various airports around the country to find out what is the total magnitude—if such individual homes affected by aircraft noise and what kinds of dollars we are talking about if we tried to apply insulation across the board in some of the major areas.

Mr. HINES. Mr. Foster, we have seen that right now there is a large development being built close to the National Airport. We see motels and hotels built next to the airport, and they claim these things are insulated. I can't quite buy this.

Mr. FOSTER. I agree with you.

Mr. HINES This is another example of your problem, the interrelation of people to the noise.

Mr. HECHLER. Mr. Gerardi?

Mr. GERARDI. Could you give us, the general magnitude of funding supplied by the Government on noise research versus what private industry is doing on its own?

Mr. FOSTER. I have some numbers here as to what we are doing. Indications are that private industry is running about $15 million a year. This is our major airframe and engine manufacturers. Within the Government in fiscal year 1968 we were running something on the order of $10 to $13 million. Fiscal year 1969 is projected but this will probably be over $20 million, and probably next year will be much greater than that.

Mr. GERARDI. Have you projected an increase in the private industry's share of basic research?

Mr. FOSTER. No. I am just saying about what the current rate is. I don't know what their projections are in the future.

Mr. GERARDI. Were they spending any appreciable amount of money until the Government began to emphasize this as a problem?

Mr. FOSTER. They started spending their money when they first put the jet aircraft into operation. They spend a lot of money trying to get suppressors for the straight turbojet engines. I think this is the real action that started it. And I think that probably one of the additional reasons was of the Port of New York Authority requiring a certain noise level to be met.

So this was where industry really first started to get into it, both in research development and actually equipping their engines with jet suppressors.

Mr. GERARDI. Thank you.

Mr. HECHLER. Mr. Lehan, how serious is the air pollution from aircraft, and what are you doing about it in terms of research?

Mr. LEHAN. The air pollution from aircraft is in particulate matter, not gaseous vapor, and particulate matter in the region of airports can create a considerable nuisance to those people who live in the regions around airports.

I believe that HEW has the authority for setting the permissive levels of pollutants from aircraft engines. I believe they are studying it, but they haven't yet settled it.

Mr. FOSTER. That is correct.

Mr. LEHAN. Do you want to elaborate a little bit on my reply? Do we have any activity that you know of, John, or Chuck?

Mr. HECHLER. Nobody is doing any research?

Mr. FOSTER. FAA has some.

Mr. WEBER. Working in cooperation with NASA on the measuring the pollutant output from turbine engines.

Mr. HECHLER. The last thing I have seen on this was 1964, which was a rather complacent breakdown that indicated that over 90 percent of the air pollution from planes wouldn't hurt anybody anyhow, and it sort of left it at that. I think we have had a great deal of development both of planes and the effect of particulates since 1964. This is an area of research that the Department of Transportation ought to take some lead on.

Mr. LEHAN. Yes, sir. We have perhaps been somewhat slow. I think we have been trying to be in a position to follow HEW's setting of standards in an analogous fashion with automobile-generated pollution.

Let me volunteer to look into the status of this activity, which I am not real current on, both at HEW and at the Department of Transportation, and report back for the record.

(Information requested is as follows:)

SUMMARY STATUS OF FEDERAL PROGRAMS REGARDING AIR POLLUTION FROM AIRCRAFT

As stated in the testimony, the Department of Health Education and Welfare has the ultimate responsibility for establishing air pollution criteria and attendant control technology as specified in the Air Quality Act of 1967. In regards aircraft emissions, the FAA and the Department of Health Education and Welfare have been working together closely to assess the magnitude of the problem today and in terms of projected air traffic growth including the newer aircraft. A six month contract effort supported by the HEW National Air Pollution Control Administration is nearing completion which should provide definitive data to serve such an assessment. A report to the Congress from HEW will be provided within the next two months citing these new data and presenting an assessment of need for action programs.

Also underway are several programs aimed at developing reliable means of measuring turbine engine emissions. The first of these is jointly supported by the Bureau of Mines and the FAA which will involve test stand runs of an engine similar to that currently operating on the four engine civil transports. This activity is directed primarily at evaluating the invisible emissions. Concurrently, preparations are being made to contract for the development of hardware usable for the measurement of emissions (including heavy emphasis on smoke) in consonance with the preliminary criteria established by the Society of Automotive Engineers. This contract effort will be jointly funded by FAA and HEW and will lead to future programs which may establish permissible aircraft pollution levels.

Smoke primarily from present two and three engine civil transports is perhaps the single most offensive aspect of aircraft air pollution insofar as public reaction is concerned. The manufacturer of these engines has developed a "fix" to reduce smoking and at present approximately fifty engine sets are in demonstration service with the airlines. If these service tests are successful, replacement of existing combusters with the new design can begin immediately in the normal airline engine overhaul cycle. It must be emphasized, however, that at present there is no federal requirement for the airlines to undertake such a replacement program. On the other hand, smoke is receiving a great deal of attention by the engine manufacturers presently developing engines for the next generation subsonic transports as a result of previous public complaints and in light of cooperative programs at the government and industry. The outlook is promising that future engines will generate less smoke as a result of careful design attention to this factor.

Mr. HECHLER. Yes. I appreciate that, because so frequently as you see the long trail of smoke, the people who are responsible say it is just esthetic, it doesn't really hurt anybody, it is just dirt in the sky, and if it was a white streak, nobody would say anything. But I think this is a seriously increasing problem over populated areas, and I am getting an increasing number of protests from individuals about this.

I would hope you would not simply wait for HEW to do something since the direction, stimulation, and leadership in transportation research comes from the Department of Transportation. Perhaps some initiative could be taken in this area.

Mr. LEHAN. Yes, sir. We will take this initiative.

Mr. HECHLER. Would you like to make any type of concluding statement, Mr. Lehan?

Mr. LEHAN. Mr. Chairman, I appreciate very much the opportunity of being here. We found the activities of your committee to be, as I said earlier, constructively helpful, and we thank you for your interest.

Mr. HECHLER. We hope we can continue to be constructively aggressive. Thank you, Mr. Lehan.

The committee stands adjourned until 10 a.m. tomorrow.

(Whereupon, at 11:45 a.m., the subcommittee was adjourned, to reconvene at 10 a.m., Tuesday, October 1, 1968.)

AERONAUTICAL RESEARCH AND DEVELOPMENT

TUESDAY, OCTOBER 1, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:01 a.m., in room 2325, Rayburn House Office Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. HECHLER. The committee will be in order.

Our first witness this morning is Dr. Finn J. Larsen, Deputy Director of Defense Research and Engineering.

Dr. Larsen has had a very distinguished career in scientific research and technology, both in Government and private industry, and I would like to put the biography of Dr. Larsen into the record prior to his testimony.

(The biography of Dr. Finn J. Larsen follows:)

DR. FINN J. LARSEN, PRINCIPAL DEPUTY DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

Mankato (Minnesota) State Teacher's College, B.E., 1939; Drake University, M.A. (Physics) 1941; Iowa State University, Ph. D. (Physics) 1948.

As Principal Deputy Director of Defense Research and Engineering, Dr. Larsen is responsible for supervision of Department of Defense research, development, and test programs. He is responsible for providing guidance to and management of the staff of the DDR&E. He often represents both the DDR&E and the Secretary of Defense in matters involving other governmental agencies. He is the Chief U.S. representative to the NATO Council of National Armament Directors and to the NATO Defense Research Group.

Experience: U.S. Naval Officer, design work in radar equipment . . . physics instructor, Iowa State University . . . Research Physicist and Assistant to the Director of Research, Honeywell, Inc., 1948–1952; Director, Ordnance Engineering, Honeywell, 1952; Director of Research, 1954–1959; Vice President 1959–1961.

In 1961, Dr. Larsen was appointed Assistant Secretary of the Army for Research and Development. Serving in this capacity from 1961 to 1963, he received the Army's Exceptional Civilian Service Award in 1962 and the Army Distinguished Civilian Service Award in 1963. During the period from 1963 to 1965, Dr. Larsen was Vice President for Research and Development of Honeywell, Inc., Minneapolis, where he directed activities of the Research Laboratory and worked closely with the firm's management and divisions in providing research program guidance and in evaluating new product developments. Under his direction, Honeywell research personnel explored wide scientific frontiers, from basic studies into the behavior of the atom to deep ocean research and problems involving man's penetration of space. Since December 1965, Dr. Larsen has been Principal Deputy Director of Defense Research and Engineering.

Areas of activity or specialty: Formerly Chairman of the Army's Scientific Advisory Panel, a member of the panel of the President's Science Advisory Committee and a National Academy of Science Committee, both concerned with oceanography, scientific consultant to the Army Ballistic Research Laboratories, member of the Army Signal Corps Research and Development Advisory Council, Vice President of the Northstar Research Institute and member of the Board of Directors of the Toro Manufacturing Company. Dr. Larsen also was a member of the Research Committee of the Upper Mid-West Research and Development Council, as well as several professional and scientific groups including the American Physical Society and the Institute of Electrical and Electronics Engineers. Member of Sigma Xi, Sigma Zeta, Phi Mu Epsilon and Kappa Mu Epsilon.

Mr. HECHLER. Before you begin, I would like to read this letter from the Secretary of Defense dated September 28 addressed to me.

I would like to take this opportunity to comment on the importance of your Subcommittee's work in looking into the adequacy of civil aeronautical research and development. By clarifying current national programs, goals and technological gaps and identifying future requirements these hearings will serve a most important public service. In addition, they will underscore the issues, challenges and opportunities facing the country in civil aviation.

There are three points which I believe merit your consideration and although each is undoubtedly familiar to you they are, in my judgment, critical.

First, during my seven months as Secretary of Defense I have been impressed again and again with the needs for, and the results of, research and development. There is little question today that research and development is truly "the leading edge" of our national security. Without vigorous innovative activity and without continuing Congressional support for this activity, our national strength could not be assured.

"Secondly, the Department of Defense continues to seek and seize opportunities to transfer the technology developed for military applications to the fields of civilian aviation and transportation. I recognize clearly that almost half of the federal research and development effort is devoted to national security and thus I recognize our responsibilities for close coordination with the Department of Transportation, the National Aeronautics and Space Administration, the Federal Aviation Administration and all other agencies concerned with civil aviation.

"Thirdly, and related closely to the last point, I believe it is fair to say that much of the progress in defense research has already found civilian applications. From advanced materials to radar technology, and from propulsion systems to experimental aircraft, defense efforts have found far-ranging multiple applications.

Dr. Finn Larsen, Principal Deputy Director of Defense Research and Engineering, will represent the Department at your hearings. I know you will find him to be a well informed and cooperative witness. Should you need any further assistance please do not hesitate to call on me or my staff.

Cordially,

CLARK M. CLIFFORD.

That is a good sendoff for you, Dr. Larsen. And I appreciate very much your coming up to expand and supplement the statement that the Secretary of Defense has made.

Do you have a prepared statement, Dr. Larsen?

Dr. LARSEN. Chairman Hechler, staff members: Yes, I do have a fairly brief prepared statement.

I would also like to add that I am accompanied this morning by Capt. Tom Brittain, U.S. Navy, who assists both Dr. Foster and myself in preparing congressional testimony.

Mr. HECHLER. Does Captain Brittain have a title also that we could include for the record?

Captain BRITTAIN. I am a Special Assistant to the Director of Defense Research and Engineering, sir—to Dr. Foster.

Mr. HECHLER. Welcome, Captain Brittain.

Captain BRITTAIN. Thank you, sir.

Mr. HECHLER. You may proceed, Dr. Larsen.

STATEMENT OF DR. FINN J. LARSEN, DEPUTY DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING, DOD, ACCOMPANIED BY CAPT. THOMAS B. BRITTAIN, JR., U.S. NAVY, SPECIAL ASSISTANT TO DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

Dr. LARSEN. Thank you, Mr. Chairman.

It is a privilege to be here and to participate in the deliberations designed to assure that we have an effective and efficient civil aircraft industry, which is of such great importance to this country.

As I understand your opening statement, the objectives of your review relate primarily to civil rather than military aviation and revolve around the establishment of research and development programs which will assure that this country will continue in its present recognized position as a world leader in air transportation. This issue, however, is one of public policy which encompasses much more than the Department of Defense's direct area of responsibility for developing military aircraft systems.

The problem of civil aviation is complex and involves so many diverse factors that it may be quite difficult to perform a comprehensive analysis. Seldom does one find a problem in which a complex modern technology is so entwined with a wide range of nontechnical factors, such as politics, public opinion, different Government agencies, and financial, labor, management, international, and biomedical aspects. To achieve and maintain leadership in a field dependent on such a large array of parameters is indeed a challenging task and one that will require the use of the best talent and resources of our country.

I believe, therefore, that the most important requirement for maintaining the goal of world leadership is the assignment of a responsible agency for pulling together the many separate factors that make up civil aviation.

Mr. HECHLER. Could I interrupt at this point, Dr. Larsen, to ask simply on that observation you just made: Is the implication there that there is no responsible agency to pull together the many separate factors that make up civil aviation?

Dr. LARSEN. No. I am aware, of course, that the Department of Transportation has this assignment. Whatever the reason may be—perhaps the lack of adequate resources—I do not believe that that work is yet being done. I think it definitely needs to be accomplished, and I do feel that the assignment to the Department of Transportation is undoubtedly very proper and can be an effective one.

Mr. HECHLER. What you mean, then, is that this arrangement should be given a little more teeth and authority?

Dr. LARSEN. Yes.

Mr. HECHLER. Responsibility?

Dr. LARSEN. Yes, Mr. Chairman. And I also feel, for example, that in some of its arrangements in conducting research and development it needs to have greater control of financial resources.

I do not believe that one can rely on other agencies entirely to sponsor programs for which one has the responsibility. Let me give an example if I may, Mr. Chairman.

The Department of Defense also relies on NASA research, which is excellent and effective. On the other hand, we do not find that NASA would always have the research accomplished which is necessary for the Department of Defense. It is very unlikely that another agency can know and accomplish all of that research which is required for, in our case, the Department of Defense.

One of the reasons—and we determined this—is that some of the research required is not uncovered until development starts. We cannot identify all of the research required until we initiate active development.

Now, in order to get that necessary research accomplished quickly, one must have funds, and that the Department of Defense is fortunate enough to have. In fact, in many cases we get the research done either from industry or from NASA. We go right back to NASA and request that they do this particular task. I think no outside agency can ever completely anticipate the needs of a developing agency.

Mr. Hechler. You have opened up a number of questions which I think we ought to defer until you have completed your statement, but I would like to go back, and I am sure other members of the committee would like to go back to this point and develop it further after you have proceeded with the rest of your statement.

Dr. Larsen. Thank you, Mr. Chairman.

The problems associated with civil aviation are so broad that any effort based on less than the very best overall planning, with full utilization of modern systems analysis followed by effective management, is unlikely to succeed.

My appearance is near the end of your hearings and I expect that the principal issues have been thoroughly presented and discussed; however, there are a few points I feel should be emphasized. These issues go far beyond the Defense Department's aeronautical efforts but we all appreciate that investments made by the military in the development of aeronautical facilities and military aircraft, and the Defense assistance provided other agencies, have a significant influence upon the course of civil aviation. Further, because of the competitive pressure required to maintain leadership over potential enemies, the Department of Defense has had the pioneering role in aeronautical advancement and has taken many risks that would have been prohibitive to civil aviation. For example, the military departments have led in jet propulsion, supersonic aircraft, new materials (notably titanium), STOL and VTOL, to name a few. This pioneering effort will certainly continue and should provide important benefits to civil aviation.

The DOD responsibility for military aviation is sufficient to occupy our resources for the foreseeable future. At the moment we are accelerating our aircraft developments. For some years a major emphasis was placed on missile capabilities, with our research and development programs reflecting this priority and showing a relatively lower level in aircraft development. Our aircraft programs are accelerating and can be expected to show an even larger change. At present we are initiating or have just initiated programs for a new Navy fighter, the VFX; a new Air Force fighter, the FX; a new Navy antisubmarine aircraft, the VSX; a new airborne warning and control aircraft, AWACS; and possibly a new light intratheater transport, the LIT. How rapidly some of these programs will be started is difficult to predict, but the prosecution of these programs on a normal schedule is expected to strain our research and development resources for the next several years.

In addition to concentration on our own programs, we have provided and will continue to provide information and assistance in every way possible to the civil program. It is essential that we recognize the significant differences that exist between military and civil aviation and why these differences are necessitating separate research and development programs. Military combat aircraft are highly specialized systems that integrate into one package complex fire control, navigation, ordnance, and electronic countermeasures equipment, escape components, propulsion systems, and airframes all directed toward a specific military mission. Formerly we tried to achieve the best possible aircraft performance and then install the best available avionics and ordnance equipment in the airframe. Such an aircraft was designed with little or no compromise of the airframe in regard to missile design or avionics. Some of these aircraft were readily adaptable to civil use. Today, however, most of our aircraft are only parts of a complete system package that performs a specialized mission in the face of sophisticated enemy capabilities. Very few of our future military aircraft are likely to be the prototypes for civil aircraft. Civil aircraft also must make compromises, for instance, to minimize operating costs, but the emphasis may be on considerably different aspects of the aircraft or of a subsystem than is the case with a military aircraft. Thus the divergence of civil and military aircraft is one of mission effectiveness and not necessarily one of technological shortage. The DOD development programs must be aimed primarily toward the solution of military problems, at the same time considering their priorities with little or no compromise of the most effective military solution. The military R. & D. program, therefore, is less effective in solving civil aircraft problems than in the past. Nevertheless, many items of aerodynamics, propulsion, materials, meteorology, stability, and control, subsystems, operational techniques, and so forth, that have been derived from military programs are transferable to civil aviation. Our research programs, as well as our exploratory and advanced development progams, as contrasted to our military development, will continue to make contributions of this nature to civil aviation.

NASA is recognized as the Government agency primarily responsible for aeronautical research in the United States. I believe this is the proper assignment and should continue. It has not been restrictive to the DOD, which has utilized NASA research and has augmented NASA's effort by conducting such research as was necessary to maintain a strong national defense. Effective coordination must be achieved to conserve our resources and provide a concerted attack on difficult problems.

We believe we have been achieving that excellent coordination for many years. DOD personnel are members of NASA's advisory groups and NASA gives valuable assistance to DOD whenever needed. However, to insure formal coordination between NASA and the Department of Defense, the Aeronautics and Astronautics Coordinating Board has been established to facilitate planning, avoid duplication, coordinate research, and identify problems of mutual interest, as well as exchange information. This Board has been functioning since September 1960. On its establishment, the Department of Transportation was invited to participate in the Board's activities. A significant portion of the Board's effort is devoted to space activities, but one of its most active organizations is the Panel on Aeronautics. The Department of Transportation has vigorously entered into Panel activities, with the result that excellent coordination is being continued. Typical of the Panel's action is a review of the aeronautical programs of the Army, Navy, Air Force, NASA, FAA, and DOT that was recently conducted. The review gave an overall perspective of the individual programs. Subsequent action by the Panel has been to consolidate and augment those programs of common interest.

Along with coordination of programs the rapid transfer of information to interested parties is of prime importance. It is a policy of the DOD to make available to civil aviation, within the bounds set by military security, all technical information, operational procedures, and management techniques. Probably the major transfer of information results from the nature and composition of our aerospace industry. That is, the developers of military aircraft are also the developers of civil aircraft and their scientists and engineers work in both fields. Information about test data and research work in progress, therefore, is almost automatically and very quickly available. While this natural transfer is effective, a more formal system also exists. The Defense Documentation Center catalogs and makes available all classified DOD aeronautical research and development reports to Government agencies and the contractors. Copies of technical documents dating back to World War II are available, and new reports are being added at a rate of approximately 50,000 per year. Companies in the aerospace industry and interested Government agencies regularly make use of this service. Unclassified technical reports are available to all of U.S. industry through the Clearinghouse for Federal Scientific and Technical Information in the Department of Commerce.

In addition, there are cases in which special arrangements must be made. For instance, in the SST program the civil developers did not have access to complete data on the XB–70, the F–111, and the YF–12 series of aircraft. To correct this situation, it was arranged for specially cleared engineers from the principal companies involved in the SST program to be briefed on the technical aspects, engineering designs, components, and flight tests of the three military programs. The SST engineers were also permitted to visit the plants of the military contractors for specific detailed discussions. As a result, I believe that there was an effective transfer of all pertinent information from these military programs to the participants in the FAA's SST program.

The recent report of the National Academy of Engineering on "Civil Aviation Research and Development" has served well to focus on the basic problems facing civil aviation:

Air pollution, including noise and smoke;
Congestion in the air and on the ground; and
Safety.

The designers and operators of combat aircraft are also concerned with these general problems, but from an entirely different aspect.

For instance, the smoke trails left by our jet fighter and attack aircraft proved surprisingly effective as aiming aids for enemy gunners in Southeast Asia. An additive, toxic to handle but harmless when burned in the engine, may provide an expedient military solution, but one which is unacceptable for civil aircraft. The longer term solution, smokeless combustors, will, of course, be of mutual benefit to civil and military aviation.

Noise is a fundamental problem for which science has yet to find a satisfactory solution. In the domestic environment, military aircraft are operated to minimize annoyance to the civil population.

Mr. Hechler. Some people would argue with that.

Dr. Larsen. Yes, sir. I think in general, as you well know, Mr. Hechler, they attempt to follow the same procedures as civil airliners do as far as takeoff and climb restrictions and so on are concerned.

Mr. Hechler. Well, they always say they are going to put their sonic booms over West Virginia because there are less people there. [Laughter.]

Mr. Pelly. I don't think you are referring to the Air Force sonic boom tests made over certain cities, including the city of Seattle, when you say they are of no consequence.

Dr. Larsen. No, Mr. Pelly. And, of course, you are even better informed than I that these were part of a deliberate series of tests arranged for the FAA, which I hope will provide better understanding.

Mr. Pelly. I hope the results will be better so they will not be of as great a consequence as you have indicated in your statement.

Dr. Larsen. Thank you, Mr. Pelly.

In a combat environment, the noise the aircraft generates is generally of no consequence, so we have not imposed a performance penalty for the sake of minimizing its noise; we have not, therefore, carried on extensive R. & D. programs to reduce aircraft noise. On the other hand, there are certain military missions that require truly silent aircraft. With presently known techniques, the penalties in performance, cost, and safety to achieve this special capability are considered so great as to rule out any significant civil application. Since we are exploring the application of these principles to more common aircraft and helicopters, benefits to civil aviation may result.

As a result of the Project Beacon report in 1961, the President directed maximum use of DOD resources to create the national airspace system (NAS). Since that time, DOD research and development programs have made substantial contributions to the NAS in the area of air traffic control. Those contributions have come from the air traffic control radar beacon system developed as an aid to military operations during World War II and later integrated into the SAGE air defense computer system. The radar beacon system was subsequently adopted by the FAA to provide identity and altitude reporting of aircraft, and, concurrently with its adoption for civil use, the FAA called for modernization of the system to new national standards. The new national standards required that new beacons and altitude-reporting features be provided in all military aircraft, and that associated FAA and DOD ground systems be modernized.

Much of the improved altimetry-reporting capability was dependent upon new development efforts for high-performance jet aircraft, all of which was sponsored by DOD.

Several major projects have been jointly sponsored by DOD and FAA in order to develop the ground-based components for the National Airspace System:

The Common Digitizer, which enables the transmission of radar and beacon transponder information from DOD and FAA radar and beacon sites to an NAS control center. Six Common Digitizer units have been installed in Jacksonville, and it is planned to install about 180 altogether in the United States.

The TPX–42 airport traffic control facility for the display of aircraft identity and altitude. FAA and DOD call for the installation of some 250 units of the TPX–42 at civilian and military airports.

Related to the broad problem of traffic control is the problem of improving all-weather landing and long-range nagivation in which the Defense Department has a continuing interest. This has stemmed from our interest in improving the capability for all-weather operation of our global transport aircraft and an even more pressing requirement for this capability in our tactical aircraft. We can identify at least 30 separate projects in the area of all-weather landing and a score of major navigational programs that have been sponsored in recent years.

A few examples might help to illustrate our interest in landing and navigation. Eleven of our aircraft carriers now have a pilot's "hands-off" capability for blind landing. This system, known as the SPN–10/–42, utilizes carrier-based radar and a direct automatic data link to the aircraft autopilot. Still another example: Two of the military departments are now installing and testing microwave scanning-beam landing system, which have also been under consideration and test within the FAA. Because of the potential of scanning-beam technology in common civil and military use, our joint interest in this program continues to be addressed.

In the area of navigation we are continuing to investigate the use of OMEGA and Loran as well as satellite technology that would be applicable to long-range in-route navigation.

In these areas, where our equipment must conform to civil standards, we participate very closely with FAA in the testing, in the planning, and in policy decisions. Our compelling interest stems from the fact that our aircraft fleet, which is now in excess of 30,000, may require a major investment to implement these programs.

A discussion of air traffic control would not be complete without mentioning Defense interest in the Collision Avoidance System (CAS) that might be adopted. We are sharing with the FAA test results of the basic techniques employed in a Collision Avoidance System utilized in a classified military project. We recognize the inherent potential of the time-frequency technique employed in CAS, but it is also apparent that unless the cost factors become more favorable than at present the DOD might be required to invest a billion dollars in order to cooperate with a Collision Avoidance System that might be adopted.

The solution to the ground congestion is far from clear. Many proposals have suggested V/STOL aircraft as a major component of the overall system, and the results of numerous studies indicate such an attractive potential that further R. & D. must be carried out. Because of the possibility of eliminating new airport requirements and also of operating into otherwise inaccessible areas, the military services have expended substantial funds on V/STOL R. & D.

More than $500 million has been invested in military V/STOL research and development and in developing 19 different models of V/STOL aicraft. At the present time no V/STOL machines other than helicopters are operational. Nevertheless the Air Force has underway the concept fomulation of a light intratheater transport (LIT) which considers STOL and VTOL capabilities and which may extend the previous work performed on the XC-142. Similarly, the Army program designated "Research Helicopters" will provide information on tilt-rotor and stowed-rotor type helicopters. Both LIT and research helicopter efforts are expected to be of great interest to civil aviation because of their possible application to short-haul commercial transportation.

All of the military V/STOL programs have been closely coordinated with other Government agencies and private industry. The resulting data have been widely disseminated.

Safety is a matter of vital concern to all aviation users. Some aspects of safety are common to both civil and military aviation—structural integrity, engine reliability, fire resistance, stability, and control, for example. In other cases our Defense safety requirements differ from those of civil users and, in fact, lead to entirely different approaches. The military emphasis is on battle damage which involves a significant probability of losing the aircraft in a hostile environment; thus a major effort is made to insure crew escape from a damaged aircraft and subsequent rescue from land or water. The system is designed with the expectation that the vehicle may be destroyed in flight. On the other hand, the civil transport is designed with the expectation that the vehicle will not be destroyed, and this generates completely different weighting factors in passenger or crew survivability. Nevertheless, in general, there are items that are of interest to both civil and military authorities that warrant coordinated effort on problems of safe flight.

The DOD has continued a strong program of aircraft engine development. Essentially all of the presently operating commercial aircraft have engines derived from military types. The engines for two of the latest aircraft, the DC-10 and the Boeing 747, had their origin in the C-5A program. The new engines now under development for the military VFX and FX fighters have not yet been programed for civil use, but certainly the technology of high temperature and refined design will find its way into commercial use if an application for these specific engines does not develop.

Of direct interest to civil operators is DOD's work in cargo handling. In this area we have developed an air-cargo-handling system based on 88 by 108-inch pallets and a rail and roller system designed for ease of moving the pallet loads into the aircraft and locking them in the restraining rails. The system includes nets for restraining cargo on the pallets, terminal equipment for sorting cargo and loading pallets, and an assortment of mechanical equipment for handling loaded pallets between terminal and aircraft. It includes equipment for loading and off-loading cargo at austere airfields without terminal facilities. The use of this system has reduced the time required to load and unload military transport aircraft from several hours to about 30 minutes.

The current R. & D. program is designated to upgrade the system to handle the increasing volumes of air cargo and to absorb the impact of much larger cargoes to be carried by the C–5A aircraft. The program includes the development of (1) a family of containers to be used with pallets, (2) improved pallets and nets, including modular arrangements, (3) more effective restraining systems, and (4) improved docks and equipment for handling loaded pallets.

Mr. Chairman, the research and development programs of the DOD will continue to contribute to the progress of civil aviation. In the newer aeronautical fields such as V/STOL, our contribution will remain significant. In many aspects of avionics we will both contribute to and benefit from civil aviation developments. I believe, however, that with the necessary airline emphasis on the rapid transfer and handling of people at minimum cost and the DOD emphasis on the transport of large, heavy equipment and the ability to land in relatively unimproved fields, even the transport aircraft of the Department of Defense and the civilian aircraft industry will diverge.

There will continue to be contributions from military aircraft development to civil aviation. Since these predominantly will be in the nature of subsystems and technological assistance, a significant and major tack remains to be accomplished—that of system integration. If our civil aviation is to continue its dramatic progress, the greatest single requirement is to accomplish adequate and complete system engineering. The system analysis and planning must consider not only an aircraft in flight as a system, but also the entire problem of moving people from destination to destination. To effectively solve the many problems involved in flight, air traffic handling, landing, and ground handling, as well as people and baggage distribution, will require the assignment of engineering and planning responsibility and the allocation of sufficient resources in people and funds to insure the execution of the many tasks involved. I am sure these requirements call for planning and resources on a considerably larger scale than are now available.

The DOD will be glad to assist in the execution of this vital and important task.

Thank you very much for the opportunity to present this statement, Mr. Chairman.

Mr. Hechler. Thank you, Dr. Larsen. Your testimony has been very helpful to the committee.

Now, I would like to ask you a question, if you would reflect on it a minute, in terms of your personal assessment and appraisal rather than as an official of the Department of Defense.

Looking ahead over the next decade in aeronautical research and development in all its phases, military and civilian, what do you think are the real priorities that we have to emphasize in the next decade?

Dr. Larsen. I think the report from the National Academy of Engineering has emphasized many parts of this problem and has done so extraordinarily well, as has previous testimony that you have elicited from witnesses, Mr. Chairman.

I would say, however, that of even greater importance are the understanding and the careful planning of the entire transportation system. And recognizing that in civil aviation, as I have just said, this is primarily a matter of moving people from home, from office, from industry, and government, in one city, getting them to a place where they may board an aircraft, transporting that aircraft safely and quickly without undue delay to a destination city, and again dispersing and planning the routing of these people to many destinations, the understanding of that as an entire system is probably the most important. That part of it, I think, will take the greatest effort and greatest time.

Mr. Hechler. I share your concern that perhaps we are not devoting enough effort to that central problem. I wonder if you care to share with the committee your suggestions as to how we might improve our emphasis on aeronautical research and development?

Dr. Larsen. Mr. Chairman, I believe in the fundamental that, in order to get a particular task accomplished, you must assign responsibility. I think the general responsibility has been assigned to the Department of Transportation. And it doesn't matter whether it is an individual or—as in this case—a major department of government, I firmly believe you must give them the adequate resources in terms of increased personnel with many skills such as local traffic handling and architectural skills, as well as skills in the aeronautical field, and at the same time give them the resources to effectively call upon assistance from NASA, other Government agencies, and private industry. I think the task is larger than the resources now available.

Mr. Hechler. What is the chief limiting factor?

Dr. Larsen. I would say that it undoubtedly is the availability of funds.

I know that I am conscious of the fact, Chairman Hechler, that there is some shortage of engineers. But I think they can be brought into tackling some of the major and most important problems of our society as we look ahead, if the resources are available.

Mr. Hechler. Several witnesses have mentioned that in the areas of noise research and subsonic aeronautical research there is a shortage of engineers and scientists, and I wondered whether DOD has experienced the same shortage.

Dr. Larsen. Well, we are certainly conscious of the shortages. And this is substantiated, by the way—I think college enrollments have risen something like 39 percent since 1961, and engineering enrollment has only gone up 2 percent during that same period. And this is true, therefore, of aeronautical engineers, electronic engineers, and the others that are needed to work in this field.

In general we have not had a problem with regard to getting our military R. & D. tasks accomplished. What has happened, of course, because of the shortage, is that the costs of getting them done have gone up every year. But we have accomplished our most important tasks quite effectively, I believe.

Mr. Hechler. I would like to recognize Mr. Pelly.

Mr. Pelly. On that very same subject, I have often worried about duplication in effort. I understand that scientists don't necessarily believe that duplication is a waste. It is only business people that believe that and they may be right. But we have the National Science Foundation, the Department of Defense, and NASA all investing in the education of scientific personnel. Is it possible that by placing these activities under one agency, we could educate more engineers and scientists and enrich the available resources by that means, than by using all the different agencies?

What is your experience as far as getting technical talent in DOD?

Dr. LARSEN. Mr. Pelly, I think there are two principal objectives that we consider when the Defense Department spends research money at universities on work which assists in the education of graduate students and turns out engineers with advanced degrees. The two objectives are: The one you have alluded to, Mr. Pelly that is, assisting in the production of qualified engineers and scientists; that is one. The second one is to accomplish some research tasks.

If we had only the first objective in mind, then I believe that we could just as effectively turn out large numbers of scientists and engineers, probably more effectively, with a single management of some kind.

I think, however, that those scientists and engineers would be not quite as well prepared, because they had had work that was simply "made" work. In the Defense Department there is a relationship between our research and our development activities. We can anticipate to some extent the research that we need, and we try to get that. We find that we are in a development program, that we have to do additional research. That is a very powerful and necessary motivation for research people, and I believe that it is very effective in stimulating better scientists and better engineers as well as in getting some useful work accomplished.

Mr. PELLY. It seems to me that you could make your needs known and work closely with any of those who might benefit from the general assistance that would be given in the way of training engineers and turning out more scientists.

I can't see what difference there is between your program, and NASA's. You both have a common objective, and I am sure that the National Science Foundation does also.

We have some 50 programs in education today—50 different agencies involved in education. This cannot be efficient or effective. I realize that each department wants its own program.

Dr. LARSEN. I might add, Mr. Pelly, that as a scientific manager and engineering manager, I do not believe in duplication. And I think that——

Mr. PELLY. What I meant is that a research man turned loose, as you have indicated in your testimony, sometimes stumbles on something never anticipated——

Dr. LARSEN. True.

Mr. PELLY. And that is why I believe the scientists feel they should turn a lot of people loose on research even if they are working on the same thing, because they may stumble on different results.

Dr. LARSEN. I think you are entirely right, Mr. Pelly, that, if we could obtain thorough and adequate execution of that research which we believe is essential for defense without any transmission of funds to another agency, we could somehow get them to do that work which

Defense really feels it needs just as effectively as if we have the money. I think you are right.

A central authority could administer it with fewer total overhead people involved.

I think we find it extraordinarily difficult, however, in either industry or in government to get tasks accomplished without the authority of having dollars.

Mr. PELLY. I agree with that. That brings us back to the assignment of a responsible agency for pulling together the separate factors that you referred to on page 2 of your statement.

Dr. LARSEN. Yes, sir.

Mr. PELLY. This same problem has arisen in connection with oceanography. The Navy is the largest research agency in this field.

Dr. LARSEN. Yes, sir.

Mr. PELLY. We were going off in all directions. Now, there is a group of top people that are working to come up with some suggestions for pulling together these factors. I would be hopeful that this would extend to the realm of aeronautical research.

Mr. Chairman, there was another question I had in mind. But meanwhile, let me refer again to what you said as to the problem of moving people from destination to destination. And that goes for not only people, I know, but also for cargo.

Dr. LARSEN. Yes, sir.

Mr. PELLY. I remember a few years ago when the then Secretary of Defense told those of us who were on the Merchant Marine and Fisheries Committee that he didn't want any defense money to go toward surface transportation by sea because the military intended to airlift everything, except a few heavy items, on a roll-on, roll-off basis. Since then, we have had the escalation in Vietnam and he has been proven absolutely wrong. They are completely dependent on sea transport. It seems that one of the great factors involved, then, if we still do need sealift—and I think we do—should be research and studies on cargo containerization, tying in the trucks, trains, and the ships with aircraft on the basis of carrying a container from destination to destination.

That would also tie into the research on the V/STOL, helicopter, and all other types of air conveyances. Are you doing any research in that field?

Dr. LARSEN. Yes, we are, Mr. Pelly. Both the Army and the Navy are carrying on research and development work in containerization, in moving standard-sized packages which will fit into our aircraft as well as into ships in an economical and orderly fashion. The dimensions, for example, of our C–5A are planned to fit standard modular containers. This was also true of the C–141, although that was smaller. And these are carried over into sealift as well.

Mr. PELLY. You mentioned pallets. I was wondering whether the containers or facilities that you have for moving and handling cargo are being researched so that they dovetail with other forms of transportation?

Dr. LARSEN. The answer to that is yes, Mr. Pelly. There is a carryover, a standardization of our containers as used either on shipboard or aircraft.

Mr. Pelly. Have you any interest, for example, in the standard sizes that were recommended in the maritime field and the chaos that occurred? Two of the largest container carriers have hundreds of millions of dollars invested in equipment that have different size containers than recommended for the maritime field. We have all these transportation cost problems when efficiency and economic feasibility are so vital. I would think that the DOD would be deep into that field in research.

Dr. Larsen. I do not know whether our standardization people have been cooperating with civil agencies in the maritime field. I will be delighted to find that out and answer that.

(The information follows:)

The Department of Defense is working with the Maritime Administrator and the Department of Transportation on all aspects of the standardization of containers. We also have representatives on the U.S.A. Institute of Standards, and we participate in all of its discussions on the standardization of containers. But it is the policy of the DOD that, while we encourage industry to adopt standards, we do not use our influence to force industry or anyone else to adopt particular standards. We accept any service offered by the shipping industry if it meets military requirements whether or not it meets standards established by the U.S.A. Institute of Standards.

Mr. Pelly. Certainly it is in its infancy as far as the air traffic is concerned?

Dr. Larsen. Yes, indeed.

Mr. Pelly. Yesterday, one of the witnesses indicated that one way to relieve congestion at the airports would be to handle our cargoes quicker and more effectively.

Dr. Larsen. Yes, sir.

Mr. Pelly. Thank you, Mr. Chairman.

Mr. Hechler. Thank you, Mr. Pelly.

Mr. Lukens?

Mr. Lukens. Thank you, Mr. Chairman.

I think that there is no doubt that we are discussing major areas of concern. We could possibly spend all day discussing causes and problems. I would like to skip over problems for the moment, if I could, to tentative solutions and address myself to a particular field outside of research and development, facilities, and personnel. I am interested in this area of coordination, and I think, Mr. Pelly, it is the same thing that you brought up so cogently.

Are there any recommendations that you would make in view of the fact it does not appear likely that we are going to combine various Government agencies we have under one roof? I don't think the DOD is going to inherit the DOT or anyone else. Do you have any recommendations that would coordinate the work going on in all of these various areas?

I notice with some interest in your testimony that there were problems at the beginning of the SST. In order to get some engineering data derived from the F–111 and XB–70 programs into the SST program you had to arrange for clearances for civilian engineers.

Is this the current practice? Must there be special arrangements made if we wish to transfer information at higher levels? Have there been improvements in that field? What means do you suggest to facilitate further this exchange of information?

Dr. LARSEN. Mr. Lukens, I think that probably a very high percentage of information developed on military programs, probably 90 or 95 percent of the information of a technological nature, is made available without any special or unusual arrangements for the immediate circumstances. We do meet regularly with the Department of Transportation and NASA people, and a concerted effort is made to make this exchange very freely.

The point I was trying to address on the SST is this: You will recall in connection with the YF-12A, for example, one of the aircraft alluded to, that the aircraft itself was under even a special security label as far as its performance activities and everything about it were concerned. Very few people in the country knew there was such an aircraft. And it was at that time that we made special arrangements. But notice that we did, and we will certainly continue to do so.

May I answer another implied question, Mr. Lukens, that was in your mind?

I think the thing that I would recommend as being even more important—for example, in the FAA or in the Department of Transportation—in getting its work accomplished effectively would be that the agency have even greater control of the resources required to do research and development.

Now NASA is clearly—and I believe very properly—the agency that should carry on the research and development work. That is where the real competence in this field for civil aviation is. I think the Department of Transportation ought to have funds which it spends at NASA instead of simply relying on persuasion to get its programs accomplished.

Now NASA has been extraordinarily cooperative and very effective, but as I said before, the real authority in getting a program accomplished vigorously, quickly, and to time schedules, and managing it, comes when you do have control of the funding.

Mr. LUKENS. I think that is a very responsible analysis and suggestion in that area. I think that I would basically agree with that.

I would like to follow on to a specific.

Dr. LARSEN. Yes, sir.

Mr. LUKENS. Has the development of the SPN-10/42, or "hands off" landing system been coordinated with the civil aviation sector?

Dr. LARSEN. Complete information on this system has been given to FAA, to NASA and as far as I know, to anyone that can make use of it in civil aviation. If we have been neglectful in that area, I will be glad to make sure this is done properly.

Mr. LUKENS. One last question, Mr. Chairman.

In this same regard, do you think the 10-percent area where information is not automatically transferred can be decreased in proportion, or do you think that is a necessary area of security?

Dr. LARSEN. It stems only from security which is beyond the normal. Nearly all of this type of information—and I was just hazarding a guess when I said it was 5, 10 percent that might have to be specially arranged. It may be less. But the point is that this problem is recognized and can be resolved through the meetings, through the exchange of information we have between NASA, Department of Transportation, and DOD. And we will unhesitatingly make special arrangements whenever they are required.

Mr. LUKENS. Thank you, sir. I would like to say that having been a participant, and a very willing one, in investigating the technology and utilization aspect of NASA, this is probably one of the finest programs we have for recovering and promoting for the general public the good work that NASA has done as well as that of the military programs. I would like to say that if the FAA and the military participate in this aspect of the NASA program, it would be doubly advantageous to the public and the Government with regard to aviation.

Dr. LARSEN. Thank you. I quite agree, Mr. Lukens, that the utilization of technology is the most important facet of it.

Mr. HECHLER. Yes, I appreciate that comment too, Mr. Lukens.

A letter was read yesterday, written by the Space Council to the Secretary of Transportation concerning the study that has been authorized between the NASA and Department of Transportation on the national airways system. This letter had this sentence: "The Vice President requested prompt action on the study and agreed that the expertise of the Defense Department should be coordinated with that of DOT and NASA."

How will this be done? Is this being done and is attention being given to this?

Dr. LARSEN. Yes, Mr. Chairman, a great deal of attention is being given to it.

I did mention the Aeronautics and Astronautics Coordinating Board, which was originally established by NASA and the Department of Defense, and the fact that——

Mr. HECHLER. Yes. And if I may interrupt again, you mention on page 6, at the end of that statement, "Subsequent action by the Panel has been to consolidate and augment those programs of common interest." And it was to that quotation I hoped you could direct an answer, to expand on that last sentence in the middle of page 6.

Dr. LARSEN. Well, this panel, which is under the Board that I mentioned, and there are other panels, of course—reviews regularly both NASA programs in the aeronautics field and DOD programs. And so we make presentations to NASA, and more recently, to Department of Transportation and FAA people, and we hold specific discussions of our programs in each of many fields over a period of time. In the course of these presentations, they ask questions; they learn precisely what we are doing; they learn what are likely to be the products of the research that is being carried on; and they either directly receive the reports as they are written, various reports of research programs, or makes requests to have some of their engineers or scientists visit our research activities and learn firsthand.

In other words, it is an information-transferring mechanism that leads to followup. And I think it is quite good in giving a fairly thorough knowledge to NASA and DOT and DOD of each other's programs.

Mr. LUKENS. Mr. Chairman.

Mr. HECHLER. Mr. Lukens.

Mr. LUKENS. I wonder if I could ask a question before we leave that topic.

Mr. HECHLER. Yes.

Mr. LUKENS. According to the information I have, the Panel on Aeronautics under the Coordinating Board has not yet issued a report or survey. Can you tell me what the date and the content of the most recent report of that Panel was?

Dr. LARSEN. I cannot give you that information now, Mr. Lukens, but we can supply that for record. I have tried to convey an impression that the Panel does meet regularly, and I can very definitely give you an account of that. And presentations are made by the various agencies involved. NASA at one meeting will give a presentation on certain of their aeronautical programs, and there will be a discussion and a comment about them. This is followed then by Defense at some other meeting. And this leads to followup by individuals in whatever detail is desired.

(The information is as follows:)

The Aeronautics Panel has not prepared a specific report covering its activity relating to the aeronautics programs of DOT, FAA, NASA and DOD. The review referred to consists of briefings by representatives of the different agencies. From these briefings, programs of interest to more than one agency, and programs of a similar nature being carried on in more than one agency, were further examined for possible joint action. Such action might consist of joint funding, increased emphasis on a particular portion of the program, additional work to satisfy the needs of an agency other than the sponsor, and reduction or transfer of effort from one agency to another. Typical of these programs being examined are: NASA's utilization of the C–5A for research on large aircraft, direct lift control, fly-by-wire control systems, advanced composite materials, and thrust reversers. Similar items will be considered on a continuing basis. Since the programs are just being established, the agreements reached on them have not actually been implemented yet. As the programs are initiated, however, it is planned and expected to make the agreements part of them.

Mr. HECHLER. Will the gentleman yield?

Mr. LUKENS. Yes, sir.

Mr. HECHLER. Is it proper to use the words "consolidate and augment" as you have in your statement? Have you really consolidated and augmented as a result of this action?

Dr. LARSEN. There is no authority for that in the Panel—for example, if it is determined that there are two duplicatory programs, the Panel has no authority to make sure that one of them is eliminated.

I believe, however, that there have been good enough results from this that Defense and NASA duplication has existed.

There has been a considerable augmentation. Well, the best known program is the X–15, which has been carried on by NASA but for which a major part of the funding has come from the Department of Defense. This is an augmentation of their program with the Defense Department both requesting that most of the tasks be carried out for Defense and providing the funding that was required to carry on that program.

Mr. LUKENS. Would the chairman yield further?

Mr. HECHLER. Yes.

Mr. LUKENS. I am simply trying to determine whether it is one of the established goals of the responsibilities of the Panel to publish a report. It has stated that, typical of the Panel's action, is a review of the aeronautical programs of the military. This is fine. But, is there to be a publication of this review or will it be contained in the minutes of the meeting for the purpose of internal consumption only?

Dr. LARSEN. To the best of my knowledge it has been only the latter, the exchange of the minutes within.

Mr. LUKENS. So it is primarily to serve the agencies represented on the Panel?

Dr. LARSEN. That is correct. There is some desirability of enlarging that responsibility and we would be very glad to consider that with NASA.

Mr. LUKENS. It states here: "The review gave an overall perspective of the individual programs." I would like to see an overall perspective of these programs. I would like to be exposed to something that would give me an idea of what we are striving to do as to coordination among the agencies.

The biggest problem today is the coordination of information. The fact is that we have a big government, and I am, as is every member here, interested in better and more efficient government. As you know, this is the year of the taxpayer. I would like to do my bit to see what wherever we have such panels, that someone is advised or informed about their activities.

I know that you gentlemen are aware of the coordinating panels, and I am very proud of the job you are doing. But sometimes I am not aware of them and yet I am the one who has to go back and try to answer for what we are doing.

Dr. LARSEN. I understand that. I must confess that the words are perhaps a little high flown.

Mr. LUKENS. Thank you, sir.

Mr. HECHLER. You have some figures on the funding of research in civil aviation by the Department of Defense you would like to submit for the record, Dr. Larsen?

Dr. LARSEN. I would be glad to do so, Mr. Hechler.

(The information requested is as follows:)

ESTIMATED DOD R.D.T. & E. CONSIDERED OF BENEFIT TO CIVIL AVIATION

[In millions of dollars]

	Fiscal year		
	1967	1968	1969 [1]
Research	(2)	(2)	(2)
Army	(2)	(2)	(2)
Navy	(2)	(2)	(2)
Air Force	(2)	(2)	(2)
Exploration development	135.2	118.2	122.7
Army	19.8	18.9	23.1
Navy	55.9	47.0	26.9
Air Force	59.5	52.3	52.7
Advanced development	99.3	74.6	94.1
Army	9.0	17.1	15.2
Navy	8.6	3.2	5.9
Air Force	81.7	54.3	73.0
Engineering development	35.8	37.3	85.1
Army	6.0	4.0	4.9
Navy	11.0	30.3	58.2
Air Force	18.8	3.0	22.0
Operational system development	258.2	324.7	136.3
Army	20.5	30.1	13.0
Navy	11.4	20.4	4.3
Air Force	226.3	274.2	119.0
DOD total, all categories	528.5	554.8	438.2

[1] President's budget.
[2] Indeterminate.

Mr. HECHLER. Would you care to give us any quick highlight? I don't want to shortchange our next witness, but if you have any figures there that indicate the extent of support of civil aviation, they would be helpful.

Dr. LARSEN. For the fiscal year 1969—and these are numbers which, of course, are derived from the President's budget, recognizing that our budget has not been approved by——

Mr. PELLY. Has any of the overall $6 billion reduction been taken out of that?

Dr. LARSEN. A fraction of the $6 billion has been taken from this, sir.

And these are not the total dollars involved in the activities I am going to describe but that fraction of them which is believed applicable by our research and development staff to civil aviation.

I might add that, in the exploratory development which follows the more basic research, we believe that transfer is quite high and that most of the dollars spent in military exploratory research are applicable to civil aviation. In engineering development, where we are turning out an airframe, we think it is very low. So with that explanation, I will read the figures for fiscal year 1969.

Our 6.2 budget category of exploratory development, $122.7 million.

In our 6.3 advanced development, $94.1 million.

In our 6.4 engineering development, $85.1 million.

And in operational systems development, that is, in engineering development that has been approved for deployment—one of the systems included in this category is the AH–56, the advanced helicopter that Lockheed is developing for Defense, $136.3 million.

The total of these categories is $438.2 million.

I will turn over, for the record, fiscal year 1967 and 1968 as well, but they are approximately the same amounts, and it is anticipated that we will be requesting similar amounts in fiscal year 1970.

(The information requested is as follows:)

ESTIMATED DOD R.D.T. & E. FUNDS WHICH ARE CONSIDERED OF BENEFIT TO CIVIL AVIATION

[In millions of dollars]

	Fiscal year 1967	Fiscal year 1968	Fiscal year 1969 [1]
6.1 Research	(2)	(2)	(2)
6.2 Exploratory development	135.2	118.2	122.7
6.3 Advanced development	99.3	74.6	94.1
6.4 Engineering development	35.8	37.3	85.1
Operational systems development	258.2	324.7	136.3
DOD total, all categories	528.5	554.8	438.2

[1] President's budget.
[2] Indeterminate.

Mr. PELLY. Has inflation reduced the amount of value that you receive from each dollar; such as 10 percent over the last 3 years?

Dr. LARSEN. Yes, Mr. Pelly. I don't know whether it is 10 percent in 3 years or 5 percent a year, but the inflation does cost us about that much and will, I think, continue to in the immediately foreseeable years.

Mr. PELLY. Do you have the number of personnel now employed as against previous fiscal years?

Dr. LARSEN. You mean within defense laboratories?

Mr. PELLY. How many are now engaged in research as compared with previous years?

Dr. LARSEN. I do not have that available. Again I will be glad to determine the information for you, Mr. Pelly, if you desire it in the record.

(The information requested follows:)

	Fiscal year 1965 actual	Fiscal year 1966 actual	Fiscal year 1967 actual	Fiscal year 1968 estimated
Average number of civilian employees in DOD R.D.T. & E.[1]	71,004	73,478	77,064	75,059
Percent of fiscal year 1966[2]	97	100	105	102

[1] Includes professional and all supporting nonprofessional Government employees whose salaries are paid by the R.D.T. & E. appropriation.

[2] The 1966 base is selected to coincide with the June 30, 1966, civilian employment limitation reference of sec. 201 of Public Law 90–364.

DOD CIVILIAN EMPLOYEES IN AIRCRAFT AND RELATED R.D.T. & E.

	Fiscal year 1965	Fiscal year 1966	Fiscal year 1967
Number	15,451	16,028	61,26

Note: Excludes aeromedical R.D.T. & E.

Mr. HECHLER. What is it, about 5 percent of the defense budget?

Dr. LARSEN. Yes; that is approximately correct, Mr. Hechler.

Mr. HECHLER. And is the squeeze on?

Dr. LARSEN. This is the amount that is estimated to be of benefit to civil aviation.

Mr. HECHLER. I understand that. But I just wondered if you felt that you are bumping your head against the ceiling. In other words, you have enough——

Dr. LARSEN. No; in fact, I think my testimony indicated, Chairman Hechler, that we would be spending rather larger amounts in aviation in the near future and that, for instance, in addition to the aircraft that I said were projected or have just started, we are currently developing the AAFSS, or AH–56, and the EA–6B. We have just completed the OV–10, and of course you all know the C–5A is under way.

Mr. HECHLER. Of course I would just like to observe it is a little easier for the Department of Defense to get $400 million than it is for the Department of Transportation to get an equal amount. And when Mr. Pelly was remarking on the multiplicity of education programs, perhaps we should recall that one pioneer education program which was initiated about a decade ago we could only start by calling it the National Defense Education Act. So sometimes it is a little bit easier to get money in the name of defense.

We certainly want to thank you for your appearance this morning, Dr. Larsen. And we have other questions that we would like to submit to you for the record since we have another very important witness this morning.

We want to thank you and Captain Brittain for appearing this morning.

Dr. LARSEN. Thank you very much for the opportunity. And of course we will be glad to respond, Mr. Chairman.

Mr. HECHLER. We appreciate that.

(The questions posed by the committee follow):

QUESTIONS SUBMITTED TO DR. FINN J. LARSEN BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. You mentioned the special arrangements for the civil developers of the SST to obtain classified data on the XB-70, F-111 and YF-12 programs. Are such arrangements desirable or being contemplated for the transfer of any classified information to the civilian sector on your current programs on VTOL, STOL and helicopter aircraft? Will such arrangements be made automatically by your agency when there appears some potential application to civilian needs from your programs or will interested civil developers be required to seek such transfer of information on their own initiative?

If the latter is the case, how are such civil developers kept appraised of technological advances in military programs which might be applicable to next generation civilian aircraft?

Answer 1. No special arrangements are considered necessary for transfer of information on VTOL, STOL or helicopter aircraft, for it is unlikely that data needed by civil developers in this field would be classified. Such data are widely disseminated in professional society meetings and publications and the trade press, as well as the various agency publications. However, in the event a problem does develop, we would take positive steps to make the data available.

Question 2. It appears that the fall out from military aeronautics research and development programs to the civilian sector will not be as dramatic in the future as it has been in the past. However, technological developments in subsystems, such as guidance, control, etc., should have substantial application. Would it be possible to increase the expected fall out from military programs in the future if increased funding was provided from civilian governmental agencies to your agencies to carry out research programs in parallel to the military objectives? Might this increase the direct application of certain technological advances to civilian use from that which we might expect normally?

Answer 2. Yes, it certainly seems possible that increased funding, as proposed, to permit civil effort paralleling the military program will accelerate or increase the fallout to civilian usage. However, because of the many factors that are significant to a program, such as priority, security, manpower, and facility limitations, for example, it would be necessary to judge each case on its own merits.

Question 3. Dr. Foster, in his testimony before the Senate in January of 1967, cited several examples of joint DOD-NASA-FAA programs such as clear air turbulence program, fog dispersal, sonic boom, and the hypersonic technology program involving the X-15 and XB-70. Could you testify as to the progress made to date on these programs and the extent of DOD participation and funding? Is the DOD contemplating entering into additional DOD-NASA-FAA programs and, if so, in what areas?

Should there not be an extensive series of such joint programs on specific technology areas to marshal the resources of the 3 agencies?

Answer 3. Dr. Foster testified before the Senate on these programs twice subsequent to January 1967. The DOD has since transferred the X-15 and XB-70 programs to NASA, because it was felt that future major interest in them would be in the civil rather than the military field. The same holds true in hypersonic technology, for which there is currently very little DOD funding; we are depending on NASA to advance this technology. The DOD continues to participate in national programs on clear-air turbulence, fog dispersal and sonic boom by providing facilities and operational aircraft to assist them. We have no project funding specifically identified for that area. As I indicated earlier, the Aeronautics Panel of the Aeronautics and Astronautics Coordinating Board is considering some programs for joint agency support. The Panel will continue to emphasize joint programs as extensively as is practical.

Question 4. Are you satisfied that the aeronautical research personnel and facilities of NASA are being used to the optimum extent in assisting your agency in carrying out its military aeronautical responsibility? Should there be a greater level of effort in this respect?

Answer 4. Yes, we are satisfied that NASA is performing well all military priority tasks assigned to it.

Mr. HECHLER. Our next witness will be Gen. William F. McKee.

General MCKEE. Good morning, Mr. Chairman.

Mr. HECHLER. Good morning, General McKee.

General MCKEE. I am up here all by myself, Mr. Chairman.

Mr. HECHLER. We are glad to have you back before this committee. The last appearance you made was as FAA Administrator, a position which—let's see, I guess it was 1965 you first became Administrator, wasn't it?

General MCKEE. In the midst of great controversy at that time, as you remember.

Mr. HECHLER. I would like to ask unanimous consent to put a biography of General McKee into the record. General McKee is now with Schriever-McKee Associates. And we are very pleased to welcome you here this morning.

Do you have a prepared statement?

General MCKEE. I do, sir.

(The biography of General McKee follows:)

GENERAL WILLIAM F. MCKEE, USAF (RET.) ADMINISTRATOR, FEDERAL AVIATION AGENCY

General McKee is currently President of Schriever-McKee Associates, Arlington, Va.

General William F. McKee, USAF (Ret.), was nominated Administrator of the Federal Aviation Agency by President Lyndon B. Johnson on June 23, 1965, confirmed by the Senate on June 30 and sworn in on July 1.

According to President Johnson, General McKee was recommended by Defense Secretary Robert McNamara as "one of the most knowledgeable and competent administrators in the Defense Department."

On retirement from the Air Force in August 1964 General McKee was Vice Chief of Staff. In September 1964 he joined the National Aeronautics and Space Administration (NASA) as Assistant Administrator for Management Development, a post he held prior to his FAA appointment.

Born at Chilhowie, Va., on October 17, 1906, General McKee was graduated from West Point in 1929 and commissioned a second lieutenant in the Coast Artillery Corps of the Regular Army.

General McKee served in Army assignments in Florida, the Canal Zone, California, the Philippines, Puerto Rico and the Norfolk Naval Station, Va., before he transferred to Headquarters, Army Air Force in January 1942. He received his first star in 1945 and was appointed Chief of Staff of the Air Transport Command in 1946. In August 1946 he went to Europe as Commanding General of the European Division, ATC, with headquarters at Paris. In December 1946 he transferred to USAF Europe (USAFE) headquarters at Wiesbaden and became its commanding general in January 1947.

When the Air Force became a separate service in 1947, General McKee returned from Europe to work under General H. H. "Hap" Arnold in setting up the new service. He was appointed Assistant Vice Chief of Staff of the USAF in September 1947 and was promoted to Major General in 1948. He remained in this post for nearly six years.

In 1953 General McKee became Vice Commander, Air Materiel Command, USAF, and continued in that post when AMC's name was changed to Logistics Command. He gained his third star as Lieutenant General in 1957, and, in August 1961, was named Commander, Air Force Logistics Command, receiving his fourth star at that time. The following July he became Vice Chief of Staff, USAF, under General Curtis LeMay.

General McKee was awarded three Distinguished Service Medals during more than 35 years of military service. He was also the recipient of the first annual Distinguished Management Award for outstanding contributions in Air Force logistics assignments.

A past president of the Armed Forces Relief and Benefit Association, General McKee is married to the former Gertrude Scheele. They have two sons and live at 2410 South Lynn Street, Arlington, Va.

Mr. HECHLER. You may proceed, sir.

General McKEE. Before I proceed with my statement, Mr. Chairman, I would like to say that this statement was written by me and represents my personal views.

STATEMENT OF GEN. WILLIAM F. McKEE, SCHRIEVER-McKEE ASSOCIATES

General McKEE. Mr. Chairman, members of the committee: I appreciate the opportunity to appear before you today. I would also like to commend you for the series of hearings on aeronautical research and development, which I think is very important.

I have been following closely the testimony before the subcommittee of Secretary Boyd, Assistant Secretary Lehan, Acting FAA Administrator Thomas, Dr. Paine, and Mr. Harper of NASA, and others. Collectively they have made a thorough case of the value of Aeronautical Research and Development and its importance to the safety and effectiveness of the air transportation system. I am in full accord with the statements and the recommendations made by this group.

To highlight the importance of aeronautical research and development, it might be worthwhile to take a brief look at the problems confronting our national air transportation system today. As we examine the problem in some detail, it becomes eminently clear that aggressive action over the entire spectrum of aeronautical research and development, and on a continuing basis, is essential if we are to prevent a much more serious crisis in the years ahead. Perhaps we should project ourselves forward to the year 1980 and try to visualize the air transportation picture or the air environment of the 1980's. We ask ourselves how many air-carrier aircraft will be operating in this environment and what types; how many general aviation aircraft and what types of general aviation aircraft will be operating in this environment? How many passengers will the system be carrying? When we have answered these questions, and there are fairly good predictions by Government and industry—although I think conservative, if history is any example—we should then back off to the year 1968 and ask ourselves the question: "What should we be doing now in the area of aeronautical research and development to insure a safe and effective and economically profitable air transportation system and one which will provide first class service to the public." Had we gone through this exercise 10 or 15 years ago, we might not be beset by as many problems as we are today.

The airways/airport crisis, to put it another way, "The Air Congestion Problem," came into focus for the Nation on Friday, July 19, commonly referred to in various areas in Washington as "Black Friday." On this day, thousands of airlines passengers were stranded in the air over New York City, and many thousands of others were stranded on the ground throughout the country.

Looking at that day, from a national point of view, it may have been a beneficial experience. I realize that no one, and that includes me, who was involved in it feels that way about it personally. But, on the other hand, it did serve to highlight a serious problem, and it raised a red flag for all of us to see.

I would like to define the problem as I see it—to explain the principal causes and suggest some solutions.

The problem is a two-part one—the so-called air traffic control system and the airport. I like to refer to it as the airways/airport problem. I would like to emphasize here that I consider the runways, the taxiways, and the ramps of an airport to be a vital part of the air traffic control system. And Mr. Chairman, this is just generally not understood, I think, in Government as a whole, and is certainly not understood by the public. In actuality, the biggest bottleneck we have in the system today is the airport. This is not to say that there are not any other deficiencies in the system. There are some very important ones which I will mention later.

There are a number of basic causes of the air traffic congestion we have today. In the first place, both industry and the Government underestimated the fantastic growth of civil aviation. To put it another way, the technical improvements in the airplane and the public demand for air travel far oustripped the progress of the ground environment to handle the problem. In the second place, our long-range planning was not as good as it should have been—and I accept my full share of responsibility for that. In the third place, we did not conduct sufficient research and development in electronic systems for air traffic control and in airport design. And, finally—and fundamentally—we have not had the necessary funds to do the job. After all, the budget for FAA and other agencies of the Government involved with air transportation, has been in competition with many other important programs, such as Vietnam, problems in our cities, and many other problems well known to this committee.

To get down to specific causes, as I mentioned before, the biggest problem of the air crisis is too little ground— not enough runways, taxiways, ramps, and not enough airports. This is true for both the scheduled air carriers and for general aviation.

An airport can be compared to a funnel. When the volume of inbound and outbound traffic becomes excessive, the funnel becomes clogged, traffic flow is restricted, and the delays build up in a chain reaction completely across the country. It isn't too unusual today for air traffic control to hold flights on the ground on the west coast because of "funnel clogging" on the east coast.

A moment ago, I said I would outline for you some of the other deficiencies in our air traffic control system. First, we need more and better long-range radars for the en route system. We need a great many more terminal radars at airports being served by commercial carriers. We need more redundancy in both systems. A great deal of improvement is needed on terminal area traffic control. I think all of our airports being served by commercial carriers must eventually have instrument landing systems, high intensity lighting, and control towers. A great many do not now have these facilities. We need better communications and better navigation systems. Our weather forecasting and reporting system must be improved. There is an urgent need for the development of a collision avoidance system which is economically practicable for all segments of aviation. In another area, we have only scratched the surface in finding the solution to the noise and the sonic boom problem. The massive effort required in aeronautical research and development becomes clear when we analyze the impact that these problems have on the effectiveness and on the safety of the entire system.

Another severe problem and an important one in our air traffic control system is the shortage of air traffic controllers. In a great many of our air traffic control facilities; that is, the en route traffic control centers and towers, the controllers are working 6 days a week, 10 hours a day. If I had my way, they would work no more than 6 hours a day on the radar scope, 5 days a week, and they would spend the other 2 hours each day in training.

Because of the air traffic congestion problem confronting us today, the FAA has proposed some quick fixes in the interest of safety and effective operation of the system. Insofar as the golden triangle is concerned, that is New York, Chicago, and Washington, these restrictions will specify the number of takeoffs and landings within the golden triangle area during peak periods. Both the carriers and general aviation will be affected. It is unfortunate that such action has to be taken, but I don't think there is any immediate alternative. Of course, this is a "band aid" solution to the problem. We need to move now toward a permanent solution as rapidly as possible in order to prevent severe restriction in many of the other air transportation hubs around the country.

The entire problem was outlined in detail to the appropriate committees of Congress this summer along with an estimate of the resources necessary over the next 5 years to solve it.

It was made clear that we need to invest $4 to $5 billion over the next 5 years for new and improved airports. At least 900 new airports must be built and improvements to 2,000 of our 3,200 publicly owned airports must be undertaken.

In addition, we need to invest some $2 billion for the same period in modernizing the airways system. In addition to the deficiencies in the airways systems, which I have previously outlined, the system must be computerized and automated both in the en route system and in the terminal areas. Additional air traffic controllers must be hired, trained, and put to work.

The problem is, Where does the money come from? While there is almost unanimous agreement between the various segments of the aviation community and the Government on what needs to be done and what the costs will be, there is little agreement on the manner in which we foot the bill. Certainly I don't think we should expect the billions of dollars required to come from the general revenues of the Treasury. The President recognized this in a letter to the Secretary of Transportation last September. And he declared, and I quote:

It is apparent that the rapid growth of commercial and private flying is creating demands for substantial expansion and improvement in the Nation's air traffic control system. The Federal government is the manager of this system. System improvement will, therefore, require large additional outlays of Federal funds for investment and operations. Those who will benefit most from such expenditures, the aviation industry and the flying public, should pay their fair share of the costs of the system needed to handle the increases in air traffic while maintaining a high level of safety. I do not believe the general taxpayer should be asked to shoulder this burden.

It seems to me that a feasible method for obtaining the resources for the expansion and modernization of the system is an airport/airway trust fund. Such legislation has been proposed by the Senate Commerce Committee. This trust fund would be similar to the highway trust fund which, as you know, has been enormously successful. The airport/airway trust fund would be supported by a system of user charges with each segment of the aviation community paying for its fair share. I am convinced this legislation, or similar legislation, would be enacted promptly by the Congress if we could get even reasonable agreement from the various segments of civil aviation.

The alternatives, Mr. Chairman, to finding an equitable means of providing the resources required are clear:

(a) Further regulatory actions on the part of the Government.

(b) A deterioration in the safety of the system.

(c) Increasing delays and the consequent frustration to the traveling public.

(d) And very important—An adverse, and I mean a real adverse, impact on the growth of our national economy.

In conclusion, Mr. Chairman, it seems quite clear that a vigorous and imaginative aeronautical research and development program, properly funded, is vital to the national interest.

Thank you.

Mr. Hechler. Thank you very much, General McKee.

How do you get more leadership into the aeronautical research and development program of the Nation?

General McKee. Well, one way you could get more leadership into it is to find some way to get the funds, Mr. Chairman, to have this job done.

We can sit up here and talk, and you can have all the witnesses you want before this committee. They can spell out, as they have, what needs to be done in the aeronautical research and development areas, along with the things that have to be done now that are really not in the aeronautical research and development program. But we look around and say "Where is the money?"

Mr. Hechler. I would like to argue with you just a little bit, or discuss that point with you, because it has been my general observation in the operation of Government that where there is a real fire, then the Congress will move to put that fire out. Maybe the need has not been sufficiently demonstrated.

General McKee. That is the reason I said in my statement that I am not a bit sorry about what happened in New York on July 19. I have made speeches and I have testified before Congress as to the problem and what is required. And that one day did more to highlight the problem on a national basis than all the speeches I have made. And thank God no one was killed or anyone injured; we were very fortunate.

Mr. HECHLER. You made a very great contribution here, I think, in showing the integral relationship between the air traffic control system and the airports. But even if we had the money to put into the expansion of all these airports and building new ones that are necessary, do you think that the job could be done as long as we have the current system of a lot of competing local authorities and argument among political instrumentalities? There is a tendency on the part of the Department of Transportation and the FAA to say, well, this is a democracy, a local problem, so let's pass the buck back to the locality. How can you possibly get the problem solved with that kind of mechanism?

General McKEE. It is a very difficult problem to solve, Mr. Chairman.

I have been involved over the country in these various disputes concerning airports. In the New York area, for example, I think they have some 1,100 different political jurisdictions. We still haven't solved the New York problem.

But again, one of the handles on this problem would be the legislation that has been reported out by the Senate Commerce Committee which sets up an airport/airways trust fund which, in effect, doubles the amount of money now available for Federal aid to airport programs on a matching basis. This gives the Federal Government some handle on the development and modernization of airports.

You are never going to solve it completely until you get the cooperation from the local authorities as to what it means to their own economy.

Now, I think in the New York area, unless a solution is found in a reasonable time and if this situation grows, they are going to have to divert flights out of Kennedy and La Guardia. There should be perhaps more flights out of Dulles or out of Philadelphia going overseas. There is just going to have to be a redistribution, because there comes a time when, as I pointed out about the funnel, you can't handle any more traffic. If traffic is going to grow and people are going to move, then they've got to depart from some other place. And I would think that the local jurisdictions around New York would realize what this would mean to New York if they on a local basis didn't do something to solve their own problem.

Mr. HECHLER. Well, this is one reason why I have observed that maybe we need not only technological research, but we need what I guess could more properly be called planning so as to try to avert this kind of crisis.

General McKEE. Of course, one of the reasons that the Department of Transportation was set up was to take the leadership in transportation policy, which includes air transportation, at the Cabinet level. I know Mr. Boyd is very intensely interested. I know he understands the problem. And I think as we go downstream, that the Department of Transportation should have the capability of providing the leadership in this area that is needed.

Now—and I think it is important—that doesn't mean that the Department of Transportation has to set up a tremendous big research and development organization. I think it means that the Department of Transportation with the capabilities they have in their administration and so forth, should spell out, looking at 1980, for example, what is needed in the research and development area in civil aviation, and let NASA do the part that they should properly do. We have a very vital one in ESSA on weather forecasting and reporting. We need a lot of work done on that. As the leader under the President, the Secretary of Transportation, can point out what needs to be done by the various agencies who have the most competence in the field. And if he can't get cooperation, and if I were the Secretary of Transportation I would write out a little memorandum and take it over to the President and have him sign it and sent to this agency—maybe it is NASA or ESSA or maybe DOD—and say, "do it," and report to me in 30 days what you have done. And these are very effective memorandums, Mr. Chairman. [Laughter.]

Mr. HECHLER. Do you think the Space Council could help any in this process?

General McKEE. I think the Space Council could help a lot. After all, they are reporting to the President, and if the Space Council is knowledgeable—and I found them to be generally knowledgeable—they can be a lot of help as to what needs to be done.

But again, the Secretary of Transportation—and Mr. Boyd understands this—can, I think, exert the leadership that needs to be applied in working with the President and the executive offices of the President and get a lot more done than we are doing now.

Mr. HECHLER. Before I recognize Mr. Pelly, I would just like to observe that Senator Randolph introduced the bill and I also introduced the bill in the House that sets up a trust fund with user charges that would be able to finance the development of airports in the future. Of course, this committee does not have jurisdiction over considering this bill, even though we are deeply concerned with advanced aeronautical research.

Mr. Pelly?

Mr. PELLY. I don't have many questions, because I don't think you left us much to ask you.

I would like to say that I am very happy to have a witness come before this committee and firmly speak out against tapping the General Treasury. And I think my chairman's bill takes the same approach as the Eisenhower highway program, which was very successful. Certainly, when the local communities and the States saw Federal money available they began to support the general program.

General McKEE. I think the same thing, Mr. Pelly. If we could get this done and get the money into the pot that is required, and if people could see a tremendous improvement in the system and service to the public, the public is going to take the same attitude they have taken toward the gasoline tax.

When I ride out on the highway I don't object to paying that Federal gasoline tax, because I have a better ride going down to Saltville, Va., where I was born. It used to be a two-lane road; now I can go down on a four-lane highway. I am happy to pay it.

Now I am in the public, I will be riding, traveling over the country on commercial airliners. I would be very happy to pay that extra percentage tax required on the ticket because I know I am going to get better service and I know I am going to have a safer operation.

Mr. PELLY. I am very happy to pay the tolls on some of these freeways because it avoids the congestion, avoids going through cities, and avoids many other hazards. I must say that I hope that in the next Congress something can be done along that line.

Getting back to actual research, you used the word "massive," to describe the effort required in this research. Would that entail twice as much as what we are doing now, or——

General McKEE. Sir, as I say, I tried to get somebody to write this statement for me like I used to do when I was in the Government, and they wrote it for me. I looked at it yesterday morning and threw it in the trash can and started out from scratch. I felt pretty strongly about this then so I used the word "massive." Maybe I should have been more conservative and used the words "a significant increase."

But I think it is clear to all the members of this committee and it is clear to the entire aviation community that had we done the research and development that we probably should have done, or if we had had the money to do it, we would not be in the terrific bind we are in today. We would have better radars, we would have better communications, we would have redundancy communcations, and maybe by this time we would have a collision avoidance device that could be put on all airplanes at a reasonable cost. Maybe we would have better weather forecasting and reporting. You name it, the whole spectrum.

Mr. PELLY. Unfortunately, it is water over the dam. But I think what you are getting at is, don't make the same mistake again.

General McKEE. No use talking about that except to project yourself into the future and say, "OK, we can't do anything about yesterday, but we can surely do something about tomorrow."

Mr. PELLY. In other words, you are agreeing with Secretary Boyd that the present level of funding for the research program is inadequate?

General McKEE. It is totally inadequate. Just look back over the research and development budget in aeronautics both in NASA and also in FAA over the past several years—and this has nothing to do with Democrats or Republicans. You can go back to the 1950's, and we have had similar problems. So this is completely nonpolitical. It is just a question of getting the resources. And I think the President has proposed an equitable means of putting some money into the till to get this job done.

Mr. PELLY. Well, one thing about you is that you are independent and you are able to speak out. The other witnesses from agencies of the Government always behave as though the Bureau of the Budget is going to say they aren't free to speak on the subject.

We have been told that the funding for aeronautical research has been going up. I maintain that it hasn't being going up, because inflation has been eating up any increase that is in the program.

General McKEE. Well, obviousily I am in a slightly different position, Mr. Pelly, than I was in the middle of July.

Mr. PELLY. But you always spoke up pretty freely, I take it.

General McKEE. I think looking at the Congress and the attitude of Congress on this whole business—and I want to make this a part of the record—I am in no position to sit here, really, and criticize the Congress. In the 1968 budget the Congress added funds to the FAA budget, a significant amount, particularly for controllers, which was very helpful. If you will read the record, you will see where the Senate in this last go-around on appropriations—after Senator Stennis' Committee on Appropriations passed the bill by this whole committee I understand unanimously and reported out to the Senate—by a vote of 68 to 2 added over $200 million to the FAA budget.

Now, that didn't come out that way in conference between the House and the Senate. But there was $50 million added for facilities and equipment, and at least we got half of the money required for additional controllers and maintenance personnel, which was a big help.

But Congress, even in the light of the $6 billion cut that I read so much about, showed an understanding of the problem and its responsibility in trying to help solve it. And I am convinced that if we could get—as I pointed out in my statement—any reasonable agreement between all the various segments of the aviation community, that we could get legislation through the Congress to get this thing rolling.

To my friends in the aviation community—and there are friends of mine both in general aviation and the airlines—I tell them, "Listen, this is the best bargain you guys ever got." Seven cents a gallon fuel tax is not going to kill general aviation for sure. The ticket tax, going from 5 to 8 percent, and a waybill tax—now proposed, it started out at 8; it is now 3 or 5, I have forgotten which—it is certainly not going to kill the airlines. They are not going to lose passenger one because of this ticket tax going up.

Mr. HECHLER. What is the trouble, then? Does the public not appreciate the seriousness of this situation?

General McKEE. With all due regard to the general public, most people look at this whole airways system and they see a terminal. They complain about the crowded condition at the terminal, like Washington National or JFK. They get on the airplane, the door closes, and that's about all they see. They have a good pilot up there and they have no more problems until they are held up over San Francisco or Los Angeles or New York. Then they start complaining again, and rightfully so. But most people have no idea of the vast system on the ground that it takes to get them there. They don't understand it. And there is no reason why they should. I guess we haven't made it clear. But the way they understand it is to have something happen again like what happened in New York in July. I don't want it to happen again. But, nevertheless, this does highlight the problem.

Mr. HECHLER. Yes.

Mr. PELLY. Thank you, Mr. Chairman.

Mr. HECHLER. Mr. Hunt?

Mr. HUNT. Thank you, Mr. Chairman.

General, first I want to compliment you on your testimony. I understand completely when you say that you would issue an order to do the job and to report on the result in 30 days. I spent some time in military service myself and I am surprised you gave them 30 days. Mine used to be 24 hours.

General McKEE. When I worked for General Arnold I didn't even have 24 hours, Mr. Hunt.

Mr. HUNT. My general orders were do it now and get it done with.

General McKEE. Or why didn't you do it yesterday.

Mr HUNT. There is an old saying everybody wants tomorrow's work done yesterday.

I heard you discussing the golden triangle. My district is currently involved in that golden triangle. I am from the southern part of New Jersey. I have had the benefit of some briefings on the Governor's report with regard to projected airports for the 1985–2000 era. I know you have been active in that respect. The seven proposals for these jetports were explained at the briefing.

We have an airfield in south Jersey called McGuire Air Force Base. And the best plan I have seen so far is one that would extend that north-south runway at McGuire into the complex of a large civilian jetport so that in case of war, it would be accessible to the military.

The very fact that we have somebody now who understands this problem and who will speak out, gives me some encouragement. We need these airports and we need the associated planning very badly. In regard to the taxes you spoke of, it has been my experience in going overseas that when I get ready to leave, the foreign government taxes me *x* number of dollars to maintain their airports. What would you think about such a scheme? For instance, every time one goes to the Bahamas, he must pay several dollars on departure for the maintenance of the airport at Nassau.

General McKEE. Well, of course that is one of the proposals that has been made, a $2 a head tax on all overseas passengers going overseas, to come into a trust fund. My position has been, Mr. Hunt, that from a national standpoint, we have got to find the resources.

Now, one of the proposals made, for example, was a straight across-the-board 7-cents-a-gallon fuel tax for all general aviation and for the carriers. The carriers violently objected to this, and I understand their reasoning—whether it is exact or not, I more or less understand it; because of the amount of money they now have in new equipment and have on order, this would come out of their operating base and make it quite difficult for them.

You could add on this $2 a head overseas tax and put this into the trust fund along with the present proposed 8 percent for domestic passengers. So there are all kinds of ways to do this.

I was hoping that we would get a reasonably equitable system that people could agree to in order to get this thing going. But so far we haven't been able to do it.

Mr. HUNT. I notice too that one major airline has now moved out of Kennedy, because of the air congestion, and is relocating at Newark.

General McKEE. I think, Mr. Hunt, you are going to find more and more of this. And I think you are going to see—if we were sitting here in 1975, my guess is that members of this committee—and I hope you are all here in 1975—that there will be complaints about congestion at Dulles. We are going to have it just as sure as we are sitting here.

Now you know the action that I took as Administrator of the FAA in keeping the flights limited at Washington National to the present level of 40 an hour. And I would hope that this is maintained. As air traffic grows I think the air traffic should go into Dulles and into Friendship. I don't think we should permit anything beyond what we've got going into Washington National right now.

Mr. HUNT. I have also been pursuing a course insofar as ground transportation is concerned. On the eastern seaboard, our highways are rapidly approaching the point of saturation.

General McKee. Look at JFK. You have one artery going into JFK. They have the same thing out in Los Angeles where sometimes the traffic backs up for 10 miles. And this has just got to be corrected.

Mr. Hunt. Los Angeles is beginning to build large centers to accommodate conferences around the airport so that one can get quickly to those centers for business meetings and back again.

But the thing that I am interested in has been rapid rail transportation in and out of the airports. We have to realize that we must not abandon our passenger service.

If a jet airport is located in southern New Jersey, it will serve the New York, Newark, Philadelphia, Wilmington areas. This is the most rapidly expanding area we have at the present time. I looked at some of the plans that call for trains to come into a point and then transfer back to another. And this to me would be totally inadequate.

Do you not agree that one of the major problems we have is getting the passengers to and from the airport?

General McKee. Oh, yes. This is a national problem of major proportions. And it is going to grow. I would hope that the Department of Transportation, in some of the projects they have, would be helpful in finding solutions to what you might call the urban mass transit problem; that is what it amounts to.

Mr. Hunt. Do you likewise agree that perhaps we should, along with our research and development, have the airlines reschedule some of their flights that carry 10 people in a huge plane that takes up airspace, and then lands at the time when flight traffic is heaviest?

I have been on planes, where there were only five passengers in a jet plane. Of course we were stacked up for some time before landing. But I can understand why; everybody is competing for that dollar. I think the airlines should begin to realize that, with the expanding of existing airports and the future development of jet airports, they must likewise begin to schedule their flights so that they are compatible with the traffic flow.

General McKee. I would like very much to see that happen, Mr. Hunt. I was unable in 3 years to get that done.

I don't know whether you or the members of the committee recognize it or not, but neither the CAB nor the FAA has any authority whatsoever. As a matter of fact, they are prohibited from having any authority over scheduling. So we have no authority in that area.

Now if this thing grows and gets worse and worse, I think the airlines are voluntarily going to have to agree to it, or perhaps you are going to have to get legislation in Congress to give an agency of the Government like the CAB the authority to do it.

Mr. Hunt. I would assume, then, you would be in favor of one central agency that would coordinate all of these research programs totally on a do-it-now basis?

General McKee. Well, I don't think you can ever get one agency to do the whole thing.

Mr. Hunt. I mean on a coordinating——

General McKee. And also, looking at scheduling, and use the FAA for example, if they tried to undertake the scheduling business, the entire staff of FAA would be doing nothing else. It is a very complex thing.

But on the other hand, it seems to me that there should be enough authority somewhere in the Federal Government, if this gets worse, to force some rescheduling, so you don't have 15 flights coming in at 5 o'clock or scheduled to take off at 5 o'clock.

Mr. HUNT. This is my point.

Thank you, General. It is nice to see you again.

General MCKEE. It is not a very popular statement with the airlines. I won't get any bouquets from the airlines when I walk out of here.

Mr. HUNT. We are not running a popularity contest. We are trying to get some research and development to take care of a problem that has become a Frankenstein in our way of life.

General MCKEE. But I can say frankly, as forcibly as I can, what I have said here. What needs to be done from the selfish viewpoint of the airlines is certainly for their benefit. I am saying it for the benefit of the public, not the airlines or general aviation. But if they want to be selfish about it, this is to the interest of general aviation, to the interest of the airlines, and to the interest of their problems.

Mr. HECHLER. Thank you, Mr. Hunt.

General McKee, you did a great deal as FAA Administrator to encourage and inspire the aerospace industry to carry on some research and development on its own. I wonder if you think that the aerospace industry is now contributing its fair share of emphasis on research and development, or are they concentrating just on applying today's technology for what they are producing?

General MCKEE. I think the aerospace industry has done a tremendous amount in research and development. And of course, a lot of this is brought about by the competitive aspects of "If I build a better mousetrap, I will sell it." And I understand that.

But I talked to the manufacturers, both the airframe manufacturers, over the last 3 years, and the engine manufacturers, on the tremendous importance of their undertaking research and development on their own in the area of noise and what it will mean to them in the future. I pointed out as long as 3 years ago that the time was going to come when we are going to have legislation just as surely as we are sitting here with regard to noise, and the Federal Government is going to have to set standards. Now that has come about and the law has been passed. And the Federal Government, the FAA now has the authority to set standards.

Well, obviously this is going to be—it has to be an incentive to industry to do a lot more in the area of noise than they have done.

Now many of them have done quite a lot. I have been frank with them. I think they could do a lot more than they have done. And they are going to have to do it.

Mr. HECHLER. In areas other than noise do you think the aerospace industry could indeed put more emphasis on R. & D. for the future?

General MCKEE. Yes, I think they could. And I think when the industry as a whole recognizes this whole airport/airways problem, they are going to realize that again their selfish benefit to participate and help anyway they can, because if they don't, downstream they aren't going to be selling all these airplanes because the system can't handle the airplanes. When the system can't handle the airplanes, the airlines are going to say, "I'm sorry, I've got all the 747's or the 727's or the 707's I can use."

Mr. HECHLER. Mr. Hunt, do you have any other questions?

Mr. HUNT. No, sir. Thank you, Mr. Chairman.

Mr. HECHLER. This testimony has been extremely helpful this morning, General McKee. We certainly appreciate your coming up and commend you for the frankness and helpfulness of your views.

If there are no further questions, the committee will stand adjourned until 10 a.m. tomorrow.

(Whereupon, at 11:54 a.m., the subcommittee was adjourned, to reconvene at 10 a.m., Wednesday, October 2, 1968.)

AERONAUTICAL RESEARCH AND DEVELOPMENT

WEDNESDAY, OCTOBER 2, 1968

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Ken Hechler, chairman of the subcommittee, presiding.

Mr. HECHLER. The committee will be in order.

This morning we are very pleased to hear from the Air Transport Association and also witnesses from some of the major airlines in the Nation concerning their ideas and suggestions or aeronautical research and development needs for future growth in aviation.

We are very pleased to call first on Gen. Clifton F. von Kann, vice president for Operations and Engineering of the Air Transport Association, after which we will hear from the vice presidents of American Airlines, Eastern Airlines, Trans World Airlines, United Air Lines.

Have I covered everybody present? If so, General von Kann, we want to welcome you to the committee, and if you have an introductory statement that you wish to present to the committee, we certainly appreciate what you have to offer.

You may proceed, General von Kann.

(The biography of General von Kann follows:)

CLIFTON F. VON KANN, MAJOR GENERAL, U.S. ARMY (RETIRED)

Personal: Born Boston, Massachusetts, October 14, 1915. Married. 2 children.

Education:

- Harvard College, A.B. Sociology (cum laude) 1937.
- Command and General Staff College, Ft. Leavenworth, Kansas, 1945.
- Harvard Business School, M.B.A., 1948.
- Armed Forces Staff College, Norfolk, Virginia, 1954.
- National War College, Washington, D.C., 1957.
- Army Aviation School, Ft. Rucker, Alabama, 1958 (Rated pilot in helicopters, fixed wing, multiengine, and instruments—about 2,000 hours as first pilot and instructor pilot).

Experience:

- 1965–Present: Air Transport Association of America, Washington, D.C., Vice President—Operations and Engineering.
- 1937–1965: United States Army.
- 1963–1965 (Major General): Commanding General, U.S. Army Aviation School and Center, Ft. Rucker, Alabama.
- 1962–1963 (Major General): Commanding General, 1st U.S. Cavalry Division, Korea.
- 1961–1962 (Major General): Assistant Chief of Staff J–3 (Operations and Training), U.S. Strike Command, MacDill Air Force Base, Florida.

1959–1961 (Brigadier General): Director of Army Aviation, Army General Staff, Washington, D.C.
1957–1959 (Brigadier General): Assistant Division Commander, 82d Airborne Division, Ft. Bragg, North Carolina.
1955–1956 (Colonel): Programs Officer and Deputy Chief of Staff (Administration), Eighth U.S. Army and Army Forces Far East, Camp Zama, Japan.
1954–1955 (Colonel): Commanding Officer, Seventh U.S. Infantry Division Artillery and G–3 Advisor to First Republic of Korea Army, Korea.
1951–1953 (Colonel): Classified activities in Central Intelligence Agency, Washington, D.C.
1948–1951 (Colonel): Deputy Chief, Management Division and Assistant Comptroller for Plans and Policy, Office of the Comptroller of the Army, Army General Staff, Washington, D.C.
1946–1948 (Colonel): Executive Office, Supply Division G–4, War Department General Staff, Washington, D.C.
1937–1946 (2d Lieutenant to Colonel): Various field artillery assignments including 2 years in combat in North Africa, Sicily and Italy, mostly as a battalion commander; awarded Silver Star and Legion of Merit.

Affiliations:
American Helicopter Society—Member; former President and Board Chairman.
National Aeronautic Association—Member; former Member of Board.
Aero Club of Washington—Vice President and Member of Board of Directors.
National Newcomen Society—Member.
American Institute of Aeronautics and Astronautics—Member.
Society of Automotive Engineers—Member.
Board of Overseers, Harvard College—Member, Visiting Committees.
Harvard Varsity Club—Member.
Army-Navy Club—Member.
Army Aviation Association of America—Member.

Prepared Statement of Clifton F. Von Kann, Vice President, Operations and Engineering, Air Transport Association of America

My name is Clifton F. von Kann. I am vice president, operations and engineering, of the Air Transport Association of America, the trade and service organization representing virtually all of the scheduled, certificated airlines in the United States.

In reviewing this complex and important subject one is struck by several significant facts.

Our Nation owes its world leadership in aeronautics to its aeronautical research and development programs and the superior technology these programs have produced.

A great deal of attention has been given aeronautical R. & D. by the most capable people from the Congress, the administration, the scientific world, and industry. The recent report of the National Academy of Engineering is one example.

There seems, however, to be a general feeling of concern and even unhappiness about aeronautical R. & D. Questions are raised about Government programs and their coordination, about the subject matter of various projects, why more isn't being done in some disciplines, whether our stockpile of space technology is being fully exploited.

The airlines share at least some of this concern. Research, especially pure research, must be unbridled and must be conducted with great freedom. However, so vast has become our store of technology that development must be a more collected process. And with aeronautical development becoming increasingly expensive, the need is great to direct this work into truly productive channels.

Regardless of how we define "productive," there is a real challenge here. The so-called technological supermarket may be an overworked expression; yet it well describes the situation. In every phase of aeronautics, we are faced with a great variety of technology but with little assurance as to which items should be pursued and which should be ignored. And our problem is complicated by the fact that two or more apparently unrelated technologies may be combined to produce a breakthrough. Such breakthroughs accelerate the march of progress, but at the same time they make it more difficult to achieve rational R. & D. choices.

We in airline management have been giving increasing attention to this problem. It may be useful to indicate some of our current undertakings which should result in improved management of aeronautical R. & D.

But before doing so it may be useful to note the difference between our situation and that of the Department of Defense which manages the world's largest R. & D. programs.

The outstanding difference is that the military has a cycle involving requirements, R. & D. and production. In other words, there is an established process for reaching conclusions and decisions on future needs; if R. & D. is required to satisfy these needs it is initiated; if the R. & D. is successful, and the need persists, the hardware is procured.

Now I do not claim for a moment that this is a perfect process. The military is a large and complex organization. Statements of requirements become compromised through extensive coordination; bitter competition occurs for limited funds; it would be a miracle if this process produced perfect results.

But whether perfect or imperfect, the process does produce forward movement. It insures that R. & D. does proceed, and along lines which relate, granted less than perfectly, to military objectives. And once an R. & D. project is initiated the weight of the Department of Defense will be used to seek success.

We do not have such a process in industry; nor within the ground rules of free competition would it be right that we should. The question is whether we in industry can generate a process which provides intelligent direction to aeronautical R. & D. without the disadvantages of the military system.

I feel that we can and that we are moving in a direction to do so. First of all there must be planning; action is underway to improve the long-range planning process in our industry—both at the airline and industry level.

Secondly, requirements must be established by operating people, against which both Government and civilian R. & D. programs can be undertaken. Here again there is action underway to generate more specific industrywide operational requirements. Given these we can more intelligently tell NASA, FAA, and civilian research organizations what we need and where they should direct their efforts.

One may wonder why these events happen to be underway at this particular time. The answer is largely one of economics. R. & D. costs more all the time, and the need to spread overhead is great. The fruits of R. & D.—the production items—also cost more than ever, so airlines must seek the economies of standardization to an ever-increasing extent. Common definition of needs is the best path to standardization—or at least the minimizing of differences.

A few remarks on the roles to be played by the various actors may be in order, for here, too, we are in transition. In the requirements—R. & D.—production cycle there is less than clear consensus on who sets the course of aeronautical R. & D., a situation due in part to the historical accident that most of the technology used in air transport has resulted from military R. & D.—subsequently engineered into commercial hardware by aircraft, engine, and avionics manufacturers.

Now, while this arrangement worked well in the past there is no guarantee that it will continue to do so in the future. There is no reason to believe that military R. & D. will be able to provide commercial transport technology to the extent that it did in the past. So we in the airlines must look more and more to the programs of NASA and FAA, as well as those that we sponsor ourselves.

Having to look to all these sources for our technology, it is inevitable that we must be better organized and more specific in our definition of our needs—and that these be endorsed by the entire industry to the fullest extent that they can be. In other words, those responsible for operating aircraft must be the ones to say what is needed, and to say so in loud and clear tones.

Needless to add, the research scientists and engineers in Government and industry must help us in this effort. Any statement of requirements depends upon a technological forecast, and we must look to the experts to tell us what technologies will be available, when, and at what cost. Without these inputs our statement of requirements would not be realistic. But with them the operator can and must take the lead in establishing the direction and priorities in aeronautical R. & D.

Finally, industry leadership must include some attention to allocation of R. & D. tasks. We must know more about existing programs so that we can determine whether the work being done under military sponsorship, under NASA sponsorship, under FAA aegis, or at industry initiative, offers the best prospect of solving our problems. In some cases we find that none of these offer too much hope; so we must sponsor a program ourselves—as with the collision avoidance system, or warm fog seeding, or demonstration of satellite communication potential. However, while this is necessary and desirable from a management standpoint, it has limited application in an economically regulated industry—particularly in the current regulatory environment.

You will receive more specific statements from the individual airline representatives here today. But in any event, I predict that you will see increasing airline leadership in pointing out where aeronautical R. & D. must go and where major emphasis should be placed. After all, we are the users for whom the R. & D. is undertaken.

STATEMENT OF CLIFTON F. VON KANN, VICE PRESIDENT, OPERATIONS AND ENGINEERING, AIR TRANSPORT ASSOCIATION OF AMERICA

General von Kann. Thank you very much, sir. And on behalf of the industry and my colleagues, we appreciate the opportunity to be here to discuss this very important subject.

I have submitted a statement for the record, and I will take just a few minutes to discuss some of the main points in my statement and more or less lay a general groundwork from which the other gentlemen here can discuss aeronautical R. & D. from their various viewpoints, because there naturally will be differences from one large airline to another, even though I think I can say that all of us subscribe very wholeheartedly to the importance of this subject and the importance of aeronautical R. & D. to our country.

Our world leadership in aeronautics and aviation is the result of the extensive aeronautical R. & D. programs which this country has undertaken in the past. And if anyone has any doubt as to the importance of this to our whole national picture and our national economy, he need only look at the export and import statistics where 40 percent of our favorable trade balance is due to our dominance in the export of aeronautical items.

If necessary, I can submit further data for the record on this, although I dare say that the manufacturing side of the house has already done so.

In emphasizing the importance of——

Mr. Hechler. May I interrupt to say we would welcome these data. We don't have scheduled witnesses from the manufacturing side of the house.

General von Kann. I will be happy to submit some data.

(The information requested is as follows:)

During Calendar Year 1967 the income to U.S. dollar account from all categories of aerospace export sales amounted to $2.2 billion, while aerospace imports were $283 million. So the net balance was in our favor by nearly $2 billion. This was 41% of our country's entire trade surplus of $4.8 billion.

This dwarfs all other items in our balance of trade. You can image what the balance would be like should we lose this advantage in aerospace exports, or should the flow be reversed, as it will be if the Concorde flies and the U.S. supersonic transport does not. Which is why the SST program is so important to our country.

But the 1967 export-import data shows quite clearly how important aeronautical export is to our favorable trade balance. And this is just one example out of many of the importance of aeronautics to our national economy.

I might say that it seems to me that some effort needs to be done perhaps as far as management of aeronautical R. & D. to develop this process perhaps a little better than we have done thus far. Coming as I do out of the military, I am of course struck that in that environment you have a programing cycle where operating people set forth their requirements and this in turn generates R. & D. objectives and R. & D. programs and in turn these work their way out and military hardware is the result.

Now, as I have said, this is not a perfect process, and with many, many elements to get into the matter of coordinating requirements I wouldn't even say that the requirements always come out exactly the way perhaps they should. But nevertheless there is a process here and it keeps moving on and the R. & D. takes place in response to agreed-upon operational objectives and requirements.

Now, for very good reasons, we don't have a process like that on the industry side. We can't. On the other hand, I daresay that under the pressure that we feel now for greater standardization and spreading of our overhead, that we can and that we will develop processes which have some similarity, where we do more industrywide planning, we do more to establish the industry requirements. And this in turn will point up for the R. & D. people the most profitable directions as well as where, from the standpoint of the users, the priorities should be.

So I would look forward to an improvement of this process on the industry side.

Needless to say, we as users will continue to be very dependent upon the technical experts, those in the Government and those in the industry as well, because part of this what I call the requirements-R. & D.-production cycle is a good technological estimate, and the first thing one has to have in starting to turn this cycle over is a good technological estimate from the best technical people that you can bring to bear on the subject. Based on that, you develop realistic objectives as to what is feasible, what is economically reasonable to hope for. And this, I think, will turn out requirement statements which in turn will help the R. & D. people in putting their efforts in the most profitable directions.

Now, with those few words, I think I will stop here. Most of what I have said is in my statement. Again, we appreciate the chance to be here, because all of us in the airlines that deal with this subject are dedicated to the idea that a greatly increased effort in aeronautical R. & D. is needed.

Incidentally, I don't know if these hearings have brought forth the material that was in this recent issue of Forbes magazine, the October 1 issue, on the transportation situation, but I don't think anyone can read that and have much doubt that a great deal more needs to be done on the aeronautical side of the whole world of transportation.

Mr. Hechler. I read that article, and as I recall, it indicated that too much emphasis in transportation was being put on highways at the expense of air transportation. Isn't that the main thrust of the article?

General von Kann. That was the main thrust. And naturally, in my objective way, I would subscribe wholeheartedly to the thesis.

So those are my remarks, sir. I would be happy to answer any questions or to turn the floor over to my colleagues.

Mr. Hechler. Let me ask one general question.

How can the channels of communication between the airlines and those who are setting the priorities for aeronautical R. & D. in the Government be improved? I gather from some of your comments, both oral and written, you feel that you are not sufficiently alerted as to what the emphasis is now or is likely to be and don't have an opportunity to feed in some of your ideas and suggestions as to what you feel the most important priorities are. Is that correct?

General von Kann. Not quite, sir. I think the communications are actually pretty good as far as our access to the R. & D. people. They are very accessible. They are very agreeable, they are very open in letting us know what they are undertaking to do. There has never been any problem there.

And as you will hear in the course of the morning, many of our airline people sit on key panels in this area.

I think what I meant to say was simply that in the evolution of our business I feel that we are coming to a point under the pressure of economics and the need with large expensive items—the need to standardize these items better where we will in the natural course of events pull together more in our planning and our requirements work so that we can put better targets out in front of the R. & D. people.

I think it is quite natural that this hasn't taken place in the past. It is the policy of the Government that there should be competition in this industry, and there is competition, as you know; and this is the way it should be. As a result of this competition, we haven't always worked together as closely as we might.

But I think the pressures of the times and the economics will cause us to work together more, again within the constraints of competition, so that we can have more impact on the selection of the goals.

Mr. Hechler. The Chair would like to suggest that possibly members of the committee might care to ask one or two questions of each witness following their opening statement and we could then go on to panel discussion.

Mr. Pelly is recognized.

Mr. Pelly. Thank you, Mr. Chairman.

I would like to inquire as to whether or not the industry is satisfied with the seminars and other meetings that are arranged by NASA in order to bring this communication about, about which you were just talking. Earlier witnesses have indicated that they are seeking to find out what the needs of the airlines are and that for this purpose they do hold seminars and bring in people to discuss the research. Do you have anything to say on that?

General von Kann. I personally don't have any problem with that procedure. But I think that some of my colleagues who have been into this process more deeply than I, might want to make some comment on this.

Mr. Hechler. Would you care, Mr. Pelly, to withhold until the others——

Mr. PELLY. I will withhold that question. But I would like to ask you to submit for the record your comments on the testimony given yesterday by General McKee to the effect that there was a great reluctance on the part of your industry to support the user-tax proposition in order to finance necessary new airports.

General VON KANN. I can say in general, subject to a more detailed submission for the record, that this has been a matter of evolution in the industry position on user charges. And at this point, the airlines feel, I believe, all the way up and down the line, that our needs, the need to get on with the development of airway and—or airport and airway capacity—probably airport capacity first, but at least this sort of capacity—the need is so great that we simply must go ahead and get on with plans for financing the generation of this capacity, and the airlines are ready and willing to accept their fair share of this burden in the form of appropriate user charges.

And I will be happy to submit for the record more detail on that.

Mr. PELLY. Thank you.

(Information requested is as follows:)

The airlines are not in any way reluctant to support a program of user charges for airport development. On the contrary, the Air Transport Association of America announced its plan prior to that of the Department of Transportation. That plan, concurred in by all the scheduled, certificated carriers except American and Northwest, is outlined below.

The ATA proposed Federal Airport Development bill is the culmination of an intensive effort by the U.S. airlines to arrive at the best possible solution, from all points of view, to our nation's airport problems. It is evident that many of our airports will be unable to cope with the rapidly accelerating growth in passenger traffic and aircraft movements unless substantial money is provided to make needed improvements. The proposed bill will generate a large fund for this purpose, will do it quickly, and will do it without undue burdens on the passenger, the airport operator, the aircraft operator or the government. It will provide urgently needed funds for terminal construction as well as runways and access roads, and will cost the general Federal taxpayer nothing.

The primary operating provision of the bill permits the Secretary of Transportation to enter into contracts with airport sponsors to pay up to 75 per cent of the principal and interest costs of locally issued bonds. Under such a contract, the Secretary would pay debt service costs each year for the life of the bond. In addition, the government would be authorized to guarantee the entire amount of such bonds, thus making them more marketable than if there were no such guarantee. In the case of bonds issued to finance needed airport construction, but which for some good reason could not be marketed in whole or in part, the Secretary would be authorized to purchase such bonds for resale. Short-term loans also would be available for advance planning or land acquisition where quick action is necessary.

The debt service payments, guarantees, purchases for resale, and short-term loans would be available to all airports served by air carriers. In addition, all these provisions would be available for general aviation airports designed to relieve congestion of major airports.

The sources of revenues for the program would be a 2 per cent tax on the domestic transportation of persons plus a $2.00 tax on each enplaning international passenger. Proceeds from these taxes would be placed in a Trust Fund, to be administered by the Secretary of Transportation.

It is estimated these taxes would produce the following revenues during the next five years:

1969	$109,063,000
1970	123,524,000
1971	140,661,000
1972	159,749,000
1973	181,431,000

Adding the 25 per cent local share to the tax proceeds produces the following total amount of debt service which can be funded in the first five years of the program:

1969	$145, 417, 000
1970	164, 698, 000
1971	187, 548, 000
1972	212, 999, 000
1973	241, 908, 000

This means that based on 25-year maturity obligations issued at a 5½ per cent interest rate, the following cumulative total amount of bonds could be issued:

1969	$1, 950, 590, 000
1970	2, 209, 228, 000
1971	2, 515, 734, 000
1972	2, 857, 129, 000
1973	3, 244, 909, 000

Thus, before the end of the fifth year of the program, three billion dollars of new capital funds will have been generated.

Federal Airport Development Act of 1968

Outline of Provisions

1. Establishes an Airport Development Trust Fund administered by the Secretary of Transportation.
2. Fund will be supported by special taxes of 2% on domestic passenger tickets and $2 per passenger in foreign air transportation. While the program will function without general tax revenues, it does not preclude such appropriations.
3. Fund will be used:
   (a) primarily for contracts of up to 40 years in length by the Secretary of Transportation with local airport sponsors to pay up to 75% of the principal and interest of local airport bonds for airfield and terminal projects;
   (b) to guarantee the full amount of such local bonds;
   (c) to purchase local airport bonds for resale;
   (d) to make short-term loans for advance planning and land acquisition.
4. Funds will be available to:
   (a) all airports served by air carriers;
   (b) general aviation airports designed to relieve congestion at major airports.
5. Contemplates FAAP program continuance for small airports served by air carriers and for general aviation airports.
6. Tax revenues of $109 million will be realized in FY 1969 and will support issuance of $1,950,000,000 in local airport bonds the first year.
7. Congress each year, through appropriation acts covering the four succeeding fiscal years, will authorize the Secretary of Transportation to make the expenditures to meet the obligations incurred.

The program is proposed as a means of generating large amounts of capital to meet the nation's most immediate major airport construction requirements without any burden on the general taxpayer and without unduly burdening airline passengers. The provision in Sec. 3(b) for federal contracts to pay a portion of local debt service costs is based on Sec. 10 of the U.S. Housing Act of 1937, as amended (42 U.S.C. 1410). The trust fund feature is patterned in part on the Highway Trust Fund (see 23 U.S.C. 120, note).

The airlines are also on record as accepting the responsibility for payment of their fair share of the cost of the airways system, based upon a proper allocation of that cost to users.

Mr. Hechler. We have a lot of ground to cover yet this morning. Mr. Lukens?

Mr. Lukens. I will defer at this junction, Mr. Chairman.

(The questions posed by the committee follow:)

QUESTIONS SUBMITTED TO GEN. CLIFTON F. VON KANN BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. On page 3 you raised the question as to whether industry can provide any intelligent direction to aeronautical research and development. Would it not be possible for the various members of the Air Transport Association to provide their inputs to the Association as to the research and development needed to meet the needs of the next decade and to have the Association consolidate and process such inputs to the various government agencies and aerospace industries involved?

Answer 1. The answer is "yes", and this is what we are attempting to do through the ATA Committee structure. What is not clear is the extent to which full agreement among the airlines may be expected in view of the diverse environments in which the various members of ATA operate.

Question 2. On page 4 of your statement you mention that there is action underway to generate specific industry-wide research requirements. Will you advise the Committee as to the status of this action to date and as to what industry-wide research requirements have been identified? What will happen to such requirements after they have been developed? Will you advise the government and aerospace industry of your needs?

Answer 2. Action is underway at the ATA staff level to establish a framework within which the various requirements may be established. This effort is in the initial coordination process. Once the requirements receive the endorsement of the airlines they can be presented to NASA and FAA as well as to the aerospace industry at appropriate gatherings.

Many industry requirements have already been identified by normal ATA staff activity. These include the Collision Avoidance System, methods for fog dispersal around airports, detection of clear air turbulence, severe weather display on air traffic control radar, and satellite communications, to name a few. As requirements are identified, they can be useful in directing both industry and government research and development.

Question 3. On page 6 of your statement you imply that industry does not have full knowledge of existing research and development programs being sponsored by various government agencies. Is there a regularly established procedure by which such information is furnished on an automatic basis to various companies or industries in general? If this is not the case do you recommend that such a procedure be established? If so, should such knowledge about existing research and development programs be distributed through the various airline industry associations?

Answer 3. While NASA gives periodic briefings on its aeronautical R&D programs, and FAA has a similar practice, I am not aware of any regularized process by which the entire span of government R&D is made known to civil aviation. I believe such a procedure should be established and made automatic to insure that the various technologies be pursued by the government—particularly military technology which has recently been declassified—should become known at the earliest possible time.

Finally, it would appear that the various industry associations be the channels for dissemination of this information in order to insure that all users have equal access to it.

Mr. Hechler. I would like to welcome F. W. Kolk, vice president, Development Engineering, American Airlines. Mr. Kolk, glad to have you before the committee.

(The biography of Mr. Kolk follows:)

FRANKLIN W. KOLK, AMERICAN AIRLINES, INC.

With American Airlines since 1943, Franklin W. Kolk is currently Vice President for Development Engineering. A graduate of MIT with a degree in aeronautical engineering, he was a senior aerodynamicist with the Martin Company before coming to American. He has worked primarily on advance design planning of commercial airplanes and has made basic contributions to the development of such planes as the Convair 240, the DC–6 series, the DC–7, the Lockheed Electra, the Boeing 707, and the Convair 990. Kolk has been a leading exponent of the turbofan engine, which powers American's fleet of "Astrojets," and has been active in the conception of the current "Jumbo Trijet" aircraft. He is an AIAA Associate Fellow and a Fellow of the Royal Aeronautical Society. He chairs the Society of Automotive Engineers' Committee A–21 on Aircraft Exterior Noise Measurement.

Mr. HECHLER. Do you have a statement you would like to make?

(The statement of F. W. Kolk is as follows:)

STATEMENT OF F. W. KOLK, VICE PRESIDENT, DEVELOPMENT ENGINEERING, AAL

Mr. KOLK. Mr. Chairman, and honorable Representatives, I am indeed grateful for this opportunity to present my views of the future of air transportation and its research and development needs. Aviation is becoming increasingly important in the day-to-day life of our people; we are dependent already on the use of air travel for our priority transportation needs, and, as the need for human contacts continues to grow, it represents a most attractive opportunity for satisfying some of the requirements of our people for a better daily life.

To support the continued growth of air transportation, much added knowledge must be acquired, both to solve the pressing operational problems of today, and to insure the availability of adequate new systems in the future.

There have been many studies and recommendations detailing the various needs. One of the most comprehensive has been prepared by the National Academy of Engineering, entitled "Civil Aviation Research and Development," issued in summary form August 1968. I heartily endorse the results of this monumental effort. Its chapters on summary of problems and recommendations, particularly those dealing with the technical problems now facing us, are an excellent general statement of the required action areas. These R. & D. recommendations should be implemented, and the appropriate funding supplied.

I am aware that various officials of the Government have appeared before this group in support of an extensive R. & D. effort in the civil aviation field. Let me call attention to a summary of the testimony of Mr. T. O. Paine of NASA, which appeared in the New York Times, September 25, 1968; this indicated a general feeling of inadequacy of the current American effort in support of civil aviation.

Likewise, Mr. C. W. Harper, in the same article, is reported as having pointed out that aircraft of French, German, English, Canadian, and Japanese origin were on trial service in the United States. He suggested the need, not only for further research and development support on hypersonic and supersonic aircraft, but also in the field of subsonic aircraft, helicopters, and STOL aircraft for interurban traffic. We heartily endorse this view, and the further point made by Mr. Harper that effort designed to upgrade the traffic control systems are very much in order.

I would not propose to discuss a complete R. & D. program from an overall viewpoint, but I would like to highlight special areas that seem especially important. Today, perhaps the most dramatic inadequacy to the broad cross-section of our passengers is the capacity of our airway and airports. In attacking this problem it must be recognized that we have inadequate facilities of obsolete design and that a major reason for the problem has been a tendency by us all to grossly underestimate the propensity of Americans to travel, for business and for pleasure. However, we got into the mess, we must provide a way to get our facilities' capacity ahead of the requirements and keep them ahead in the future. Specific suggestions which might be helpful are as follows:

AIRPORT AND AIR TRAFFIC SYSTEMS

1. There has been an inadequate amount of governmental research and development specifically devoted to the airport itself. There is a very specific need to concentrate on airport designs and configurations that will provide an increase in the operational capacity. Special consideration should be given to the use of multiple runways, parallel runways, and taxiway design aimed at facilitating ingress and egress from runways during high capacity operations. Because of the unavailability of large tracts of suitable land, we must concentrate on improving what we now have.

2. Research and development leading to practical means of reducing currently required ATC separation standards should be undertaken.

3. Development of a practical air-ground-air data link capable of serving the air traffic control system should be accelerated for implementation at an early date. Any automatic air-ground-air data link should be coupled to the automatic elements of the ground ATC system.

4. There is a longstanding need for providing to air traffic controllers dynamic information concerning the presence of severe weather to preclude the controllers from inadvertently directing air traffic through severe weather. FAA has been unsuccessful in providing this capability to its controllers.

5. The provision of satellite relays of communications for air traffic control, particularly in remote parts of the world, or in over-ocean operations, should be accelerated.

6. Development of a successor to present day radar systems as a means for air traffic surveillance should be undertaken promptly.

7. Any research and development program by the Government should recognize that air space users, particularly those engaged in long-range navigation, are interested in self-contained navigation equipments so as to minimize the need for reliance upon ground support. In this connection, we should deemphasize the interest in satellite navigation. There is great need for air traffic control facilities including traffic surveillance over the oceanic areas to allow lesser spacing between aircraft.

8. The ultimate long-range view is to put the control into the hands of the pilot; in the meantime, however, we must vigorously attack the problem of improving the capacity of the present system.

NOISE

Of interest to large segments of our population is the problem of aircraft noise. The current effort should be continued at a vigorous level. I endorse the NASA programs, and those funded through other agencies. I would caution that from the long-term viewpoint, attention must be concentrated on the reduction of noise at the generating mechanism. To do this a program is needed that will—

(*a*) provide suitable experimental hardware for scientists to try out their ideas in the engine area on representative configurations; and

(*b*) develop means—now lacking—for assessing accurately the subjective effect of a flyover from noise measurements made statically on the ground.

SHORT-HAUL INTERMETROPOLITAN SYSTEM

Probably the area of greatest long-term payoff is in the field of short-haul intermetropolitan service. This is the problem of the ordinary guy who has to make the average journey. The shorter range transport systems have always lacked the glamor of the long-range systems, and they are essentially less economical, particularly in the environment of the congestion bred by modern urban and suburban complexes. We have been talking about these systems, but very little has been done about them. Even in our Nation's Capital, we rely on a conventional air transportation system, based on an outmoded and hopelessly overcrowded short-haul facility, because, bad as it is, it still represents the best compromise we can devise.

Orderly urban development requires a short- to medium-haul air transportation system; that is—

(*a*) Separate and distinct from the current long-haul facilities,

(*b*) Economical with real estate (high capacity per unit time per acre of land),

(*c*) Acceptable to adjacent residential land users, and

(*d*) Economical to operate and convenient to use.

It is generally hoped by most planners that such a system will emerge from STOL, nonrotary wing, VTOL, or helicopter technology. Yet we see the rapid economic disintegration of most existing urban helicopter operations, and little or no progress toward the practical use of STOL's or VTOL's; interestingly enough, the only vehicles that seem to be practical transports are of foreign origin. Irrespective of national origin, virtually all flying prototypes have been militarily oriented.

It is my belief that the worst problem we face in this connection is our lack of practical experience in powered lift flight. There are few pilots, no facilities, and no "lore of flying" to back up the designers and engineers. This lack, moreover, must be highlighted by the fact that most prototype VTOL aircraft types have suffered serious mishap, for an assortment of reasons, adding up to disappointing progress.

What then can we recommend as a practical program? Here are a few thoughts:

1. Fly airplanes: Provide sufficient funds to fly the more commercially promising machines—to check out more pilots, explore real

transport environments and refine the machines. Broaden our experience base, not only within the Government, but more especially within the operating industry.

2. Fund studies to determine in depth what the optimum commercial vehicle configuration will be. Determine the tradeoffs necessary to approach best the problem of thrust or lift asymmetry—whether it be cross-shafting, cross-ducting and the like, or reliance on adequate aerodynamic control power.

3. Concentrate on STOL at first, as this represents the obvious first step into the area and because the things that will refine STOL will lead to the availability of practical VTOL.

4. Fund initial development studies of the most promising VTOL configurations so that practical vehicles can be started, and be made ready to put into the hands of operators for assessment of their real worth in real life environment.

5. Concentrate on the problems of the urban STOL port—its size requirements, clearances, nav-aids, traffic control facilities, noise limitations, and its potential political problems and assets, so that urban planners will have accurate, realistic, and uniform information on how best to provide these facilities.

WHAT ARE WE DOING?

I have tried to highlight the areas about which we are most concerned. We have, as an industry, and as a corporation tried to develop plans to support these areas in a meaningful way. American Airlines can isolate the following contributions from our own limited resources currently devoted to the support of the points made above.

1. Air traffic research and development: one professional, full-time specialist (draws on whole organization for support).

2. VTOL/STOL: one full-time professional specialist; two professionals, continuous support.

3. Aircraft noise: two professionals, continuous support (average at any one time).

The above manpower is deployed generally in problem definition work.

Among our recent accomplishments are as follows:

1. Service test and feasibility demonstration of an area navigation system. (This allows controlled flight in any area on any arbitrary course, regardless of the configuration of nav-aids.)

2. Installation of and certification of an inertial navigation system.

3. Feasibility demonstration of a continuous running flight crew proficiency monitor.

4. Participation in research on aircraft noise measurement.

Other significant corporate programs are currently in the planning stage. However, these can only be viewed as contributions to the solution of the overall air transportation problem—which is of far reaching national importance and which, as such, requires the combined attention of government and industry and the backing of funds sufficient to provide lasting solutions.

Thank you.

Mr. HECHLER. Mr. Kolk, we appreciate your assessment, analysis, and suggestions here on what you are doing and what needs to be done in the future in aeronautical research. I think it has been extremely helpful to the committee. And I am sure it will be to the agencies of Government who are working in this area. And I want to emphasize again that we are very pleased Chairman Miller has authorized these hearings. And Chairman Miller is with us this morning.

Mr. Chairman, would you care to make any comments or observations?

Chairman MILLER. I want to congratulate you upon the paper. I think it is fine and I think you have pointed out a lot of the problems.

Our trouble is, I am afraid, that it is not hard to isolate the problems; it is rather difficult to find solutions for them. I imagine that although we are concerned in this committee with the technical and hardware problems pertaining to the operation of aircraft, there are other problems that fall into other areas. And someplace up and down the line, these are going to have to be considered.

I think that while great strides have been made within the last few years, we still have problems in ticketing, handling of baggage, and other similar problem areas. I think we have to take an overall look at the location of airports, transportation to airports, and the modernizing of airports themselves.

I used to think when I first saw Dulles that it was a great mass that didn't mean anything, but the more I travel the more I think that Dulles Airport is the ideal airport. Without mentioning any names, there are airports where, if you have to change from one airline to another, you have to walk three-quarters of a mile up and down ramps. These are things that have to be corrected. And the airlines themselves have to make these studies.

We are going to confine ourselves to the practical application of research.

I want to congratulate the chairman of the subcommittee on the very fine work that he is doing.

I think it is a very fine thing we are doing. We have to pay more attention to aeronautics if we are going to become fully efficient in the field.

Mr. HECHLER. Thank you, Mr. Chairman.

Mr. Pelly?

Mr. PELLY. I think you are running a little behind schedule. I think it would be better for me to defer until we get into a general discussion afterward.

Mr. HECHLER. All right.

Mr. Lukens?

Mr. LUKENS. Likewise, Mr. Chairman.

Mr. HECHLER. We are very pleased to welcome to the committee Mr. Scott Crossfield, division vice president, flight research development of Eastern Air Lines.

Mr. Crossfield joined Eastern after a successful and notable career as test pilot for North American. And it is of particular interest to us, of course, on this committee that he was the first test pilot to fly the X–15 and bring it through its first test phase.

Congratulations to you on the great contributions you have made to research and development in a personal way as well as in your official capacity. Welcome to the committee, Mr. Crossfield.

Chairman MILLER. I may say, he is sort of an alumnus of NASA, and therefore we claim certain relationships over and above his present capacity.

Mr. HECHLER. Correct.

(The biography of Mr. Scott Crossfield follows:)

A. SCOTT CROSSFIELD, DIVISION VICE PRESIDENT, FLIGHT RESEARCH AND DEVELOPMENT, EASTERN AIR LINES

Guiding Eastern Air Lines into the supersonic age is one of America's best known test pilots and most honored men in aviation, A. Scott Crossfield, division vice president-flight research and development. His responsibilities include the direction of Eastern's research and development programs for new aircraft, flight safety, flying procedures and air traffic. He also directs flight tests for all new aircraft.

From 1950 to 1955 Mr. Crossfield served with the National Advisory Committee for Aeronautics. He was the first pilot to reach a speed of Mach 2, piloting the D558–II in 1953, and successfully completed the first Mach 3 flight in the X–15 in 1960. During this period he flew more than 130 air launch rocket flights, most of them at altitudes of 60,000 to 80,000 feet. In 1961, he became division director of test and quality assurance for North American Aviation's Houndog missile, Saturn, Apollo and Paraglider projects.

Mr. Crossfield received the International Clifford B. Harmon Trophy in 1961 and the Collier Trophy in 1962, both presented by President John F. Kennedy.

Mr. Crossfield is an honorary fellow of the Aerospace Medical Association and a fellow of the Society of Experimental Test Pilots and the American Institute of Aeronautics and Astronautics, and has served on the National Aeronautics and Space Administration Committee on Flight Medicine and Biology and the American Academy of Sciences ad hoc Committees. He has been active also in the American Society for Quality Control and was co-founder of the Society of Experimental Test Pilots.

Born at Berkeley, California, October 2, 1921, Mr. Crossfield graduated from Boistfort High in Klabber, Washington, studied chemistry and physics at the University of Nebraska Extension College 1939–1940, served as a naval aviator 1942–1945, attended various Navy aviation officer schools, and received bachelor and master of science degrees in aeronautical engineering at the University of Washington in 1949 and 1950.

Mr. Crossfield joined Eastern in July 1967, as system director of research and development for flight and was promoted to division vice president-flight research and development effective January 1, 1968.

In 1943 Mr. Crossfield married the former Alice Virginia Knoph of Seattle, Washington. They have six children—four sons and two daughters.

STATEMENT OF A. SCOTT CROSSFIELD, DIVISION VICE PRESIDENT, FLIGHT RESEARCH DEVELOPMENT, EASTERN AIR LINES

Mr. CROSSFIELD. Chairman Miller, Mr. Hechler, gentlemen, I am going a little slower these days. [Laughter.]

I don't have a written statement, but I am prepared to submit anything that you would like to help you in your endeavor here. But I would like to discuss a moment the things that my colleague from American and other people are concerned with, and that is that we at Eastern, in the face of, since 1965, a diminishing of Federal funds of about a factor of 3 and equipment funds of about a factor of 4, are faced, like everybody else today, with the fact that this air traffic problem is just grinding us to a halt. And we can identify nearly $1 million a week of direct operating costs wholly attributable to air traffic problems.

I was assigned to back off and look at the whole picture and see what we as an airline could do about it even if we had to finance it, because, even in the face of a diminishing Federal budget, the airlines are supporting this by about 30 percent through their customer taxes, and it looks like we are going to do more. We might as well get our money's worth.

So we looked at what research moneys were being spent and found that maybe it was just adding on to the problem rather than resolving the problem and carrying forth even to further complication the system of traffic control and airport handling that couldn't, with all the funds in the U.S. Treasury going in that direction, solve the problem.

The answer has got to be in the technology. It has got to be in the ability of airplanes to come and go and not have to thread through the several needle eyes that we are doing. There is really no congestion except that we force everything onto one railroad track and onto one runway and that sort of thing.

So we have identified a system and are demonstrating it practically today wherein we feel that without any additional tools or investment we could greatly relieve the congestion problem on our airways and at our airports in the areas that the airlines have some control, and that is the utilization of unused runways, the utilization of unused airspace in and out of the airports, and the utilization of unused airspace on our airways.

We right now, then, have the capability on an airplane, in fact, on several airplanes—and we have in excess of 2,000 flights of demonstration to several degrees. But on the STOL airplane I have the capability of laying down a glide scope and an ILS on any piece of concrete in the United States without the use of a ground base aid except the navigation system. We feel that this is going to be one of the steps that are viable today and in the very near future to relieve this archaic method of radar tracking and manual voice control wherein we ask a man to literally fly 15 lost airplanes in heavy weather around Kennedy Airport at a time even though we require three men in the cockpit to keep that airplane safe.

We feel that we can reduce the separation standards with more confidence and safety by a substantial amount. In fact, I am thinking in terms of better utilization of separation, to reduce the cubage of the air by a factor in excess of 10.

We have with these systems complete automatic data links with the ground wherein I can tell on a video map or through a computer exactly where that airplane is at all times. Even though it is under command of the pilot, he has electronic instructions, if you please, as to what to do with respect to changing his flight plan or flying his flight plan. We have the capability of identifying the miles and minutes to go on any problem that we have inserted in the navigation system. So I have the capability of even reserving landing times.

We demonstrated we can paint the tire marks and the numbers on any runway we want. In fact, we have added simultaneously here at Washington National with this system with jet traffic on another runway wherein at that moment we have doubled the capacity of Washington National Airport. We think we could do this very easily.

We operated for 4 days flying right on schedule five to six flights a day and never once did air traffic control divert another airplane to let us in and out of Washington National. We are having a similar experience at La Guardia, and with the help of the Massachusetts Port Authority, the New York Port Authority, the Mayors' Commission for Aviation and Marine, the Mayors' Planning Commission, the State of New Jersey, the FAA, and everybody else, we have gotten all of these people together and laid down new departure and arrival routes at Logan, La Guardia, and Newark, and Washington National. We have used these routes and are demonstrating to the controllers' satisfaction that because we have complete control of where we are at any one time on predetermined paths, that we can come and go with them having confidence that they don't have to lead us by the hand with radar.

Now in addition to that, again looking at the Government research, we found we have had to go into clear air turbulence research of our own and we are carrying on extensive research in that regard.

We are looking very hard at noise abatement. And incidentally, part of this STOL program is that it is very quiet and we can come and go without disturbing communities. In fact, we have an authorized holding pattern over the Empire State Building on Manhattan Island, and that is some accomplishment.

We are following this research through. But of interest to this committee, I think, is that I had to go to France to get the airplane, England to get the elements of the navigation system. And we are are also looking to England and France for quiet and nonpolluting engines. I think that should be of very great interest to anybody in this country, how it happens that we are going back there to get the things that really we should be doing.

So that in an off-the-cuff statement that I would like to address to this committee, in that I do think that the airlines can put on board their airplanes the total capability to literally resolve this traffic problem in the near future, but that this committee should think and address their funding and ideas to the long-range thing as to when we also crowd the skies that I am opening up.

Thanks.

Mr. HECHLER. This has been very helpful, Mr. Crossfield.

How do you decide in Eastern the relationship between the research that you have to undertake yourself, as you indicated on clear air turbulence and STOL and the quiet engine, and what you will depend on from NASA or other agencies of the Government?

Mr. CROSSFIELD. How do we decide?

Mr. HECHLER. Yes.

Mr. CROSSFIELD. The need, as ever, comes from the economic pressure, doesn't it? We cannot survive as an airline if we continue to grind to a halt with this traffic. We cannot as an airline really expand with the real market if the community doesn't like our smoke and our noise, can we? So we decided for that reason.

We have customers and we want to give them the benefit of what they pay for out of profit. It is just that simple.

Mr. HECHLER. Do you have any suggestions for the future as to what NASA or other agencies of the Government ought to be emphasizing or expanding on or priorities they ought to establish?

Mr. CROSSFIELD. I think this NAE report that was referred to probably identifies those problems and where we should direct our efforts better than I could off the cuff state.

Mr. Hechler. Any other questions before we go on to our next witness?

Mr. Pelly. I just want to comment that a million dollars a week is really a lot of pressure to get in and do something yourself, isn't it?

Mr. Crossfield. Yes.

Mr. Pelly. I think your testimony has been very helpful. I agree with the chairman.

Thank you, Mr. Chairman.

Mr. Hechler. Mr. Lukens?

Mr. Lukens. No, sir.

Mr. Hechler. Thank you, Mr. Crossfield.

We will now proceed with Mr. Robert W. Rummel, vice president—equipment planning and research, of Trans World Airlines.

Mr. Rummel has been with TWA for 25 years. Prior to that time he had been associated with Hughes Aircraft, Lockheed, Grumman Aircraft Co., and others.

It is a pleasure to welcome you to the committee, Mr. Rummel. You may proceed if you have a prepared statement.

(The biography of Mr. Robert Rummel follows:)

Robert W. Rummel, TWA Vice President, Equipment Planning and Research

Robert W. Rummel is vice president of Equipment Planning and Research for Trans World Airlines. He was elected vice president of Engineering in 1956 and vice president of Planning and Research in 1959.

Mr. Rummel joined TWA in 1943 and has served in various engineering capacities, including chief engineer for TWA. He was also chairman of the airline's jet planning committee during the years TWA was preparing for the introduction of jet aircraft into its fleet.

He formerly was employed by Lockheed Aircraft Corporation and Hughes Aircraft, and later was chief engineer for Rearwin Aircraft and Engines, Inc., of Kansas City, Missouri, for whom he designed two types of light aircraft and saw one go into production when he was only twenty-four years old.

He has contributed to numerous transport development programs including the Constellation, Martin 404, Convair 880, the Boeing 707 series, and others, and remains actively engaged in current advanced-technology jet and supersonic transport programs.

Mr. Rummel is a member of the Research & Technology Advisory Committee on Aeronautics of the National Aeronautics and Space Administration, the top-level aeronautical research coordinating group in NASA. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics and a member of the Society of Automotive Engineers, and has served on numerous government, technical society, and Air Transport Association committees.

He has authored a variety of technical articles through the years.

He was born in Dakota, Illinois, August 4, 1915, and was graduated from Curtiss Wright Technical Institute of Aeronautics, Glendale, California. He is married and has five children.

Mr. Rummel's headquarters are in New York.

(The prepared statement of Mr. Robert W. Rummel is as follows:)

PREPARED STATEMENT ON AERONAUTICAL RESEARCH AND DEVELOPMENT BY R. W. RUMMEL, VICE PRESIDENT, EQUIPMENT PLANNING AND RESEARCH, TRANS-WORLD AIRLINES

Introduction

This statement is in direct response to an invitation from Mr. Ken Hechler, Chairman, Subcommittee on Advanced Research and Technology of the Committee on Science and Astronautics of the House of Representatives by letter of September 16, 1968, to Mr. Stuart G. Tipton, President of the Air Transport Association. The letter invited the ATA and representatives of Eastern Air Lines, American Airlines, United Air Lines, and Trans World Airlines to participate in a panel discussion in the Rayburn Building on Wednesday, October 2. The purpose of the discussion is to examine the adequacy of the national research and development effort in the field of aeronautics in relation to demands on technology foreseen for the next decade and beyond. Mr. Hechler requested each participant to submit a prepared statement to the Committee Staff prior to the hearing. This statement, divided into two principal parts, is TWA's response.

Part I, entitled "Adequacy of Aeronautical Research and Development" presents TWA's general views on this vital subject and urges inclusion of a number of listed R&D projects in the national effort.

Part II, entitled "TWA Aeronautical R&D Projects" presents selected current or planned TWA projects believed to be of interest to the Subcommittee. Recommendations on further federal R&D efforts are also included as appropriate. The projects listed in this section by no means represent TWA's total aeronautical R&D effort, which contains numbers of projects believed to be of little interest to the Subcommittee.

I. ADEQUACY OF AERONAUTICAL RESEARCH AND DEVELOPMENT

The ability of the U.S. to maintain the world aeronautical leadership it now enjoys is dependent on developing and maintaining that level of research and development activities which insures the timely development of aircraft and aircraft operating systems economically or militarily superior to other contemporary systems. The general level of aeronautical research and development activity this nation has engaged in since World War II is believed to have been less than desired to maintain leadership over the long term. The sooner expanded programs are undertaken then the more certain will be the generation of a greater ability to insure world acceptance of vehicles and systems.

TWA endorses the recommendations of the Aeronautics and Space Engineering Board of the National Academy of Engineering contained in "Civil Aviation Research and Development—an Assessment of Federal Government Involvement" issued August, 1968. All segments of industry contributed to the development of the NAE recommendations. TWA participated in this through membership in a number of AIAA working groups and also as a member of the Senior Advisory Review Board. TWA is sympathetic to the general recommendations and urges early implementation of the specific research projects recommended by the NAE.

TWA also subscribes to a more dominant and financially reinforced NASA role in aeronautical research activities. NASA's classic role in aeronautical research, i.e., fundamental research only, should be expanded. Because of the likelihood that military aeronautical developments will not provide beneficial technical fallout in the future to the degree it has in the past, NASA should also undertake "proof of concept" developments. The application of this principle, however, should be judiciously applied through consultation with industry and the military services. NASA "proof of concept" projects should be implemented only in those cases where private interests find it impossible to economically support the venture. "Proof of concept" projects should be undertaken to the degree necessary to develop acceptable risks for industry.

Additionally, research and development efforts should be intensified in airway systems research aimed toward expanding the capacity of the airways, the development of STOL airways compatible with but independent of CTOL airways, research in satellite or other potentially more capable air traffic control systems, airport research and design studies, as well as the FAA's excellent safety research programs.

Further, it would be advantageous if this nation's aeronautical research and development activities could be more completely coordinated in the future. NASA seems uniquely situated by both experience and organization to play a central role in this activity. In any event, it seems appropriate to respectfully suggest to the Subcommittee that responsibility for over-viewing and coordinating total aeronautical government research and development activities, including NASA's, be assigned to an appropriate government function.

TWA also wishes to point out to the Subcommittee that in its opinion the ability of the airlines of this country to work directly with the manufacturers from conceptual through pre-design, design, and post-production developments has been a dominant factor in producing U.S. transport aircraft whose quality is second to none in the world. The successful inclusion of lessons learned from operating experience and the ability to so tailor the designs as to more nearly optimize the economic characteristics of the vehicles to suit customer needs are important practices that need to be continued in the future. These practices represent a valuable asset not found in other countries to the degree that it exists in the United States.

TWA wishes to emphasize the need for expanded R&D programs in the following areas:

1. External Aircraft Noise Suppression Research

R&D efforts to reduce aircraft noise at its source and to suppress external aircraft noise should be intensified. Proof of concept projects should be undertaken when necessary to advance the state of the art.

a. *Sonic Boom Research.*—In addition to continuing current research programs to better understand sonic boom phenomena, further research efforts specifically oriented toward relieving its intensity should be undertaken. While solutions to alleviate are neither obvious nor easy, the oncoming sonic boom problem warrants significant further research efforts in this general area. In addition to airplane design configuration analyses, research in all fundamental aspects should be vigorously pursued.

b. *Vehicle Design and Operation.*—

(1) Evaluation of noise as a basic design parameter by means of parametric design trade studies of all types of future aircraft. The objective of this study is to evaluate current and prospective state of the art developments in noise suppression and generation, and to predict variations in aircraft operational characteristics and operating costs as a function of the degree of noise suppression or attenuation that can be reasonably obtained through basic aircraft design. All prospective general aviation and air carrier aircraft types including V/STOL's should be included.

(2) Explore noise characteristics of supersonic compressors to determine feasibility of designing compressors so that primary frequencies are out of the hearing range of humans. Supersonic compressors give promise of being both efficient and light in weight. If the state of the art can be advanced to produce high air flow in the inaudible sonic range a tremendously important breakthrough will have occurred.

(3) Continue airplane performance evaluation studies including glide slope research. NASA's efforts should be encouraged with respect to new aircraft designs including STOL types.

(4) Development of retractable noise suppressors for engine inlets and exhausts. Contracts with airframe and/or engine manufacturers to develop and test various types of retractable suppressors might be appropriate. The objective is to determine whether or not effective sound suppression can be achieved at reasonable weights without imposing unacceptable penalty in the altitude climb, cruise, and descent regimes.

c. *Airport and Community Soundproofing.*—

(1) Develop basic information and techniques to permit greater containment of aircraft noise within airport boundaries. To date, maximum research effort has been spent on reducing airborne vehicle generated noise. These efforts should be continued. On the other hand, minimum effort has been extended toward determining how the undesirable effects of airport generated noise on communities can be minimized through containment of noise within airport boundaries. Ways and means for attenuating sideline and close-in approach and takeoff aircraft noise by use of various types of vegetation, airport surface treatment, fences and deflectors, building locations, various external treatments of building surfaces to absorb noise, shapes of buildings to deflect noise, effects of land gradients on noise deflection, etc., etc., should be explored. The overall objective should be to develop sufficient empirical data to enable achieving significant improvements in community noise.

(2) Explore and evaluate ways and means for soundproofing communities. (Similar to the preceding item.)

2. Human Factors Research

The area of human factors is one in which appreciably greater R&D effort should be spent. As automation extends man's usefulness and more reliance is placed on machines, reassessment of the man-machine interface should be made.

The optimum balance of workload/responsibility between man and machine, should be determined to assure maximum reliability of the system particularly under non-routine conditions. A great deal of research on this subject has been done for the space program. These efforts should be integrated with and extended to include research of air transport operations and private flying. Research on the cause of pilot fatigue, i.e., time zone changes, effects of cabin humidity, of cabin oxygen content, of cabin noise, of diet, of inactivity (sitting for long periods), etc., should be included.

3. Air Traffic Surveillance Via Satellite

Systems research to provide maximum use of advanced technology benefits from the United States space program toward development of complete control of prime air space and the reduction of collision hazard should be continued. (Also see Part II, Item 6.)

4. Auxiliary Decelerator

Needs exist for development of an operationally practical device that is independent of the airplane/runway interface which will provide aircraft decelerations under all-weather conditions roughly equivalent to those now available with modern wheel brake systems on dry runways. Such a system could replace the relatively ineffecient thrust reversers now in use. Need is evidenced by overrun incidents that occur during periods of wet or icy runway conditions.

5. Environmental Sciences

As advanced as our technology is, the air transport industry still faces major operational problems as a result of the physical characteristics of the atmosphere which are not fully understood. Examples range from airport fog to turbulence upsets and lightning strikes. More basic research must be conducted to fully understand the nature of the atmospheric disturbances so trouble can be effectively avoided in the future. Research should also include development of accurate meteorological forecasting of the upper atmosphere at SST cruising levels in enough detail to permit reliable dispatch of SST's without incurring avoidable payload penalties.

6. Fuel Research

(*a*) One of the most difficult problems in supersonic transport design is the very low ratio of payload to mission fuel. The development of a safe, economical, high specific energy fuel would increase payload or range. Such a fuel would also be of great benefit to subsonic aircraft operations. Research in this area, in addition to being applicable to existing engines, should be well coordinated with advanced technology engine programs so that developments can be efficiently integrated to yield maximum early benefits.

(*b*) Expedite development of high energy "safety" fuels and practical aircraft fuel systems to permit their use. While research in the use of jellied and other safety type fuels has been extensive, further research and proof of concept testing is required and should be undertaken. (Reference: Part II, Item 3.)

7. Advanced Technology Propulsion Systems

The development and use of higher altitude airways appears essential for the sustained growth of air transportation. Airway saturation and delays currently being experienced must be alleviated. The development of suitable power plants capable of propelling airframes efficiently at altitudes from 40,000 feet to 60,000 feet is highly desirable. Basic research needed for development of such engines should be vigorously pursued. Such concepts as variable compression ratio and variable bypass ratio engines should be included. Noise attenuation at lower level operations as well as smoke-free operations should also be primary research targets.

8. Development of Low Cost Collision Avoidance Systems or Proximity Warning Indicator

Sophisticated and expensive collision avoidance systems now being developed by the airlines will be too expensive for widespread general aviation applications. The development of practical, low cost collision avoidance systems or proximity warning indicators practical for installation in all general aviation aircraft operating on airways or at air carrier airports is essential to safety. Such equipment does not now exist. Further research including "proof of concept" developments should be vigorously pursued. (See Part II, Item 5.)

9. Emergency Aircraft Power Unit

Need exists for development of an efficient new type emergency power unit capable of providing emergency hydraulic and electric power to permit control and essential systems operation of transport aircraft in the event all of the main power plants fail. While the probability of complete power plant failure is remote, the nature of advanced technology aircraft systems is such that development of this kind of emergency power unit is appropriate. Research should be oriented toward developing equipment which would be reliable, fast in operation, light, and subject to pretesting. New, low or zero aerodynamic drag solutions are needed.

10. Development of Communications Techniques to Provide More Discrete Frequencies in the Congested Spectrum such as VHF

Current communications frequencies are becoming overloaded. New relieving techniques or systems should be developed.

11. V/STOL Systems Research

Further basic and proof of concept research is needed to permit the development of economical and fully operational V/STOL type transports for volume market applications. Vehicle and power plant research should be expedited since STOL operation has the potential for relieving airport and airways congestion while providing new attractive services to the public.

Since vehicle oriented developments including the power plant can be applied to only one part of future V/STOL transportation systems, it is important that a systems planning research and development program which embraces all essential parts of the system be undertaken. All system components should be developed in a timely and compatible fashion. Areas other than the development of the vehicle requiring greater effort are: airways and air traffic control, navigation and communications systems, establishment of V/STOL airport facilities including passenger service systems, modification and/or expansion of existing airport facilities to accommodate V/STOL operations, and, of course, definition of the broad national function V/STOL's should perform, i.e., what part of the total transportation system they should play, and, finally, resolution of V/STOL route franchise questions.

Greater study and/or R&D efforts are appropriate.

II. TWA AERONAUTICAL R&D PROJECTS

TWA's aeronautical research and development projects believed to be of interest to the Subcommittee on Advanced Research and Technology of the Committee on Science and Astronautics of the House of Representatives follow. In numbers of cases additional government-sponsored research and development cooperative activities would be helpful and appropriate as noted. In addition to the R&D projects listed herein, TWA has numbers of other projects under way which are not listed because, while collectively important, they are believed not to merit, individually, the attention of the Subcommittee.

1. Airborne Integrated Data Systems

In 1963, TWA pioneered the first installation of an AIDS system on a Boeing 707–131 aircraft. The system initially monitored and recorded maintenance information from 207 power plant, hydraulic, navigation, electrical and aircraft performance parameters. The evaluation program was expanded in 1964 to cover 315 parameters.

This experience in automatically collecting and recording numerous measurements from a wide variety of aircraft systems provided the knowledge to proceed with a fleet installation of AIDS on TWA's Douglas DC–9 aircraft. This program is now over 50% completed and has provided maintenance with a basic diagnostic tool for defining and locating troubles in the aircraft's power plant and fire warning systems.

TWA has recently contracted with the Boeing Company to install provisions for a 512-parameter AIDS on its fleet of Boeing 747 model aircraft to be delivered starting in 1969, and is laying the groundwork with Lockheed to have a complete AIDS installed on its L–1011 aircraft.

The military has also been doing extensive work in the development of AIDS. AiResearch Corporation has, under contract, run an extensive investigation on the use of AIDS on F104 and F4C aircraft. C141, C133, and C5A aircraft have or will have AIDS systems installed and extensive evaluation and data diagnostic programs conducted. Unfortunately, although commercial airlines have readily made the preliminary results of their AIDS experience available to the military, the airlines have been unable to obtain, to date, any of the reports and results of the various military programs.

As more and more complex aircraft are built the need for AIDS becomes more urgent if effective maintenance is to be performed in reasonable time.

The Supersonic Transport affords the biggest challenge. With ground time costs at a premium, maintenance items will, in all probability, need to be automatically transmitted from air-to-ground. This will allow non-routine maintenance to be scheduled ahead of aircraft arrival and started immediately upon termination of the flight.

The development of the recording, diagnostic, and data techniques is of mutual concern to both military and commercial aviation and it is hoped that better means will be established for dissemination of military AIDS information so that a greater mutual assistance can be established toward the objective of improved reliability.

2. CAT II and III Reduced Weather Minimum Operations

TWA was one of the first two airlines to receive authorization for jet landings. Both obtained FAA approval on May 15, 1962. TWA immediately began a multi-million dollar fleet modification and pilot training program to permit All-Weather, Category II operation. The development of this program was also based on the need to provide a solid foundation for the further requirements of a Category III operation later on. For this reason, the full capabilities of some components of the present program provide facilities and capabilities beyond the minimum Category II requirements but are being utilized to increase the immediate safety and reliability of the present operation. TWA expects to achieve full Category II capability by the third quarter of 1969.

Significant in the development of this program were TWA's pioneering efforts with Kollsman in refining the accuracy of the present barometric altimeters and with Safe Flight in developing the unique speed control system utilizing aircraft angle-of-attack information as the basis for signaling automatic throttle operation.

Looking toward Category III, TWA has already placed in operation two 707–131B aircraft and two 727–231 aircraft having full provisions installed to accept all anticipated equipment needed for such operation, based on present interpretation of the requirements. The FAA has not released any final requirements for CAT III operation as of this date.

Working with the various manufacturers, TWA expects to develop the remaining equipment to permit Category III evaluations to be made with these aircraft during 1969. Full fleet implementation could follow in the early 1970's, depending on operational and cost benefit analyses.

The airline industry's portion of a joint industry-government effort to improve the safety and reliability of approach and landing in all-weather conditions is far ahead of the government's installation of ground facilities. As late as July, 1968, the FAA had only one runway capable of CAT II (1200 ft. RVR) day and night operation. The government should accelerate these installations to enable the airlines to better meet the needs of travelers and shippers. All developments which increase the capability of the airplane and the pilot to operate at lower minimums offer significant and tangible benefit to the industry. Recent experiments with fog dispersal techniques at airports and along turnpikes are promising. It is recommended that these programs be continued and expanded.

3. Fuel System Inerting

The Air Force is conducting a great deal of research in this area, particularly aimed at improving fire protection for the fuel systems of helicopters. Flight Safety Foundation and others have conducted research in the field of fuel containment in the event of crashes. TWA's experience in the installation of the Fenwal Fuel Tank Inerting system is an example, and Parker Aircraft has developed a new system which purges the fuel tank with dry nitrogen to reduce the oxygen content. Many such activities are under way, some aimed at protecting fuel systems against ignition from sources such as lightning or external fire (or, in the case of the military, against incendiary bullets). Both fuel containment and protection against ignition sources need to be con-

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sidered. Jelled fuel offers some prospects in this area, but poses major problems in the handling of fuel and its use in flight. At the present time the FAA is undertaking to coordinate the current R&D projects by a Fuel Safety Advisory Committee, for which B. M. Meador of TWA is the ATA representative. Strong coordination and further research are appropriate.

4. Clear Air Turbulence Detection

Clear air turbulence, or, simply, CAT, is a hazard to aviation and the problem becomes more acute with the advent of high-speed, high-flying, and large (thus, more flexible) jet airplanes which interact with CAT across an increasing area of the atmosphere. Suitable means must be developed for detecting the presence of CAT in time for the pilot to take appropriate action to minimize its effects.

Today's effort on this subject is being concentrated at three aspects of the problem:

(*a*) Theories and measurements concerning the origin and the structure of CAT.

(*b*) Methods for forecasting CAT.

(*c*) Methods for the remote detection of CAT.

While the physics are not fully known, there are some promising developments in the field of remote CAT detection. Ground based radar has to date provided the most reliable detection of turbulence. However, even this success is rather limited. With 60 ft. diameter antennas and 3 megawatt peak power, the range of detection is less than seven miles. Furthermore, even if a network of high-power ground radar stations were feasible, it is obvious that aircraft must carry their own detection system since CAT areas are very small and unstable. Ground radar stations for detecting CAT would be even less practical than depending on ground weather radar for thunderstorm avoidance.

Two concepts are presently undergoing equipment development for remote airborne detection of CAT. These are LIDAR and infrared measurements of temperature variations.

LIDAR refers to light detection and ranging, which includes the use of laser beams. Results to date with this type of system have been inconclusive and much additional research is needed before a practical system can be developed.

Barnes Engineering Company has an infrared spectrometer which mounts in the existing periscopic sextant location. An equivalent system has been evaluated by the Canadian National Aeronautical Establishment who found a high correlation between temperature variations and turbulence.

TWA approached Barnes in January 1968 to evaluate a system they had developed for airline use. By present planning, this system will be installed on domestic TWA aircraft during October, with the evaluation period extending through the winter of 1968–69 in order to accumulate as much meaningful data as possible.

Until a positive solution to the hazards of CAT is established further fundamental research efforts are appropriate.

5. Collision Avoidance System

The development of a cooperative collision avoidance system has been progressing through efforts of the airlines and the Air Transport Association since 1966. Flight test and evaluation of several prototype systems will begin in mid 1969 to prove or disprove the feasibility of the time frequency concept as applied to collision avoidance.

Even if this system becomes operational and practical, it would be expensive and heavy, and probably unacceptable to general aviation. Additional research and development are needed before total protection from the threat of mid-air collision is achieved.

The development of an effective CAS is of paramount importance, especially in view of current congestion problems at our major airports and along the air traffic corridors. Development of a fully acceptable, universally applicable collision avoidance system deserves continued full support of both industry and government to better insure early success.

6. Satellite Communication System

TWA, along with other major U.S. and foreign flag airlines, is involved in a joint ARINC/NASA program to develop a practical VHF satellite communications system capable of providing reliable static-free, air-ground communications with aircraft on long flights over oceans or uninhabited land areas. Numerous flight tests during the last two years, utilizing the NASA ATS–1 and 3 satellites, have proven the feasibility of voice and data communications via a synchronous orbit satellite, but we will require further development of these aircraft antenna systems.

This program will continue in 1969 to further improve the basic voice communication system and will also be directed toward the development of additional applications of satellite techniques to the aeronautical services. Such applications will include automatic data communications, aircraft navigation and ground surveillance of aircraft position for improved air traffic control in the high density over-ocean air routes.

7. Inertial Navigation System (INS)

Military developments in the field of INS have played a major part in the programs of many airlines to use INS equipment on future aircraft.

Within the next few months, TWA will install an INS, built by A. C. Electronics, on one of its Boeing 707–331B international aircraft. This program will help provide the experience needed to operate and maintain INS equipment on future fleets of aircraft.

Inertial Navigation Systems are being installed by Boeing at TWA's request on its fleet of 747 model aircraft to be delivered starting in 1969. Supersonic aircraft will also utilize this source of navigation.

8. Head-up Instrumentation Display

R&D activities in the field of computed display generation is of major concern to the airlines. TWA is closely evaluating the techniques whereby necessary flight information and commands from navigation and attitude systems can be superimposed on the pilot's view outside of the cockpit and focused at infinity. This feature provides the important advantage of eliminating the need for crew members to refocus their eyes and adjust for possible light variations as is done today whenever a flight crew member looks from outside the aircraft to the instrument panel, or vice versa.

TWA is currently discussing with one equipment manufacturer a program for installing and flight evaluating a set of airborne hardware on one of its autoland aircraft.

9. Vertical Scale Instrumentation

The development of vertical scale instrumentation for military aircraft has found direct application in the cockpit of commercial aircraft. TWA was the first airline to specify vertical scale instrumentation for the primary engine instruments on all Boeing model 747 aircraft. This decision was prompted to some extent by the numerous military sponsored human factor studies which showed that presentation of vertical scale indicators allows a faster and more complete scan of instrument data than dial display instruments.

The supersonic cockpit is sure to employ vertical scale instrumentation to an even greater extent.

10. On Board Weighing System

A requirement exists for more accurate and reliable gross weight and C. G. control on aircraft where considerable spreads in operating loads are common, and particularly where performance is marginal.

TWA's development efforts and the impetus provided by selection of the equipment on the 747 airplane should permit initiation of an installation program for on board weighing systems in 1969.

11. Outside Research Projects

Generally, TWA has gone to such agencies as Midwest Research Institute, Stanford Research Institute, Battelle Memorial Institute, ARINC Research Institute, and other such agencies where technical research of any depth is required, but not sponsored by one of the airframe or system manufacturers. These cases are rather infrequent and certainly would not warrant the generation of special agencies for their handling. Similarly, they do not produce large projects of a magnitude sufficient to involve industry or governmental R&D agencies.

STATEMENT OF ROBERT W. RUMMEL, VICE PRESIDENT, EQUIPMENT PLANNING AND RESEARCH, TRANS WORLD AIR LINES

Mr. RUMMEL. Thank you, sir.

Chairman Miller, Mr. Hechler. I am very pleased to be here today to briefly discuss the statement that I submitted earlier. I believe it is probably appropriate that I limit my remarks, since the statement is available, to those things that I believe to be especially important.

The statement is divided into two parts. The first relates to the adequacy of aeronautical research and development in the United States, and the second part relates to TWA aeronautical R. & D. projects.

I might say at the outset that in TWA we have an advanced technology planning and coordinating function that starts at the vice-presidential level and permeates the entire organization. One of the things which this activity embraces are the subjects that Chairman Miller mentioned, baggage handling, design of airports, ability to transfer passengers between terminals and the like. However, my prepared statement did not address itself to that general area, and if it would be of interest to the committee, I would be glad to develop a supplemental statement and submit it to outline what we are doing in that area of activity as well.

Mr. HECHLER. That would be very helpful to the committee.

Mr. RUMMEL. I will be happy to do so.

Mr. HECHLER. Thank you.

(The information requested can be found in the committee's file.)

Mr. RUMMEL. Continuing, then, on adequacy of aeronautical research and development, we believe in TWA that there is need for expanded Government funding and expanded research effort if this country is to remain preeminent in the development of the best transport aircraft in the world. There are plenty of signs that leadership in many areas may be slipping away. Other members of this panel have addressed themselves to that, so I won't belabor it.

We believe that there is urgent need for a continuation of past efforts with expansion on a long-term basis because the backbone of development to a large extent does rest with fundamental research and development, much of which in the past has come from military programs. We are not certain that in the future the military programs will develop the techniques that can be used commercially to the extent that they have so far.

We endorse the recommendations of the Aeronautics and Space Engineering Board of the National Academy of Engineering that were contained in the civil aviation research and development booklet. This was a notable effort that was participated in by many, including TWA. We believe the conclusions are sound and we would urge early implementation of the recommended projects that are contained in that work.

We would endorse the expansion of NASA's activities. We feel that their classic role which has been essentially limited to basic research and development should be expanded to include further "proof of concept" activities. Our only limit, I think, would be that the "proof of concept" activities should be carried on to the extent that is necessary to permit private interests to undertake the risk that is involved in such developments and that they should go no further. But we would urge, as I say, that their historic role be expanded somewhat in order hopefully, with adequate funding, to expedite the development of both vehicles and systems that would prove to be commercially useful.

Going on to just a few of the several specific projects that are listed, we would urge greater effort in R. & D. in examining external aircraft noise suppression. And we include determination of better understandings of noise generation, the limits of generation at the source as well as the suppression of that noise once it is generated. We include in this activity much more on sonic boom research and efforts to find ways to alleviate the probable nuisance that might be encountered later if these supersonic aircraft are allowed to be flown over land. With respect to vehicle design and operation, much more can, I think, and should be done.

I list numbers of projects—and I won't bother to use your time to repeat them. They are certainly available.

Now, there is one area on noise, though, which I think very little has been done on, much more can and should be done on. And that is the undertaking of research to find ways and means to, in effect, soundproof airports and communities.

You obviously cannot soundproof airports and communities when aircraft are high in the air other than reduce the noise of aircraft. But for low-flying airplanes in the approach, taxiing, sideline noise and the takeoff, there may well be many things that can be done with respect to the configuration of airports, the location and shape of buildings, the material used in the construction of buildings, maybe foliage. And we believe that—without taking time now to go into many areas that certainly are worthy of further exploration, we would certainly urge that an appropriate Government agency undertake an extensive and large-scale program to find ways to alleviate noise or to provide for the absorption of noise in airport communities.

On human factors research, as the newer type aircraft emerge, they will be found to be much more sophisticated. Their systems will be more automatic. The relationship of man to system, man to computer becomes increasingly important with respect to a clear definition of workload, the use of the man efficiently.

And I might say here that the work that has been done to date by both NASA and the military we believe has been particularly important and noteworthy. But this is an important area, and we think it should be expanded in the future, particularly recognizing that supersonic aircraft, even the 747's and Lockheed 1011 types, will require and should enjoy much closer attention to this very important factor. Supersonics, especially.

Air traffic surveillance via satellite is a new field. It is receiving attention. And here we believe this effort should continue, it should receive much more attention to determine how promising it really is, cost effectiveness and the like. And hopefully this may open the way toward a much more positive control and more complete surveillance.

We want all traffic given surveillance to the extent that that traffic may introduce hazards to our transportation; not just air carrier aircraft, for example.

On fuel research, here again we in TWA believe that much more should be done than has been done to produce fuels really with two improved characteristics: One is we want higher energy fuels, fuels that produce more B.t.u. at the same weight. This would have great impact on the economics of just about all air carrier aircraft to which the fuel could be applied, and especially, though, on supersonics again, where the ratio of payload to gross weight of the airplane is rather low. The other area is the further development of safety fuels to reduce crash hazards. The problem there seems to be not so much development of the fuels, as I understand it, but the development of fuel systems and powerplants which can accept the fuels in a practical and economic way. This may be one of the areas where further proof of concept activities, for example, might be appropriate.

Now, in advanced technology propulsion systems, we see the need here for the long time—in fact, it would be delightful if we had powerplants of this type today, but we don't. But we see the need for development of engines which can economically propel airplanes at from 40,000 to 60,000 feet elevations to open the skies in a large way for added traffic at those elevations.

Now this is not a simple thing to do. It may call for variable compressor ratios or variable bypass ratios, or combinations of those two items and other things. But we would urge fundamental research in this vital area.

Another item I want to emphasize is the need for a low-cost collision avoidance system or proximity warning indicator to reduce the probability of midair collisions. The collision avoidance systems that are currently under development for air carrier use—and there is a program underway that is being participated in by the airlines and the ATA and others, but that system is really much too expensive and too elaborate for practical application in nonair-carrier aircraft, smaller airplanes. There is need, in order to provide more complete protection once these systems are implemented, for a low-cost practical system. We think much further effort—basic research, development and testing of hardware is important and should be undertaken in this area.

On V/STOL's, we would support what has been said so far this morning as to the general need for the development of a fully practical and fully operational either V/STOL or STOL type aircraft. We think that there is good prospects that these types of aircraft, if and when developed, will tend to relieve air traffic problems, but will also create problems of compatibility at airports. There are many system problems I think that go along with the development of the V/STOL's, to which coordinated attention should be given.

Development of communications systems, navigation systems, the airways themselves, whether they are a lower level or whether they are integrated or what the case may be—keep in mind that I am speaking now in contemplation that if the vehicle can be satisfactorily developed, then we would expect a fairly large-scale operation to someday emerge; it would be in volume, particularly on the shorter segments. And this then calls, I think, for much further definition of not only the national interest in this vital area, how this should fit in the broader transportation picture, but resolution of route franchise questions and the technical questions that pertain to it.

In the interest of saving time, if it is agreeable, I will skip TWA's activities. They are gone into in some detail in this report. I would be glad to answer any questions on them. If you like, I could review them briefly now. But they are put forth here rather completely.

I might point out that the TWA R. & D. activities that cover some six pages here are only those which we thought would be of special interest to the committee. We have many other R. & D. activities in specialized areas that are more or less a continuous process, have been, now are, and probably will be in the future. I didn't include those.

My final remark would have to do I think with the need for, as we see it, further coordination of aeronautical research activities on a national scale. We think NASA has done an excellent job in their assigned area in this respect.

The organization of industry committees—I happen to be on the Aeronautical Advisory Research Committee; I have been on others. But I think through the years their coordination that has been brought about through industry participation has been excellent. I don't refer to that. I am referring to the broad gamut of aeronautical research, and we would suggest that there is need for the establishment of some sort of an overview body, whether it is NASA or someone else, to be given cognizance and power to make recommendations in all facets. And I think I would invite the committee's attention to that thought.

Thank you very much.

Mr. HECHLER. Mr. Rummel, this has been an outstanding statement, and it raises many, many questions that members of the committee I am sure will want to pose. We congratulate you on both the statement and the activities that TWA is carrying on.

Mr. RUMMEL. Thank you.

Mr. HECHLER. Are there any immediate questions by members of the committee before we proceed to Mr. Rhoades?

I particularly would like to ask a few questions on your last observations also later on after we have heard from our other witness.

We are very pleased to welcome Mr. W. E. Rhoades, vice president for engineering of United Air Lines.

Mr. Rhoades, I understand you were commissioned Air Corps pilot in 1929, in the old Air Corps. You were then a pilot for United Air Lines until 1941, and were General MacArthur's pilot during World War II.

Then since World War II, as I understand you have been associated with United Air Lines. You are the vice president for engineering.

It is a pleasure to welcome you to the committee, Mr. Rhoades.

Mr. RHOADES. Thank you, sir.

(The biography of Mr. W. E. Rhoades follows:)

W. E. RHOADES

W. E. (Dusty) Rhoades, Vice President of Engineering for United Air Lines, nurtured an early interest in flying into service as Gen. Douglas MacArthur's personal pilot and recognition as a foremost aviation authority.

Rhoades joined United in 1933 as a co-pilot after serving for several years with the U.S. Army Air Corps in California and Hawaii. He became a captain four years later and went on to fly all the company routes before being appointed Manager of Flight Engineering in 1949.

Rhoades was elected Vice President Engineering in 1962. He manages a staff of 350 engineers and technicians with responsibilities including study and recommendation of new aircraft, development, testing and improvement of flight and ground equipment, and support in solving maintenance problems.

Rhoades' wide experience in aerial navigation led to his being assigned to the various global flight programs of the Air Transport Command during World War II. He regularly covered the North Atlantic, Aleutian and Transpacific routes and made one of the first globe-girdling flights during the war. He also taught celestial navigation to flight crews.

From 1943 to 1946 Rhoades served as the late Gen. MacArthur's personal pilot in the South Pacific and flew him to Tokyo for the Japanese surrender ceremonies aboard the battleship Missouri.

He was assigned to the Air Transport Association in Washington for three years following the war to aid in designing a usable air navigation and traffic control system for the expanding industry.

Rhoades is on the Technical Board of the Society of Automotive Engineers and a member of the Engineering & Maintenance Advisory Committee for the International Air Transport Association.

STATEMENT OF W. E. RHOADES, VICE PRESIDENT FOR ENGINEERING, UNITED AIR LINES

Mr. Rhoades. Chairman Miller and other gentlemen of the committee, I have no prepared statement. I would subscribe wholeheartedly to the various statements that have been advanced by my compatriots here.

Also, my company has participated quite extensively in the preparation of the pamphlet that has been referred to before, and we subscribe wholeheartedly to the research and development program outlined therein.

I would like to spend just a few minutes amplifying and giving you reasons why I support some of these suggestions that have already been made.

Now, I submit that we have a very severe traffic problem, air traffic problem in the country today. But I also submit that even if we could solve that problem immediately, we would still have a pressing need for additional airports, because we might make some advancement, 10 percent, 20 percent, 50 percent more movements in the air traffic situation today, but the growth to which we are now exposed will eat up that improvement almost immediately. So the long-range program that we must embark on is the supplying of additional airports, additional concrete on which to land airplanes.

This is not a research project necessarily; it is more a development project, because there is not much research that is needed to arrive at a conclusion as to how to build an airport.

There are detailed bits of research that we need very badly. We need to know more about how to stop airplanes on concrete. We need to know more about the lighting of the runways themselves. So there are detailed parts of airport design that need some extensive research and development. But by and large, the problem that we are facing in the airline industry is that of having more places to put the airplanes or to take off the airplanes that we see coming at us in the very near future.

Now, in the traffic control field, we have had lots of genuine research and development. There have been many attempts made to try to computerize this very complex problem of airplanes moving in great quantities in three dimensions and being unable to stop. It has not been really determined yet whether this problem can be computerized. As I would see it, we have a very real need for a study—a determination of whether or not the very complex problem can ever be mechanized. If it cannot, then we must go ahead and take care of the problem by individual handling as we do today.

But this problem of trying to computerize the overall program is a most complex one, as any of you would know who have been involved in this type of attempt to reduce a complex problem to a completely machine computed and handled situation.

I point this up as an area that although there have been many honest and good attempts made to date, they have not probably been made on the scale that is necessary if we are ever to determine for sure whether the problem is solvable in this method or not.

Another thing that bothers me somewhat as an individual—and there may be very good solutions to this problem: We talk rather blithely of satellite communication, satellite navigation. Yet most of our frequencies that we use for these processes are in the frequency spectrums that are also very desirable for television, and there are present voice communications and navigation communications.

Someday we probably will determine that the airplane can put out the necessary signals and the ground can put out the necessary signals to the airplane to accomplish this very complex traffic control situation. It would be very sad if on that day we found that the frequency spectrum available to us was not sufficient to allow us to accomplish the job.

Now, I don't know whether this is a problem or not, but I suspect that it is. And I don't know whether anyone is looking at this total problem, because today we can only guess at the bandwidth we might need—frequency spectrum we might need to accomplish an automatic control system if we had one. So I submit this is an area that needs some investigation.

This would be complicated further if we were to go to satellite communications, because today at least we can segregate line-of-sight frequencies geographically so they don't interfere with each other. In a satellite situation this might not be possible.

These two problems I submit as real ones that need some intense investigation: One, the possible computerization of the air traffic problem; the other is that of whether or not we will have enough room in the radiofrequency spectrum if and when we find the solution.

The noise problem has been well covered. I would not attempt to cover that one.

I do believe that Government funding should not be spent in those areas that we can best know our own needs and spend our own money. As an example, I don't think personally that the Government should spend money on developing airborne equipment for a better landing system. Ground equipment is one thing, but the airborne equipment is a thing that we should be developing. We probably know more about it, we know what the problem is, we know our capabilities, our limitations. There are areas of this type that we should not ask Government assistance on.

And with those few comments, I think that is all I can really say.

Mr. Hechler. Well, thank you very much, Mr. Rhoades.

I would like to throw out a couple of general questions that were prompted by your observations on airports and the need for advanced research and planning in the developments of these airports.

There has been a lot of testimony before this committee on the development of short takeoff and landing planes, and there has also been a definition of the applicability of those planes. It has been my observation that the discussion about short takeoff and landing planes has lulled many areas into complacency about the development of airports. They have read this observation that we are going to have these short takeoff planes; therefore, why do we need these big airports? Why should we invest in longer runways?

Likewise, I would like to raise a question with the panel as to whether the method of local municipal bond financing of airports isn't in many instances a very serious limiting factor on the development of a proper site for an airport that would serve the national interest and work in with our overall transportation system.

I would like to throw out these two questions and get comments by members of the panel on those two questions, anyone who would care to shoot at them.

Mr. RHOADES. Well, I for one would like to comment on this V/STOL operation. We have done a lot of study of the feasibility of this short-haul airplane. It is very true we can move one airplane or 10 airplanes quite effectively without interrupting the rest of the traffic. But if we are to do this job totally between the really high density centers—we are not talking about one airplane or 10 airplanes; we are talking about dozens of airplanes. Now they create their own traffic problem, they create their own parking problem at their airport if they have one. If they don't have one, they interfere with the long-haul traffic.

So there are many, many problems that come up: Where do you park the airplanes at night when they are not being used, the gate space problem, the distance between arrivals and departures. So that we have the same problem all over again once the density of the traffic arrives at the point where we are today. And this is one of the problems that is a little bit discouraging when we look at the overall concept that we might mix this traffic with our present heavy traffic.

Mr. RUMMEL. I would like to add to that, if I may: The development of STOL's, I think, should be kept in a perspective of time. There are STOL's that exist today, but most of them are for air-taxi-type work, or the smaller type machines.

I believe that most of the airlines when they speak of STOL's for either trunkline short-haul operations or other purposes perhaps tend to think of STOL's as do the manufacturers, as being larger machines and being machines which would be economical for these types of operations.

Now, the earliest that the larger, more sophisticated machines could reasonably be developed—and this is the opinion of the manufacturers that has been given to me, not my personal appraisal, but I think it is reasonable—puts them around 1974 for experimental use. Large-scale usage would perhaps be during 1974–75 and onward. That is the general time scale.

But we have airport problems today. We have problems of congestion. We face the need for properly equipping airports so we can make good use of—the public can make good use of the 747's. The 747's will first be delivered in late 1969. They will be in fairly large-scale use by the end of 1970. This will be followed in 1972 by large quantities of Lockheed 1011's and Douglas DC–10 trijets. The equipment already on order by the airlines to satisfy the increasing public demand for conventional types is also a problem. And all these things in combination present a very difficult airport problem.

We lack airport capacity at many existing airports. We have the need for additional airports. STOL's, as I said earlier, I think will offer good relief. So would other things. These things should be pursued and pushed. But I don't really think that relief will be immediate.

And so what I am really saying is that in response to your question, both must move forward, and early attention to relief of airports for conventional-type airplanes, I think, is imperative.

Now, the ATA airlines generally have tried to address that. Perhaps General von Kann will want to talk on this point. The question of financing, the Federal Government's levying of head taxes and the like and other ramifications have been given consideration, and while the ATA has not come to a completely final position, we strongly subscribe to some device which will permit early and quick attention to this problem on a large scale—I am speaking of airport construction and expansion—so that we can better cope with that which we as airlines must place first and foremost, and that is public convenience.

There is no reason why we shouldn't try our utmost to find ways to provide services on the ground which are at least commensurate with the progress that will be made in the air. The air will be in good shape, we will have comfortable airplanes, convenient schedules. But the problem of ground access, of airport construction is a big bottleneck as I see it, and that is one with which we are vitally concerned, and we certainly subscribe to any relief or any reasonable help that can be made available.

Mr. Hechler. Do you care to make any observation on the method of local financing? Is that an inhibiting factor at all?

Mr. Rummel. That seems to vary a great deal with the community. It is probably—frequently when there is a problem encountered, it is a product of maybe the timing locally in the community, ability of the community to respond at the time when the need is there. And the ATA airlines, I think, generally have come to the conclusion that there is definite need for assistance in this general broad area.

Mr. Hechler. Mr. Kolk, would you care to comment on this general question?

Mr. Kolk. Yes.

With reference to STOL, it is the proper thing that is going to cure all our problems, and it really isn't unless we do a lot of hard work. We have a "today's problem," and we can't buy STOL's to fly today, so we have to worry about today's problems today. But if we don't accept the principle that we have to develop more airports to operate from in the various municipalities and do this on a system basis so that it is done cost effectively and with proper use of real estate and acceptable to the community—if we don't face that challenge, the problems that we have today are going to be magnified 15, 20 times, 10 years from now.

We have the technology for STOL airplanes today. There is a fine STOL airplane flying. It is a French Army airplane, and Scotty has got the thing trundling around New York today. There is no reason why that airplane couldn't be put into production, and it would be a useful tool.

Part of the problem that we have is that the technicians, the airplane technicians have outstripped the rest of the system.

I would say that—well, for instance, there is a military airplane built in Canada called the Buffalo. I went up and inspected it about a year ago, and I asked them, if I bought one of these how short a field could I operate in. They quoted a number, which the exact value I don't recall, but it was about 4,500 feet for landing. Now the fact of the matter is that we are certified legally to land a 727 in a shorter field.

Now, this kind of thinking, disjointed thinking, completely permeates the whole area of STOL and VTOL. What can you do about it if you really want to do anything about it? You are hamstrung by all of the people who tell you what you can't do. And this is, I think, a very, very important point.

But I want to emphasize that if we are going to have satellite airports instead of one major terminal for a city, that the satellite airports should not be developed as superairports, but we should make an attempt to divert the short-haul traffic from our current superairports and put them in the most convenient place for short-haul transportation. In order to do that, you want to have a system of transportation that is based upon conservatism of real estate, both in runway requirements and parking requirements—airplane parking requirements. And you must develop systematically airports around this concept so that you can move people quickly and efficiently with a minimum use of resources.

And this is, I think, the message of STOL, and it is that simple.

Mr. Hechler. Would you say the Minneapolis-St. Paul example is a good one?

Mr. Kolk. I am not really familiar with Minneapolis-St. Paul. We don't serve it. But it is certainly true in most any area.

New York is a perfect example. They can't find a place for a big jetport, but maybe they could find a place for three or four STOL ports around the city.

Mr. Hechler. Before I ask Mr. Crossfield, I understand Mr. Pelly has to leave and he wants to make an observation or ask a question.

Mr. Pelly. After yesterday's reference to possible FAA control over airline schedules, we ought to have on the record your comments with regard to such control over your schedules.

There has been some criticism, as you know, that the airlines are causing their own congestion by scheduling all their planes at the popular hours.

Mr. Kolk. I would like to make a statement on this.

Airline scheduling is put together for the convenience of the traveling public. We hold from the Federal Government a certificate called a certificate of convenience and necessity. We are in business to serve the public.

We know darn well that if a guy wants to leave Washington at the end of his working day at 5 o'clock and go to New York, that running airplanes at noontime between New York and Washington isn't going to satisfy the public requirement. Now it is that simple.

They are scheduled there for the use of the traveling public. And we have a transportation system that is designed to save time. If the time is going to be saved by the ordinary traveler—and you yourself are probably a good example. You know when you want to travel.

Mr. PELLY. Yes; but if there is no slot running into New York the public is inconvenienced. You don't get off the ground.

Mr. KOLK. Well, what are you going to do? Tell us we can't fly airplanes in those periods of time?

Mr. PELLY. Well, I think that you have stated your case. I just wanted to——

Chairman MILLER. I was just wondering, if the gentleman would yield—because this sounds like a thing that happenend to me some time ago. Now there is a great deal of automobile congestion on the San Francisco-Oakland Bay Bridge——

Mr. KOLK. Yes.

Chairman MILLER (continuing). Between 8 o'clock in the morning and around 6 o'clock at night. We were discussing this and the wife of a very prominent businessman said "I never see any trouble; I never have any trouble."

"When do you travel?"

"Oh, I always get home around 4 o'clock."

So between 10 and 4, they had no problem. I think that is the same thing that is happening here.

Mr. RHOADES. Mr. Chairman, may I comment——

Mr. HECHLER. Mr. Rhoades.

Mr. RHOADES (continuing). On this problem of limiting schedules? We can solve any problem by just not creating it. We can solve the traffic problem immediately by just taking half the airplanes off the airways. But we think the only way to solve the traffic problem is to move the traffic that desires to move, and any other solution has to be a temporary one until we can find the way to move the airplanes.

Mr. PELLY. I think Mr. Crossfield's testimony on what they are doing in the way of research indicates that you are capable of scheduling your planes and satisfying the public convenience and solving something of the airport congestion. I thought it should be on the record.

General VON KANN. If I may, sir, in this respect, as you know, the FAA is—well, having hearings at this time on this subject, and the airline position is very well described by the testimony which Mr. Tipton gave last week, much of which has been reflected here in what has been said. But it might be appropriate for me to also submit a copy of that statement.

(The statement referred to may be found in committee files:)

Mr. HECHLER. Yes. I don't want this committee to get out of its jurisdiction.

Chairman MILLER. Well, that is one of the things we have to be very careful about. But I think as background information this would be very valuable.

Mr. HECHLER. Yes.

Mr. PELLY. It would do a lot in research, I think, to develop it.

Mr. Hechler. I shortchanged Mr. Crossfield here. Did you want to make any observations on this question?

Mr. Crossfield. Yes, I did, because we talked about what we can't do for the immediate problem, and this I guess I didn't state myself very clearly. We have the capability of developing today an improvement of our air traffic control system which will in fact relieve this problem and not just constrain trade. And I say that it is easy to show that. If I pulled 20 percent of the traffic out of Kennedy, Kennedy would go back on schedule. Well, it happens that 30 percent of the traffic at Kennedy is short-haul traffic. If we could move that out to the peripheral airports—and we can—but we can't today because we don't have all-weather capability, we don't have a traffic control system that will allow us to go out there. The traffic control system is designed to pull us all through the needle eye of the ILS runway to land right at Kennedy, and that is where we all have to go. And I am saying that as a development thing for the country to enter into, it is here today, to use the peripheral airports and decongest the major airports.

You made reference to financing. It seems to me that money invested like in Los Angeles where they float a half a billion dollars worth of bonds, and the port authority has money—what I rather regret seeing is this being all aimed at building airports that perpetuates the system that we already know isn't working. Now they are putting a STOL port in downtown Los Angeles at a lot of cost in money, but there is no place to park an airplane on it. So a flat tire is going to hold up the world there.

They are also doing it under the concept that STOL airplanes are these little airplanes that put down in a glide slope at 50 miles an hour and hold up the whole world. We don't envision that in any of the airlines here. We are talking about mass transportation in STOL airplanes, and that is why it is going to take some time to get there.

We have the capability of doing it in the interim sense which is, as I say, modifying existing transports where we can take a step in that direction and use the short runway. But we are already certified, as American Airlines says, for the short runway, but we can't get on it because we don't have the precision landing capability. This is where the development has to be done, the immediate development work.

We are presenting to the FAA the system that I am trying to develop. Maybe it isn't the way, but it is a way to step in that direction, because most of the money is going into automating at present our manual control systems which just can't handle the volume of traffic. It is a "Keystone Cops" operation. So I think we are here. You don't have to think in the future. I think we are here if we make some directional development effort and utilize the technology available to us.

The other thing about the STOL that is going to help us is its very low demand for real estate. We can begin to move our traffic closer to city centers, and that in itself should relieve the ground traffic problem. This is our hope.

Mr. Hechler. It disturbs me that some Members of Congress and Federal officials tend to say that if you devise a solution to this, it somehow will be antidemocratic, and will be too dictatorial. Somebody might say "That's another example of why we ought to throw the briefcases of the bureaucrats into the Potomac."

Yet we are dealing with a national problem, and we are certainly going to have a national transportation crisis of increasing proportions in the future unless we do some advanced research as to how to solve this problem in the national interest.

General von Kann. You have a basic problem, of course, in that the air transport system has three subsystems: An airborne subsystem which is generally provided by the airline industry, the airborne equipment; the ground environment which is provided by Lord knows how many jurisdictions; and then the interface of the air traffic control system which is provided by the Federal Government.

Mr. Kolk has pointed out, the part that has to do with the airborne system has really moved ahead faster than the others. And there is differential R. & D. emphasis on all three.

We in the airlines are very highly dedicated to technology. We ride technology, and our customers do, too. But on the other hand, a regulated industry cannot go all out in all the R. & D. that it might like to do, even though we get into a lot. But there still is a financial problem as to how far we can go ourselves with it, and that is why we are so interested in the very programs that you are considering.

Mr. Hechler. We have one more witness this morning. I also neglected to recognize Mr. Hunt. Mr. Hunt?

Mr. Hunt. Thank you, Mr. Chairman.

I came in a little late and I have been listening to the discussion on the peripheral airports. How much thought is being given to peripheral airports that would handle nothing but executive and private planes rather than their using the major airports?

General von Kann. I think I can answer that. A great deal of thought. As a matter of fact, there is almost universal agreement, as far as I know, in the aviation community that this is the general pattern that should obtain. And most of us look upon the Minneapolis example as a very good one. Again, the problem is that the action has to be taken largely by local jurisdictions, and this brings the patterns in, which vary all over the country.

It is an unfortunate fact that although I think you can prove that an airport system is good for any community, the communities themselves don't seem to want them or at least want them in the places where logic might indicate that they should be. And maybe we in the aviation community should do a better job on selling this point to local people.

Mr. Hunt. Do you think that perhaps some of the reasons why you cannot get local cooperation in response to the dictates of modern travel are due to the financial strangulation that is now occurring in many small municipalities?

General von Kann. This undoubtedly plays a part.

Mr. Hunt. What do you suggest as a solution to that?

General von Kann. We are busily engaged on that problem right now. As a matter of fact, Mr. Rummel is a member of one of the key airline committees that are working on that and are engaging in discussions with other interested people.

I had indicated before you arrived, sir, that I would submit a statement for the record on our latest position on what our proposals would be in the way of airport financing. And that will be forthcoming.

(The statement referred to follows:)

Federal Airport Development Act of 1968

OUTLINE OF PROVISIONS

1. Establishes an Airport Development Trust Fund administered by the Secretary of Transportation.

2. Fund will be supported by special taxes of 2% on domestic passenger tickets and $2 per passenger in foreign air transportation. While the program will function without general tax revenues, it does not preclude such appropriations.

3. Fund will be used:

(a) primarily for contracts of up to 40 years in length by the Secretary of Transportation with local airport sponsors to pay up to 75% of the principal and interest of local airport bonds for airfield and terminal projects;

(b) to guarantee the full amount of such local bonds;

(c) to purchase local airport bonds for resale;

(d) to make short-term loans for advance planning and land acquisition.

4. Funds will be available to:

(a) all airports served by air carriers;

(b) general aviation airports designed to relieve congestion at major airports.

5. Contemplates FAAP program continuance for small airports served by air carriers and for general aviation airports.

6. Tax revenues of $109 million will be realized in FY 1969 and will support issuance of $1,950,000,000 in local airport bonds the first year.

7. Congress each year, through appropriation acts covering the three succeeding fiscal years, will authorize the Secretary of Transportation to make the expenditures to meet the obligations incurred.

The program is proposed as a means of generating large amounts of capital to meet the nation's most immediate major airport construction requirements without any burden on the general taxpayer and without unduly burdening airline passengers. The provision is Sec. 3(b) for federal contracts to pay a portion of local debt service costs is based on Sec. 10 of the U.S. Housing Act of 1937, as amended (42 U.S.C. 1410). The trust fund feature is patterned in part on the Highway Trust Fund. (See 23 U.S.C. 120, note.)

Mr. Hunt. In other words, your problem is much the same as politics in that it changes from day to day, depending upon who's talking.

General von Kann. To some extent this is true. Although I think there has been a good deal of movement getting the diversion of views closer together.

And subject to Mr. Rummel's thoughts on it, I would say that we are much closer to consensus than at any time in the past. Is that a fair statement?

Mr. Rummel. Yes; I agree with that.

Mr. Hunt. The reason I asked this question is that I am pursuing a line of questioning here in regard to a proposed jetport in what is now referred to as the "golden triangle." I live in the southern part of New Jersey. Of course, we have that horrible congestion in New York City and we have Newark where one of the major airlines is moving their facilities.

The problem is where they are going to put this so-called super jetport. I have had the occasion to see several of the proposed sites and inspect them. I might say there wasn't too much planning given to one proposed site because it was to go on two of our major reservoirs constructed within the last 10 years, Bruce Run and Round Top. I don't think you can put a jetport over top of two huge natural reservoirs. So someone in their planning forgot to go look at the mosaic.

I am concerned with this problem because it has been my thought for a number of years that some of our congestion is caused by executive planes and private planes using the major ports. In fact, I used to fly quite a bit, in a little two-engine Apache.

We have a small airport directly across the river from Philadelphia International, and we take our landing instructions and takeoff from Philadelphia. It is only a matter of 2 or 3 miles across the river. Now this port is being lost to that locality because they are going to build a new school at the end of the runway. And for 10 years we have been trying to interest someone into developing this old port for the express purpose of bringing in executive and light planes to relieve the congestion at Philadelphia International that was being forced on us 10 years ago. But it has been nothing but a series of planning, planning, and talking, and no "doing."

One of the things, of course, is that it is a developing locality, sparsely populated, excellent location for an airport, but with no money available. We could not interest any major concern into developing the area. We have had many of them down there to look at it, but they have all walked away and said "we'll call you, don't call us." Now they are going to get bit with this bug, because time is of the essence and it is rapidly running out. I will be very happy to see your paper when you present it.

Mr. Hechler. Any further questions, Mr. Hunt?

Mr. Hunt. No.

Mr. Hechler. We would like to encourage members of the panel to submit any additional information, particularly with reference to what Mr. Rummel was saying about the need for an overview body and the need for coordination on a national scale. What you could submit on this and other members of the panel could submit will be helpful to this committee in guiding the research and development in aeronautics in the future.

Thank you very much, gentlemen.

Chairman Miller. Mr. Chairman.

Mr. Hechler. Mr. Chairman.

Chairman Miller. I would like to pose one question for these gentlemen and let them give it some thought.

Are we looking far enough into the future? Or is the problem that confronts us today so great that we are just working on phases of it?

I have in mind a metropolitan area in this country that the Corps of Engineers, in order to do some planning, asked the Bureau of Standards some years ago to project its population by the year 2020, which seems a long way off. There are now 3,700,000 people in this area; they came up with a projection of 14,400,000 people. They are doing some studies on this basis.

However, it affects 40-odd cities and communities and there is always the party that wants to pull out with no way to regulate him. In my opinion, this is going to be the pattern of our metropolitan areas, where we are going to outstrip cities through the country.

Now, as I see it, we have outstripped the practical operational problems by the development of new planes and new technology that has come into the field.

I suppose 20 years ago even you gentlemen didn't anticipate what you have today in the line of aircraft and what you will have tomorrow.

I was interested in Mr. Crossfield's statement that he had to go to Europe to get certain aircraft systems and aircraft. Yet, in this recent book called "The American Challenge in Europe," the author makes the statement that all the effort they put into the *Concorde* will go to naught because they didn't build it with the proper material, so that it can't sustain the higher speeds without burning up, and that America is way ahead of them because we have used titanium and other materials capable of sustaining such speeds. If this is the case, then where do we go from here in this particular field?

I think our technology is here, but are we using it and giving enough emphasis on the future so that 5 or 6 years from now we will not be forced to retrace our steps because of a new development. I wish you would give it some thought and include it in your comments.

Mr. HECHLER. Thank you again, gentlemen, for appearing this morning. It has been extremely helpful to the committee, and we will look forward to comments on Chairman Miller's observation and some of the other things that you care to add on what other members of the panel have offered.

General VON KANN. Thank you, sir.

Mr. HECHLER. The committee will resume.

Our next witness is Mr. Edward Driscoll, president, National Air Carrier Association.

Chairman Miller, would you like to say something welcoming him?

Chairman MILLER. I would like to welcome Mr. Driscoll aboard. He is a very old friend of mine. He represents a very important segment of the industry, and I am very happy to see him here and happy that you called him as a witness.

Mr. HECHLER. Mr. Driscoll is accompanied by Mr. Robert F. Creson, vice president, research and analysis, for the Flight Safety Foundation. We are very pleased to have you before the committee. And Mr. Driscoll, do you have a statement you care to make?

Mr. DRISCOLL. Yes, sir. Thank you.

(The biography of Edward J. Driscoll follows:)

EDWARD J. DRISCOLL, PRESIDENT, NATIONAL AIR CARRIER ASSOCIATION

Edward J. Driscoll was elected President of the National Air Carrier Association in September of 1967. His prior experience includes the areas of military, federal regulatory and airline operations.

A 1952 graduate of the Columbus University School of Law in Washington, D.C., he served as legal advisor to the Commander of MATS from 1952–1958. From 1958–1960 he was Special Assistant to the Secretary of the Air Force for Communications and then from 1960–1963 he served as Deputy Assistant Secretary of the Air Force for Transportation and Communications.

In 1963, Driscoll left the Air Force to accept an appointment as Executive Director of the Civil Aeronautics Board. He served in this capacity until May of 1966. At that time he joined World Airways and assumed his duties as Vice President and Assistant to the President until being elected President of NACA in September 1967.

He is a member of the District of Columbia bar and has been admitted to practice before the Supreme Court, the U.S. Court of Appeals and the U.S. District Court for the District of Columbia. He has also been a member of the President's Steering Committee for preparation of the International Air Transport Study.

PREPARED STATEMENT OF EDWARD J. DRISCOLL, PRESIDENT, NATIONAL AIR CARRIER ASSOCIATION

My name is Edward J. Driscoll. I am president of the National Air Carrier Association. The association represents 10 supplemental airlines.[1] The supplemental industry is composed of 13 airlines which are certificated by the Civil Aeronautics Board for both domestic and international charter activity. They are certificated for "inclusive tour charters," which is a system whereby low-cost package vacations are marketed to the general public through a tour operator. This latter authority was recently affirmed by the 90th Congress in Public Law 90–514, which was signed by President Lyndon B. Johnson on September 26, 1968. Although presently small, this is the fastest growing segment of the U.S. air transport industry. These airlines operate 92 jet aircraft and by 1971 the industry's aircraft, including the Boeing 747's, will represent an investment in excess of $650 million. We are vitally concerned with research and development as it pertains to aeronautics and the air transport industry.

I am pleased to have this opportunity to appear before your committee in connection with research and development activities. I am accompanied this morning by Mr. Robert Creson, vice president, research and analysis, Flight Safety Foundation, who will address himself to general technical aspects of the need for increased research and development activity in connection with aeronautics. Prior to Mr. Creson's statement, however, I would like to address myself to some of the broad aspects of research and development as it affects us now and will affect us in the future.

The need for adequate and comprehensive research in the field of air transport has been evidenced in recent months. We are all aware of the air traffic congestion problem currently facing our country. This problem was highlighted in July of this year by reason of excessive delays in the New York area. The need for a comprehensive analysis of both the technical and planning functions relating to air transportation has been clearly shown. Many reasons have been advanced for this specific problem, among which are:

1. A slowdown by air traffic controllers;
2. Overscheduling by the route air carriers;
3. A lack of adequate air navigational facilities; and
4. Improper planning to provide for the expanded system of transport, including general aviation which is now a part of our expanding economy.

I do not intend to dwell on this problem but merely use it as an example of what happens when proper preplanning is not accomplished. Preplanning, in this instance, would necessarily be applied research and development in order to have the capability to adequately provide the capacity necessary to satisfy the present demand.

We are in a dynamic society; the aerospace industry is expanding at the rate of two and a half times our gross national product. Therefore, the question arises—What is to be done for the future? What actions are necessary today to insure that 5 years from now we will have the capacity for the technological developments in aviation that will have occurred during that span of time? The answer lies wholly in research and development. It is no longer a question of applying additional manpower periodically to provide the capacity; it is no longer a satisfactory answer that we will install complicated navigational communications and other related equipment when the problem arises. We must develop these through research and development. The only answer is the development of a time-phased system to provide for the required increased capacity. We are all familiar with the mammoth strides that have been accomplished in connection with our space exploits. These have been accomplished because of thorough research and development activities. To achieve the same in aeronautics will require the same concentrated approach.

The supplemental airline industry fully supports the objectives of your committee and subscribes to the theory that only through proper research and development can the United States continue to provide leadership in the field of aeronautics and provide the capacity necessary to expand our economic well-being.

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[1] Capitol International Airways, Inc., Nashville, Tenn.; Modern Air Transport, Inc., Miami, Fla.; Overseas National Airways, Inc., Jamaica, N.Y.; Purdue Airlines, Inc., Lafayette, Ind.; Saturn Airways, Inc., Oakland, Calif.; Southern Air Transport, Inc., Nuanu, Fla.; Standard Airways, Inc., Seattle, Wash.; Trans International Airlines, Inc., Oakland, Calif.; Universal Airlines, Inc., Ypsilanti, Mich., and World Airways, Inc., Oakland, Calif.

STATEMENT OF EDWARD J. DRISCOLL, PRESIDENT, NATIONAL AIR CARRIER ASSOCIATION

Mr. Driscoll. I am very pleased to be here.

I am president of the National Air Carrier Association, and I have submitted this statement for the record, so I will summarize from it.

We represent the supplemental airline industry, which is one of the smallest of the airline segments, but it is the fastest growing. We are certificated air carriers by the Civil Aeronautics Board. We presently operate about 186 aircraft, 92 of which are of the latest jets; and by 1971 we will have a total investment in aircraft of some $650 million, which will include the Boeing 747.

I am accompanied this morning by Mr. Robert Creson, who is the vice president, research and analysis, of the Flight Safety Foundation, who will address himself to the general technical aspects of the need for increased research and development activity in connection with aeronautics.

Chairman Miller. Mr. Driscoll. I have to go. I want to apologize that I cannot stay to hear you, but I hope that you will excuse me. I have a very important engagement right now.

Mr. Hechler. Thank you, Mr. Chairman.

You may proceed, Mr. Driscoll.

Mr. Driscoll. I might add here that since we are a relatively small segment of a total industry, we do not have in-house capability within many of our carriers for the research and development which some of the other members of the airline industry have. We rely upon the research and development brought about through Government auspices as well as industry, and for that purpose have associated ourselves with the Flight Safety Foundation who aids us in the technical aspects as well as in the research area.

We really feel that there is a need for an adequate and comprehensive research in the field of air transport. This has been evidenced in recent months as has been cited to the committee here, as well as from questions from the committee by the air traffic congestion problem which is currently existing and to which a solution must be found.

Many causes for the air traffic congestion problem have been cited. Among them are: a slowdown by air traffic controllers; overscheduling by route air carriers; lack of adequate air navigational facilities; and improper planning to provide for the expanded system of transport, including general aviation which is now a part of our expanding economy.

I do not intend to dwell on this problem but merely to use it as a highlight to point out the need for the expanded research and development activity.

We are in a dynamic society; the aerospace industry is expanding at the rate of two and a half times our gross national product. Therefore, the question arises: What is to be done, and what actions are necessary today to insure that 5 years from now we have the capacity for the technological developments in aviation that will have occurred during that span of time? We feel that the answer lies fully in the research and development area in order to provide the adequate systems that are going to be needed and are needed today.

The supplemental airline industry fully supports the objectives of your committee in inquiring into the role of research and development in the aerospace industries. And we feel that in the air transport phase, that the same emphasis should be applied to research and development as has been applied in the space application and which has been tremendously successful.

Mr. Chairman, with your permission, I will ask Mr. Creson to go into some of the general technical aspects as we see them.

Mr. HECHLER. Thank you, Mr. Driscoll.

Mr. Creson, welcome to the committee.

Mr. CRESON. Thank you, sir.

Mr. HECHLER. And if you have a statement, you may proceed.

STATEMENT OF ROBERT F. CRESON, VICE PRESIDENT, RESEARCH AND ANALYSIS FLIGHT SAFETY FOUNDATION

Mr. CRESON. Thank you very much, sir.

First I would like to briefly tell what the foundation objectives are. We are an independent, nonprofit organization, as stated in my statement. And we are looking into enhancing all levels of flight safety. Of course, this gets into anything from the aircraft to people flying the aircraft, to facilities, to equipment, to control.

The foundation was established in 1945, and we have three functions, and one, of course, is an accident prevention information interchange with all of our members throughout the country and throughout the world. And we have flight safety research and problem solving. And then we are charged with being a representative for the public interest in aviation safety.

I am very pleased to have this opportunity to appear before the committee concerning what we should be doing in aeronautical research and development to meet our future needs. After reviewing the statements previously presented to this committee—and this was the statements prior to today, prior to the ATA presentation—I notice that many of the recommendations have been toward an overall plan or a concept for future development. Therefore, I will confine my remarks to the three main areas that require immediate research and development attention. These are (1) en route navigation and air traffic control; (2) terminal control; and (3) airports.

Under en route navigation and air traffic control, I have four points for your consideration. The first is radar.

This capability requires extensive research and development to refine and improve for better target detection, increased range, removal of ground clutter effect, and improved reliability.

The satellites have been mentioned by other members this morning. The use of satellites in air traffic control has tremendous potential, in our opinion, not only in communications for air traffic control, but in the use of the satellites as navigation aids. With adequate research and development, satellites could well prove to be the breakthrough that we need in en route air traffic control.

COLLISION AVOIDANCE SYSTEMS

There are several pilot programs at this time; however, this concept requires extensive research and development. Today, a collision avoidance system in all aircraft would prevent many of the disasters that occur annually. With the forecast increase of aircraft by 1975, the collision avoidance system will be an absolute necessity. It is felt that a side effect of any good collision avoidance system will be improved air traffic control. This system could also be used to indicate position to air traffic control radar and could even incorporate automatic position reporting to en route facilities.

CLEAR AIR TURBULENCE

There have been several studies and test programs conducted on this major problem; however, as of this date most of the questions of how to detect clear air turbulence and where it forms are unanswered. Vast research is required and it will be a tragedy if we wait until a jumbo jet with 490 persons plus crew is shaken apart to place the required effort in detection of clear air turbulence.

In terminal control, again I mention radar from the standpoint that terminal control radar requires even greater refining and improving for better target detection, removal of ground clutter, and improved reliability. It is time to examine the state-of-the-art possibilities in this area and not continue down the same road. We make this particular statement and I would like to qualify it: That in our endeavors we find that the state-of-the-art equipment right now is beating what FAA has scheduled in some of our airports in the future. So this needs some attention.

LANDING SYSTEMS

We must advance to a landing system that can land aircraft without delays regardless of the weather. The present ILS—instrument landing system—is not adequate for this purpose. Research and development is required for a reliable automated system to control the aircraft to touchdown. Some work has been performed in this area incorporating head-up display—HUD—with an automated landing system. I might comment that this has been highly successful and the Navy is setting a good pace in this, from our understanding.

TERMINAL CONTROL AUTOMATION

Extensive research must be done on all phases of terminal control automation in order to permit controllers to increase the number of aircraft which they can control in a given period of time. The ultimate objective of this research should be to permit the handoff terminal area control and landing of individual aircraft without air-to-ground communication except in emergencies. To do this will require extensive research in controller displays and data display systems in the aircraft. In addition, we must develop equipment that will provide the pilot with independent positive position indication and independent in-flight collision avoidance equipment.

And under "Airports"—I know airports have been mentioned already this morning, and we agree with the statements that have been made about the lack of airports.

As we are already 6 years behind in airport development, the first requirement is to build more airports. These airports should incorporate new criteria for optimum design based on location and consideration of all factors and problems to include noise abatement and expansion.

I would like to comment on that. I think it was outlined this morning that an airport has to be tailored to its locale. The Government has for years provided airport criteria, a new one was recently published by the FAA. But the airport criteria of one airport doesn't work at all places. You have to tailor an airport for that particular location and design one for that particular location based on the noise abatement problem, based on expansion problems, based on other airports, and air traffic control.

An airport system integrating all supporting requirements should be studied and developed with utmost haste as the airport requirement is already reaching crisis proportions today.

FOG REMOVAL

Fog removal could greatly assist in the uninterrupted flow of terminal air traffic. Research and development is required to determine which of several possibilities should be pursued. At present there is considerable study in the use of infrared for fog removal which in the initial phases has proved highly successful. And I might add, sir, that in this case we have talked for years on fog removal and we have done very little.

RUNWAY TRACTION

Improved braking action without the risk of hydroplaning is needed on the 50 major airports. The present runway grooving program initiated by NASA and the FAA is the first step to meet this requirement.

Mr. Hechler. Why only 50 airports? Why not most airports?

Mr. Creson. It could be extended. It is expensive and it is very time consuming. It requires extensive maintenance. But these are the critical airports that I mention, sir, right away, the ones that handle about 80 percent of our traffic today.

HIGH SPEED TURN-OFFS

For improved traffic flow, we need to determine which types of high speed turnoffs are workable and are the most efficient and incorporate these into airport design criteria. This is a small point, but it could keep the traffic flow going in an expeditious manner.

ARRESTING MECHANISMS

To reduce runway downtime, an adequate arresting system is needed to stop overrun accident. We have looked into it with the airport people and the Government. And every time an aircraft overruns, you have a major runway tied up for usually 2 to 3 to 4 hours.

RUNWAY ICE

In many of our major airports, this problem continues to remain critical several months of the year. Accidents are caused and aircraft have to be diverted as a result of the lack of a capability to alleviate runway ice conditions. Several systems are under study and along with fog removal, infrared is also a possibility in keeping a runway clear of ice and snow.

EMERGENCY LANDINGS

My comment on this one—this is a pretty big bill, but it is something we should look into and consider. We should develop a separate runway and crash system to handle emergencies whereas not to tie up primary facilities and to provide more adequate crash protection.

AIRCRAFT PARKING AND HANDLING

There is a great need to develop improved parking and handling techniques to accommodate the forecast increase of aircraft from numbers and size.

REFUELING

This service continues to remain an airport bottleneck, therefore creating a requirement for new concepts to meet this problem.

I would like to mention two other points that should receive adequate research and development attention. One is the development of the V/STOL aircraft which would greatly influence airport capabilities and air traffic control requirements. The other point concerns the extremely large aircraft which we expect in the early 1970's. With as many as 500 persons or more aboard this type aircraft, there is a need for totally new emergency evacuation concept. The evacuation problems will be greatly compounded due to the size of the aircraft and the numbers aboard. An emergency egress programing system should be studied and developed prior to employment of these types aircraft. Also, new considerations must be given to the passenger handling techniques to be used and the facilities required to accommodate the passenger load.

Mr. Chairman, the Flight Safety Foundation will be glad to assist in the study and development of these critical and important programs. Thank you for the opportunity to present this statement.

Mr. Hechler. Thank you, Mr. Creson.

And unfortunately, we didn't give Mr. Hunt enough time previously, but it was only to bring on these other witnesses.

I now recognize Mr. Hunt.

Mr. Hunt. I want to commend you on the capsulated form in which you presented your case. It was done precisely. What you have said echo my sentiments which I believe have been expounded throughout these hearings.

Mr. Hechler. How closely, Mr. Creson and Mr. Driscoll, have you followed the research and development work which NASA is carrying on?

Mr. Creson. I think I can answer that. We work very closely with NASA, sir. We do studies in conjunction with NASA and we do work in conjunction with FAA, in conjunction with all the various airlines, and even cities and municipalities on airport planning from the safety standpoint. So we are fairly familiar with most of the NASA programs and most of the other programs.

If I might comment, sir, as a nonprofit foundation dedicated only to one thing, that is, enhancing flight safety, working with the Government has been very pleasant because everyone discusses with us openly and tells us what their problems are to see where we can help out. And this has been true throughout the land, and even throughout the world, because our membership is worldwide.

We do notice that certain Government agencies are restricted in their capabilities, and the FAA probably has the hardest job in the Government today, in our opinion, and we have touched on it briefly.

But two or three points that are extremely difficult, one is long range, it is time consuming for the FAA to develop new airports, and we really sympathize with how they have to go about it and go down through into the municipalities to get approval and so forth.

And the other point, it is difficult for them to come up with new equipment. I noticed the airlines' comments today on new equipment in the aircraft. But there are other ramifications, and that is all the business aircraft and the private aircraft, because this equipment that the airlines can afford can be useful equipment, but if we don't have equipment going down through all the aircraft, then that little aircraft can bang into that big one just as easy like the accident where we lost the Secretary of the Navy down in North Carolina.

So we will bring out this more in detail, if we may, in another submission.

Mr. HECHLER. We have many questions, I am sure, that we will want to submit to you.

Are there any further immediate questions that anyone cares to submit? If not, we want to thank you, Mr. Driscoll.

Mr. DRISCOLL. Mr. Chairman, may I, with your permission, submit our position that we gave the FAA in connection with the air traffic congestion problem just for the record and for your information?

Mr. HECHLER. Fine. This would be helpful.

Mr. DRISCOLL. I will submit that.

FAA HEARING ON PROPOSED RULEMAKING 68–20

Why were supplemental air carriers not specifically addressed in FAA proposed rule 68–20

As a result of congestion at the New York airports in July of this year and the attendant delays incurred by air carriers in the performance of air transportation services a serious problem was highlighted. Many reasons for the congestion and resulting delays were advanced. Among these were:

1. A slow down by air traffic controllers.
2. Excessive scheduling by air carriers.
3. Saturation of congested areas by general aviation.
4. Inadequacy of existing navigational aids.

Several meetings were held by the Secretary of Transportation with members of the air carrier industry and with representatives of general aviation in an effort to develop solutions. Following these discussions Trans World Airways requested authority from the Civil Aeronautics Board to hold multicarrier discussions for the purpose of exploring means by which the air carriers could alleviate the critical air traffic congestion problem. By Order 68–7–138, dated July 26, 1968, the Board authorized TWA and other carriers to engage in requested discussions, and on the 8th day of August 1968 by Order 68-8-30, authorized discussions of charter services.

As a result of the Civil Aeronautics Board's authorization the air carriers met on August 13 and established an organizational framework and set forth specific areas for study and discussion. Discussions were held on various dates during August and September and culminated in the proposed establishment of a scheduling committee. Its purpose was to seek to control scheduling at high density airports with a view toward alleviating the congestion problem. During the course of these discussions it was clearly established that the supplemental air carriers were to be included with all other certificated carriers. However, prior to final establishment of the scheduling committee, the Federal Aviation Administration on September 3rd issued its notice of Proposed Rule Making which on its face excluded the supplemental carriers from consideration. This proposed rule was issued following a meeting on August 23, 1968 of all segments of the air transportation industry with the Secretary of Transportation and the Administrator of the Federal Aviation Administration. At that meeting, the supplemental carrier position, i.e., that the phrase "air carriers" be used in determining allocation of space, was advanced. It was suggested that the public need should be the criteria. The Air Transport Association, through its President, generally concurred with this position. The pertinent excerpts of the transcript of that meeting are attached to this statement as Exhibit 1.

In light of the foregoing, the supplemental air carrier industry was shocked to learn that the Federal Aviation Administration in their notice of Proposed Rule Making 68-20, Docket 9113, did not make any reference to supplemental air carriers. We were advised by a representative of the FAA General Counsel that the supplemental air carriers were considered in the third class "Other" along with general aviation. However, the proposed regulation states as follows:

"Allocations of IFR reservations would be made to three classes of users: (1) scheduled air carriers except air taxis; (2) scheduled air taxis; and (3) all other aircraft operators. In addition scheduled air taxis would be granted any reservations not taken by the scheduled air carriers. In the event the total reservations allocated for the scheduled air carrier and scheduled air taxi operations were not taken by those operations for any hour, the remaining reservations would be available for other operations, principally, general aviation. Accordingly, IFR general aviation would be limited to the figures specified for 'other' operations only when the other classes of users take all their allocated reservations."

Therefore, it appears that the public need for the supplemental air carrier services has been ignored, as it is quite implicit in the proposed rule that the term "other" was meant to apply principally to general aviation.

In the light of the FAA General Counsel's opinion and in view of the absence of any consideration in the order itself of supplemental air carriers, I transmitted a message to the Secretary of Transportation and to the Acting Administrator, FAA, on September 6, 1968, followed by letter to both on September 9, 1968. I was advised by the Acting Administrator of FAA that the supplemental air carriers are included in Class "Other" and that if we wish, as I requested, to be placed in Class I, we should submit our views and substantiating data in this proceeding. Copies of this correspondence are attached to this statement as Exhibit 2.

Who determines public convenience and necessity

The Civil Aeronautics Board has determined by certificating the trunk, local service, and supplemental carriers, that they are needed to satisfy public convenience and necessity. The certificated carriers provide, either in whole or part, the following services:

A. Individually ticketed or individually waybilled service available to the general public;

B. Charter service available to the general public through group membership or through a tour operator or for plane loads of cargo.

The services of both are programed services, otherwise one would be unable to sell available seats. Each satisfies a public need, each transports members of the public from point of origin to point of destination. The time of departure and the time of arrival for each type of operation is a necessary ingredient in operating an air carrier service. The time of departure and arrival of a charter service may be more important to a larger number of the general public than another service, as a charter service normally operates with a 100% load factor in a multi-engined transport aircraft.

Inasmuch as the Civil Aeronautics Board has determined that the public convenience and necessity requires the services of supplemental air carriers, the Federal Aviation Administration should not frustrate this determination by establishing a priority system for holders of certificates of public convenience and necessity. Therefore, the Federal Aviation Administration should not select one class of certificated air carrier over another for preferential treatment. Nor should the Federal Aviation Administration grant priority treatment to air taxi operators in preference to supplemental air carriers who are certificated by the Civil Aeronautics Board.

The supplemental carrier industry position

The supplemental industry agrees that an air traffic congestion problem existed in July of this year; however, evidence available indicates that due to scheduled cutbacks which normally occur during the Fall and Winter months, this has been substantially reduced or has been eliminated. However, we realize that congestion will occur again during the heavy traffic seasons; therefore, we agree that action should be taken to alleviate this condition. We do not agree, however, that the only solution to the problem is the imposition of ceilings on aircraft operations into and out of high density airports; rather, we believe that aggressive action to increase the capacity at these airports is not only the ultimate answer but is an immediate requirement.

It would be presumptuous in this forum for us to attempt to delineate specific actions and specific capacity increases which would stem from such actions. However, we believe that there should be established an industry/government task force composed of representatives of all segments of the air carrier industry to be charged with the responsibility of developing a time-phased improvement program to identify what actions must be taken to increase the capacity. We are discussing the establishment of limitations which, under the best of procedural systems, would probably not be effective until sometime in the first quarter of Calendar Year 1969. Certainly by that time action should have been taken that would have increased the very capacity we are discussing. We are not arguing that there should not be a capacity limitation at a specific point in time; what we are arguing, however, is that the establishment of a capacity should have a relationship to the time in which it is to be effective and take cognizance of increases which will occur prior to its effective date and increases which will occur periodically after its imposition. As a beginning point, if limitations are to be imposed, we recommend the following: 90 for Kennedy; 70 for LaGuardia, Newark and Washington, and 150 for O'Hare.

In our opinion, the limitations proposed by the Federal Aviation Administration are too low. However, the limits recommended should be increased periodically as action is taken to increase the capacity.

The proposed rule indicates actions to be taken are intended to provide the best service for the greatest number of the general public. In keeping with this goal, we propose that Class 1 be "air carriers", and that all air carriers be included in that class, and within that class a specific number of flights per hour be identified for particular classes of air carriers; such as supplemental air carriers with at least five reserve movements per hour. In justification of this, we submit that the supplemental air carrier operations are in large part scheduled operations in the sense that they operate at predetermined times and that they serve the general public in the same manner that other air carriers serve the general public. Supplemental carrier operations at the affected airports for 1968, and projection for the first nine months of 1969 are:

	1968	Projected 1st 9 months 1969
John F. Kennedy	3,790	4,604
La Guardia	40	2
Newark	3,526	2,359
O'Hare	1,134	1,521
Washington	18	6

To relegate the supplementals to Class 3 "Other" would discriminate against those members of the general public who use the supplemental services as opposed to those who use the trunk or local service carriers. Additionally, this would have serious and adverse economic impact upon the supplemental air carriers. The days of unscheduled operations have long since vanished. The supplemental carrier operations are predetermined and programmed, designed to provide a system of low-cost transportation to the general public and designed to achieve high utilization—a necessary ingredient to produce low-cost transportation service. Thus, the imposition of restrictions which limit the hours of operation from a given base or to relegate to a class which inhibits the ability to schedule would impair operations to such an extent that the economic viability of this class of carrier will be affected. Supplemental carrier operations, whether they be domestic or international, are normally operated in a back-to-back manner, operating on fixed schedules with minimum ground times at turn-around points. Thus, to blackout any period at an originating or terminating base can only increase turn-around times. This will produce low utilization and reduce revenues substantially. We do not argue that we must have favored treatment; we do argue that we must have equal treatment and equal access to airports with all other air carriers.

The inclusive tour charter program operates on fixed schedules and is a competitive service with those of other classes of air carriers. Operational restrictions on the supplementals would result in favored treatment of other classes of air carriers and give them a competitive advantage. We are sure that this was not the intent of the Federal Aviation Administration. The problem can easily be remedied by including the supplemental air carriers in Class 1, as we have suggested. An alternative would be the establishment of four classes of users—Class 1 Scheduled Air Carriers; Class 2 Supplemental Air Carriers; Class 3 Air Taxi Operators; Class 4 Other. Classes 1, 2 and 3 would operate under the same rules and regulations, the only difference being that each would have its own separate allocation. For example, under an 80 maximum as set forth in the proposed rule, the allocation would be 65 scheduled, 5 supplemental, 5 air taxi, and 5 all other. However, if the maximum were 90, there would be a proportionate increase in each of the first three classes.

All air carriers must be accorded equal treatment and operate subject to the same criteria. Any blackout period such as has been proposed for John F. Kennedy Airport should be applicable only to non-air carrier users. To do otherwise would discriminate against the general public who use a particular class of air carrier and would also discriminate against an air carrier which might be a tenant on a particular high density airport. A tenant air carrier cannot operate effectively and efficiently if he is subject to a restriction that precludes his operating from his main base for a particular period of time. Such would be the result if the Federal Aviation Administration proposed rule, as drafted, were adopted. We feel that this was another oversight on the part of the Federal Aviation Administration.

Likewise, the operation of cargo charter flights for any user must be accorded equal treatment. Limitations on airports which take into consideration insufficient passenger gate facilities such as at Newark, should not be made applicable to cargo operations, since these operations are handled at special cargo facilities. Therefore, any limitations established must be flexible enough to take into account the differences in types of operation.

In summary, the National Air Carrier Association's position on behalf of its member carriers is:

(1) That all air carriers must be accorded equal treatment.

(2) That any limitations imposed must be realistic, that such limitations should only be imposed after a detailed analysis and then only for a limited period of time.

(3) That there must be developed a program to increase the capacity of high density airports to adequately provide for transportation requirements and that a program to increase the capacity should be undertaken immediately.

We recognize the seriousness of the air traffic congestion problem. We trust that any rule which will issue as a result of this proceeding will recognize the needs of the general public as well as all segments of the air carrier industry, and will not discriminate against any particular class of air carrier.

DOT/FAA Air Space Congestion Meeting, August 23, 1968

(Pages 83 and 96)

AFTERNOON SESSION

Secretary Boyd. I believe Mr. Driscoll had something.

Mr. Driscoll. Mr. Secretary, this bears on the allocation and comments by Mr. Tipton in which they were talking about the scheduling committee, which again Mr. Phillion qualified as coming up for further discussion at a meeting on the twenty-seventh.

But getting to the discussion of allocation, the phrase keeps creeping in "scheduled carriers." I would like to suggest the phrase "air carrier" be used as "scheduled carrier" can either mean route, local service, or it can mean supplemental carrier, because our operations are now scheduled operations because of the long lead time they are sold and some schedules are in effect six months in advance.

So, for purposes of allocating, it appears to me that the public need to be served should be the criteria and in the degree of any allocation and the phrase "air carrier" rather than a particular class of air carrier.

Secretary Boyd. Thank you.

Mr. Karant. I see. Well, I did not understand that before.

Secretary Boyd. No. I gathered you did not accept that interpretation, either. Now does anybody have any discussion on allocation?

Mr. Tipton. Just one further point that goes back to the statement made by Mr. Ed Driscoll in which he emphasized the fact that the supplementary carrier has need as a public carrier for recognition in, shall we say, the allocation of slots. That does not mean to indicate that they should not. The supplemental carrier has a good deal more flexibility than the scheduled airline does to move about. Once he sets up his operation, which may be a charter or as Ed says, six months in advance, he gets to be pretty inflexible, and as a public carrier I stand to agree with what he has had to say.

Mr. Ward. Mr. Secretary, I don't think there is any question in anybody's mind that the air carriers fulfill a major public requirement. However, there is another side to the story. They do not fill all the public requirement. There is a very substantial portion of the public that needs to use aircraft to get to destinations like we are talking about, and the only way they can do it efficiently is by using their own aircraft. The reason they do this is because the air carriers simply cannot do it for them.

Washington, D.C.

Hon. Alan S. Boyd,
Secretary, Department of Transportation,
Washington, D.C.:

This will confirm my phone discussions with you on 5 September concerning FAA proposed rule, docket 9113, notice 68–20, dated 3 September 1968. NACA on behalf of its members, and the U.S. supplemental air carrier industry specifically requests that an interpretation to cited proposed rule be issued placing the supplemental air carriers in class 1, scheduled air carriers, except air taxis, in lieu of class 3, all other aircraft operators. This request is based on the following:

1. The supplemental carriers are certificated by the civil aeronautics board to provide air transportation services for the general public.
2. The supplemental carriers' operations are scheduled operations in the sense that firm operating schedules are developed and published well in advance of the month of operation.
3. The supplemental air carriers are presently part of the air carrier group working together under CAB auspices in developing a system and procedure for the allocation of air space for air carrier operations.

4. The ATA and specifically Mr. Tipton, president of ATA, has recognized on the record that the supplemental carriers provide a public service on the same basis as other air carriers and that their operations constitute scheduled operations.

Designation of the supplemental carriers in class 1 of the proposed rule would be in keeping with the statement of policy contained in the first full paragraph on page 9 of your proposed rule.

By agreement with ATA, NACA and its member carriers are continuing to work toward a mutually satisfactory solution for all air carriers including the supplementals and designation of the supplementals in class 1 will be in keeping with this undertaking.

We believe that such interpretation can be issued immediately not awaiting the outcome of the proposed rule and further believe that such interpretation will facilitate an agreed-upon solution among the air carriers to alleviate air traffic congestion problems.

EDWARD J. DRISCOLL,
President, National Air Carrier Association.

WASHINGTON, D.C.

Hon. DAVID D. THOMAS,
Acting Administrator,
Federal Aviation Administration,
Washington, D.C.:

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EDWARD J. DRISCOLL,
President, National Air Carrier Association.

WASHINGTON, D.C.

EDWARD J. DRISCOLL,
President, National Air Carrier Association,
Washington, D.C.:

Reurtel Sept. 6, under proposed section 93.123, supplemental air carriers would be included in the classification "other" operators. Your telegram and this reply will be placed in the rules docket. Your comments on the NPRM should be based on the foregoing interpretation.

D. D. THOMAS.

NATIONAL AIR CARRIER ASSOCIATION, INC.,
Washington, D. C., September 9, 1968.

Hon. ALAN S. BOYD,
Secretary, Department of Transportation,
Washington, D.C.

Hon. DAVID D. THOMAS,
Acting Administrator, Federal Aviation Administration,
Washington, D.C.

DEAR SIRS: Reference is made to my telegraphic message to you dated 6 September 1968 concerning FAA Proposed Rule, Docket 9113, wherein it was requested that the supplemental air carriers be designated in Class 1 of the Proposed Rule in lieu of Class 3. I am transmitting herewith a copy of the Summary Report Joint Meetings of Committees 1, 2, and 3 of the Air Congestion Conference; and your attention is specifically called to the second paragraph on Page 1 which is underscored. It can be seen from the referenced remarks that the designation of the supplemental carriers in Class 1 is essential to enable them to work within the framework of the scheduling committees currently being developed by the air carrier industry.

It is therefore requested that the interpretation requested in my message of 6 September be issued at the earliest possible date in order to permit proper consideration of supplemental air carrier requirements in connection with scheduling policies and criteria being developed by the air carrier industry.

Sincerely,

EDWARD J. DRISCOLL, *President.*

DEPARTMENT OF TRANSPORTATION,
FEDERAL AVIATION ADMINISTRATION,
Washington, D.C., September 13, 1968.

Mr. EDWARD J. DRISCOLL,
President, National Air Carrier Association, Inc.,
Washington, D.C.

DEAR MR. DRISCOLL: This will acknowledge your letter dated September 9, 1968, addressed to Secretary Boyd and to me requesting that section 93.123 of NPRM 68–20 be interpreted to include supplemental air carriers under the classification of scheduled air carriers.

By telegram dated September 10, 1968, you were advised that supplemental air carriers are included in the "other" classification of the provisions of section 93.123 of the proposed rule.

If you believe that supplemental air carriers should be included under the scheduled air carrier classification in order to permit proper consideration of their requirements, you should, as suggested in the telegram, submit your views and any substantiating data for incorporation in the public rule making docket. If you wish, you may also present your views at the public hearing which will be held on this proposal on September 25, 1968, at 9:30 a.m. in the Auditorium of the Department of Transportation Building, 800 Independence Avenue, S.W., Washington, D.C.

Sincerely,

G. S. MOORE, *Acting Administrator.*

Mr. HECHLER. If there are no further questions, we want to thank you, Mr. Driscoll, and Mr. Creson, for appearing before the committee.

(Questions posed by the committee follow:)

QUESTIONS SUBMITTED TO ROBERT F. CRESON, FLIGHT SAFETY FOUNDATION, BY THE SUBCOMMITTEE ON ADVANCED RESEARCH AND TECHNOLOGY

Question 1. How does the Foundation get its input into Government R&D channels? How much acceptance have you experienced on your recommendations to date?

Answer 1. The Foundation gets its input into Government R&D channels by answering requests for proposals and by submitting unsolicited proposals. In the last several years acceptance has been at an absolute minimum with contracts going to agencies with vested interest.

Question 2. Does the Foundation sit on any Government Boards even as an ex officio member?

Answer 2. The Foundation does not sit on any Government boards as such. When invited or when permitted it will sit as an observer or provide testimony when possible in areas pertaining to flight safety.

Question 3. How can the channels of communication between your Foundation and the Government R&D agencies be improved?

Answer 3. A direct line of communication between the Flight Safety Foundation and Government R&D agencies can be established by regular meetings and by additional utilization of the Flight Safety Foundation for those research projects in flight safety for which the Foundation is uniquely qualified.

Question 4. Does the Foundation act as a focal point for R&D efforts in the field of aviation safety in overseas areas?

Answer 4. Inasmuch as the Foundation is an International organization, nonaligned and objective, it does in fact serve as a focal point for R&D efforts in the field of aviation safety in overseas areas. The results of studies that are conducted are passed on to member operators and manufacturers in all the countries of the world.

Question 5. Do you have any suggestions or recommendations as to how the overall approach to aeronautics R&D in the future can be better organized?

Answer 5. A planned R&D program as applied to aeronautics directed to those problems now in existence and those problems which can be forecast as a result of the increase of the gross number of aircraft, traffic movement and size of equipment would provide a more organized approach to Government R&D.

Question 6. What input does the Foundation receive from the Airline operators, pilots, and the public on R&D needs regarding aviation safety?

Answer 6. Input to the Flight Safety Foundation from airline operators and pilots comes about through semi-annual meetings of the Industry Advisory Committee and the Corporate Aircraft Advisory Board, letters from individual pilots and the public as well as specific requests for research to be conducted on a contract basis by individual companies.

Mr. HECHLER. The committee will stand adjourned until 9:30 tomorrow.

(Whereupon, at 12:03 p.m., the subcommittee was adjourned, to reconvene at 9:30 a.m., Thursday, October 3, 1968.)

AERONAUTICAL RESEARCH AND DEVELOPMENT

THURSDAY, OCTOBER 3, 1968

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Advanced Research and Technology,
Washington, D.C.

The subcomitttee met, pursuant to adjournment, at 9:32 a.m., in room 2325, Rayburn House Office Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. Hechler. The committee will be in order.

This morning we will have as our first witness Mr. Herman C. Meyer, executive director of the Professional Air Traffic Controllers Organization, accompanied by Mr. John Meehan of the controllers organization. And we will put short biographies of both gentlemen in the record, so I needn't identify more specifically your backgrounds.

Mr. Meyer, do you want to start out?

(The biography of Herman Meyer follows:)

Herman C. Meyer, III

Herman C. Meyer was born November 4, 1939, at Petoskey, Michigan, and attended the Petoskey public school system through the twelfth grade. He enrolled thereafter in the University of Michigan College of Engineering and in 1961 he received a degree in Aeronautical Engineering, and in 1962 a degree in Mathematics, and in 1965 a Bachelor of Laws degree.

Mr. Meyer began flying at the age of fifteen and presently holds a single and multiple engine commercial pilot's certificate and is instrument rated. He also holds a current flight instructor certificate. In October of 1966 he was type rated in the Lear Jet.

After graduation from Law School, Mr. Meyer was employed by the Federal Aviation Administration at the Office of General Counsel. In April of 1966 Mr. Meyer was employed by the Lear Jet Corporation as its Staff Attorney and prior to resigning, he was promoted to the office of Secretary and General Counsel.

Mr. Meyer resigned from Lear Jet Industries to accept the position of Executive Director with the Professional Air Traffic Controllers Organization in August 1968.

STATEMENT OF HERMAN C. MEYER, EXECUTIVE DIRECTOR, PROFESSIONAL AIR TRAFFIC CONTROLLERS ORGANIZATION, ACCOMPANIED BY JOHN MEEHAN, VICE CHAIRMAN OF THE BOARD, PATCO

Mr. Meyer. Thank you, sir.

Mr. Chairman and members of the subcommittee, the Professional Air Traffic Controllers Organization is appreciative of the opportunity to express its views on the technological area of the air transporta-

21-064—69——18

tion system, with its view toward the total spectrum, including research and development, financial responsibility, and technology, itself.

Everyone is certainly aware of the present crisis, and the projected dilemma that exists in the present air transportation system. This awareness has led knowledgeable and responsible persons into courses of action that, hopefully, will provide direction toward a technological system that is contemporary and is oriented toward serving the aviation industry.

It is an acknowledged fact by all segments of the aviation industry that two prime factors contributed to our present situation. First, an underestimation of aviation growth created an atmosphere of complacency toward the present need for updating the system, and the explosive potential needs that lie ahead. Second, the inability of the research and development departments of the concerned agencies to produce practical system advancements in sufficient time forced the air transportation system to resort to, and rely upon, outdated and unreliable equipment.

It is the judgment of the Professional Air Traffic Controllers Organization that neither of these errors would have occurred had correct concepts been applied; had proper developmental information been made available; and had responsible agencies consulted with and listened to the aviation industry and active air traffic controllers, as well as to one another.

We do not mean to imply that the industry, or the professional air traffic controller have all the immediate answers to this complex question. But, we do contend that they have a significant "slice of the pie" to offer, and that their contribution would make for a more realistic and reliable air transportation system.

It is our opinion that false concepts have developed. It is a technical error to evaluate the air space system solely in terms of the airport's concrete, and the number of airplanes that land on that concrete. This is what we term vertical analysis, and a conceptual error.

It is, however, technically correct to consider the entire matrix of information affecting the flow of air traffic; that is in terms of geographic variables, approach procedures, airway structure, terminal and enroute traffic flow and its control satellite airport systems, and technology that will computerize and combine the meteorological, navigational, control and communications data fed through the system. This is what we term lateral analysis. It is an objective consideration of the total air transportation system for the concerned air and ground space.

Clearly, no one yet knows specifically what individual steps should be taken to optimize the performance of our air transportation system, but it is possible, if we assume that lateral analysis is more valid than vertical analysis, to outline the past weaknesses of research and development, to look at the prospect of financing a total air transportation system, and to assess present attitudes toward technology, which could provide an acceptable solution.

First, no organized method exists whereby the Congress, the aviation industry, or the air traffic controller may ascertain specifically what projects are undertaken by the Department of Transportation, the

National Aeronautics and Space Administration, or the Federal Aviation Administration research and development departments. Nor is it possible to ascertain what contracts or studies are initiated, and their contribution to the national development of the system, or the status of the many programs falling within the purview of this group.

A release to the public of reports is often delayed for long periods of time. Frequent or periodic reports of projects and contracts being initiated, their status, and target dates for significant accomplishments should be made available. There is no information as to the origin of some statements that have been used as justification for such projects. Lack of this information makes it difficult, if not impossible, to determine what recommendations by the industry or air traffic controllers should be offered, or whether work has been undertaken to satisfy the users' or the controllers' valid operational requirements.

Since the objective of the research and development effort is the attainment of a safe, coordinated, effective and economically practical total air transportation system, the Professional Air Traffic Controllers Organization considers it essential that the users of the airspace and the active air traffic controllers be kept fully informed of all projects undertaken to the end that productive results may be achieved.

It is recognized that the responsible agencies have occasionally made presentations of its plans to the aviation industry. However, these presentations were in the nature of briefing sessions devoted to acquainting the user with the work in progress. Except to a limited degree, time was not made available for a detailed discussion of individual projects for the purpose of ascertaining the merits of the research and development endeavors.

The Professional Air Traffic Controllers Organization has many specific recommendations relating to technical improvements in the air transportation system. These recommendations encompass three dimensional radar, uninterrupted radar service, computer backup for controller workload, and reliable radio communications, but time obviously precludes a detailed presentation. In this respect the Professional Air Traffic Controllers Organization, without qualification, offers its services on a cost-free, professional consulting basis to the Congress, to the agencies, and to the industry. The Professional Air Traffic Controllers Organization will voluntarily provide any additional data that this committee might consider necessary because it is the basic philosophy of the PATCO that through participation in establishing the feasibility of new programs for the air transportation system, the controller can substantially give direction to the contributions made by research and development.

The second problem is money. Tremendous sums of money will be required for the financing of a sophisticated and contemporary air transporation system and it is evident that no single sector of the economy can or will underwrite this requirement. It is equally evident that a systematic approach to financing cannot be developed until data on the operation of the total system can be assembled and reviewed. Unfortunately, fragmented fiscal operations have made it essentially impossible to assemble consistent and systemized data. Furthermore, estimates of future costs show such divergence of interest and do not provide a proper basis for adequate decisionmaking. In this vein, the efficient use of appropriated money must also be considered. As a reminder of what can be done it might be well to review the accomplishment of that small group of engineers in Indianapolis, who in a short period of time developed all of the current aids to navigation, at a cost which I am led to believe was less than the present budgeted houskeeping cost at NAFEC. Unless data is centralized and publicized, the outlook for implementing a responsible fiscal policy does not appear to be on the immediate horizon.

Our third point is technology. It is not likely that technology will give us an air transportation system that is free from noise, air pollution, air traffic jams, an irate public, or selfish public and private sectors. The problems in the air transportation system take on the dimension not of, what can the system do for technology, but rather, what the industry and the air traffic controller expect technology to do for the system. This forces us to conclude that there is an immediate need for an organized plan geared toward the total air transportation system. None of the options available can be implemented with confidence unless the gaps in available data, technical knowledge, and professional experience can be closed and organization of these levels becomes the critical target for attention. More effort should be made primarily to establish lines of research and development that fit the controllers' needs, rather than spurious development initially with some secondary effort to fit new advances into the system.

To summarize, then, the Professional Air Traffic Controllers Organization calls for an organized plan by all responsible parties that can give direction to research and development, that will stimulate financial response, and that will make technology perform.

Thank you for this opportunity to express our views.

Mr. HECHLER. Thank you very much, Mr. Meyer.

Mr. Pelly, do you have any questions you would like to pose?

Mr. PELLY. Yes.

Mr. Meyer, were you here yesterday?

Mr. MEYER. No, sir, I wasn't. I am sorry.

Mr. PELLY. Have you seen the prepared testimony of the airlines?

Mr. MEYER. No, I haven't. I believe we picked it up this morning.

Mr. PELLY. Mr. Crossfield, of Eastern Airlines, indicated that the company had to get into research in order to survive and that traffic congestion was costing the company a million dollars a week. He gave what I thought was rather exciting evidence as to what Eastern hopes to accomplish in the way of its own research programs. It is focused on computerized control of planes at all times and even landing two planes on the same field at the same time.

I wonder if you would comment on his statement on research.

Mr. MEYER. Well, I have not read his statement, but I am aware of an interest by the airlines to have computer systems built which would be similar to the autopilot in the airplane. And this would be of tremendous benefit, of course, to the controller just as the autopilot is to the pilot, because it then allows the pilot to set aside the functional jobs that are required in flying an airplane and allows him to become more of a supervisor of the system that he is flying, allows him to become an observer and a check pilot of sorts. And naturally the same thing would be advantageous on the ground for the same reasons, because if you did have a mechanical device which would maintain separation between airplanes, that could allow the controller to be in a position to monitor the system, to back it up, to step in when it failed, to turn it on and off as his fatigue may require, as his number of hours on the job may require, as his lunch break may require, it would be a great asset to the controller.

At the present time he is flying the airplane manually all the time from the ground.

Mr. Meyer. Mohawk has come to the same decision as has Eastern.

Mr. Pelly. That is all, Mr. Chairman.

Mr. Hechler. Thank you, Mr. Pelly.

I would like to ask you concerning the information that is received by your organization and your people concerning ongoing research. What suggestions do you have on what ought to be done by whom to be sure that you are kept better informed within your organization, concerning the developments that are being carried on?

Mr. Meyer. Well, we have to first off be a little bit humble and admit we have only been in existence since January of this year, and that may possibly be part of our problem.

But the controllers as a group have been controlling airplanes, and what we are saying here is that they have never been consulted. New technical advances are being brought into the system, and they are asked to work them. And a good example of these new R. & D. advances is the new common IFR room in New York. It has been a miserable flop; it has been certainly substantially responsible for the delays that people experience in New York.

I wonder if John, who has been a controller for some 7 or 8 years, might like to comment a little bit more on this problem.

Mr. Hechler. It would be helpful to have your full name for the record.

Mr. Meyer. John Meehan.

(The biography of John D. Meehan follows:)

John D. Meehan

John D. Meehan, Born August 12, 1936, in Boston, Massachusetts, attended St. Angela's Grammar School and Mission High School. He enlisted in the Air Force, was assigned in Korea and Otis Air Force Base as an Airborne Radar Operator, and was discharged with the rank of T/Sgt and 3,200 hours of flying.

Mr. Meehan began his career in the Federal Aviation Administration in 1959 and attained the grade of GS-12 Radar Air Traffic Controller in 1962.

In 1965, Mr. Meehan entered St. Anselm's College in Manchester, New Hampshire, as a full-time undergraduate student pursuing a Baccalaureate in Political Science and attained a 3.34 quality point average in three years of attendance, with 3.0 required for the Dean's List.

In August of 1968, Mr. Meehan took a one-year leave of absence from the Federal Aviation Administration and the Senior Year of his college program to become a full-time employee of the Professional Air Traffic Controllers Organization.

Mr. Meehan. This has been one of the primary problems, we feel, in air traffic control today; that is, that the air traffic controller has not participated at the policy level in development and research. And if he had participated he probably could have given some direction and some professional advice as to its real workability.

And what they do is like in the case of the common IFR room, they develop a concept, put it into operation and then see—work the bugs out. The controllers knew 2 years in advance when they were asked in NAFEC about the project going on that this thing, as then developed, would not work, the common IFR room. And as a matter of fact, it did not work, yet it was put in. If the controller was consulted on this, he could have given his viewpoints, could have said this was not going to work under the present setup in the metropolitan area. It would not have gone in, nor would it have caused the chaos that it has today.

Mr. HECHLER. Mr. Meyer, I wonder if you would submit for the record some examples similar to this along with your suggestions and recommendations as to a mechanism that would better enable the people in your organization to become informed on projects that are being undertaken. Who should inform them, and also any other suggestions which you have as to how this two-way flow of communication could be improved.

(Information submitted may be found in the committee files.)

Mr. Meehan?

Mr. MEEHAN. Mr. Chairman, I would like to submit one item that bothers us. There was a statement made to this committee by Mr. Ben Alexander, Chairman of the Air Traffic Control Advisory Committee for the Department of Transportation.

Mr. HECHLER. Yes.

Mr. MEEHAN. It shows this committee makeup, and there is not one pilot and there is not one air traffic controller on the committee. What we want to know is how can anyone study air traffic control without the two prime people that participate in the system?

Mr. HECHLER. A good point. I appreciate your advising the committee of that.

Thank you very much, Mr. Meyer, for appearing before the committee.

Mr. MEYER. Thank you, sir.

Mr. HECHLER. We will next hear from the Air Line Pilots Association, whose president is Charles H. Ruby.

This is a very impressive representation that you have, Mr. Ruby.

Mr. RUBY. Thank you. We attempted to bring the necessary people that have expertise in particular fields, particularly from the standpoint of answering questions and also anything that they could add to the written presentation.

Mr. HECHLER. Fine.

Before you start, Mr. Ruby, I would like with unanimous consent to put the biography of each of the witnesses into the record.

(The biographies of the witnesses are as follows:)

CAPTAIN J. H. BARTLING

Captain J. H. Bartling was born in Lockwood, Missouri, December 20, 1920. His educational background includes academic training at Drury College, Springfield, Missouri. He has been with Trans World Airlines since 1942 and was advanced to the rank of Captain in 1944. He is qualified as Captain in DC-3, B-307, B-247, DC-4, Constellation, Convair 880, and B-707 aircraft. He has been IFALPA Observer to ICAO meetings on matters pertaining to air traffic control. He is presently Chairman of the Air Traffic Control Committee of the Airline Pilots Association.

CAPTAIN WILLIAM H. JAY

Captain William H. Jay was born November 25, 1920 in Social Circle, Georgia. He attended the University of Georgia and graduated in 1941 with a degree of B.S. in Agriculture. He entered the U.S. Army Air Corps in 1941 and served with distinction in the South Pacific Theatre with the South Pacific Combat

Air Transport Command. He has been employed by Eastern airlines since 1945 where he serves as Captain on Eastern jet transports. He is Safety Representative for the Airline Pilots Association in the Jacksonville, Florida, area.

Captain Howard C. Kelly

Captain Howard C. Kelly learned to fly in 1935 and was a flight instructor in the Civilian Pilot Training program and for the Army aircraft before and during World War II. Following a short period of charter and executive flying, he joined Piedmont Airlines in 1948. He is presently a member of the Airline Pilots Association. In 1968 he was medically retired from Piedmont Airlines and is now serving as a special consultant to the Airline Pilots Association on Air Safety matters.

Theodore G. Linnert

Theodore G. Linnert is director of the Engineering and Air Safety Department of the Air Line Pilots Association, International. He was born on April 30, 1912, and holds the degree of B.S. in Aeronautical Engineering. He is a registered professional engineer in the State of Illinois.

He has been continuously employed for 34 years in aviation activities in areas affecting the manufacture, design, flight test, and operation of aircraft. He has been Director of ALPA's Engineering and Air Safety Department for 24 years. He is an Associate Fellow, Institute of Aeronautical Sciences, member of the Aircraft Owners & Pilots Association; member of the NASA Committee on Aircraft Operating Problems; member of the Caterpillar Club 1936. He has a current FAA Aircraft and Powerplant License and maintains a private pilot license.

Captain J. W. Meek

Captain J. W. Meek was born in Memphis, Tennessee, and received his education in aeronautical engineering at Mississippi State College. He has been flying since 1938 and has spent the last 21 years with Delta Airlines. He is qualified as Captain on DC–3, DC–4, DC–6, DC–7, DC–8, CV–240, CV–340, CV–440, CV–880 and Curtiss C–46 aircraft. He also holds a license as a balloon pilot. Captain Meek is presently a member of the Airworthiness & Performance Committee of the Airline Pilots Association and is Chairman of the Region II Air Safety Board.

Charles H. Ruby

Charles H. Ruby, President of the Air Line Pilots Association, International, AFL/CIO was elected to his present post in June 1962, after a long and varied career in aviation.

Mr. Ruby was born June 26, 1909, in Mt. Vernon, Illinois, and was educated in St. Petersburg. His education included two years of study in mechanical and electrical engineering.

A veteran pilot, Mr. Ruby soloed in mid-1927. He operated an overhaul base and charter and flying school in the early 1930's in addition to building experimental aircraft. He was employed by National Airlines on January 16, 1935, in whose service he continued in various capacities until election to his present position.

With National, he flew both jet and piston aircraft as an air line pilot and served in a management capacity as chief pilot for six years.

Throughout his career in both union and management capacities, Mr. Ruby has been exceptionally active in the field of air safety including accident investigation and prevention, aircraft evaluation, flight simulator development, and many others.

Mr. Ruby has logged 20,000 flight hours. He is the holder of Air Transport Rating and Aircraft and Power Plant license. He holds ratings on the L 18–50, L–188, Convair 240, 340, and 440 and the Douglas DC–4, DC–6, DC–7, and DC–8.

Mr. HECHLER. Briefly, I wonder if you would identify your board of directors here.

Mr. RUBY. Yes. Starting on my left, Mr. Howard Kelly, formerly with Piedmont Airlines, now working with the association. And Mr. Joe Meek, who is a Delta pilot but also a member of our performance and air worthiness committee. And on my right, Mr. Ted Linnert, who is the director of our engineering and air safety department. And next is Bill Jay, from Eastern Airlines, who has been very active in air safety work, including airport surveillance and associated problems. And Mr. Joe Bartling, from TWA, who is the chairman of our air traffic control committee.

And with the exception of Mr. Linnert, all of the rest of us here, including myself, are either active airline pilots or formerly such; and Mr. Linnert also is a pilot, but has never flown, so far as I know, as an airline pilot. But he has had considerable test flying experience.

Mr. HECHLER. You were with National Airlines; is that correct?

Mr. RUBY. Yes, sir.

Mr. HECHLER. You may proceed, Mr. Ruby, with your statement.

Mr. RUBY. Thank you.

PREPARED STATEMENT OF CHARLES H. RUBY, PRESIDENT, AIR LINE PILOTS ASSOCIATION, INTERNATIONAL

The Air Line Pilots Association appreciates the opportunity to present our views with respect to the aeronautical research and development that will be required to meet the problems an airline pilot, operating an aircraft in scheduled air transportation, will face during the next 10 years and beyond. To be of as much assistance as possible to the subcommittee, we are highlighting problem areas which have repeatedly caused catastrophic accidents due to lack of research and development and also lack of application of completed research and development for accident prevention. Some of the problem areas have had research and development to the point where airplane design and operational regulatory action should be taken. We have also given consideration to try to foresee what new types of accidents of a repetitive nature could occur. We believe we are speaking to the thrust of the hearing when we present the problem areas requiring research and development not only for solving today's aeronautical problems, but also as we visualize for aeronautical problems of the next 10 years and beyond, as follows:

Aircraft:
1. Airframe integrity.
2. Avoidance of augmentation means for stability and control.
3. Catastrophic effects of turbine engine disintegration.
4. Inflight fire prevention and postcrash fire prevention.
5. Clear air turbulence instrumentation.
6. Sabotage prevention.
7. Control of irrational passengers.
8. Airplane noise reduction.

Navigation of aircraft:
1. Air traffic control improvements.
2. Collision avoidance system and proximity indicators.
3. Clear air turbulence forecasting.
4. Airborne radar and weather improvements.
5. Standardization of all aircraft instrumentation and navigational facilities.

Airports:
1. Runways.
2. Fog dispersal for safer takeoffs and landings,

Flight recorder:
1. In-flight recorder instrumentation for airplane airworthiness.
2. Flight recorders for accident cause determination.

AIRCRAFT

1. Airframe integrity. By the record we continue to have catastrophic structural failure in airline aircraft due in some cases to metal fatigue or the operation of the aircraft into unknown turbulence of such magnitude that the design load factors are exceeded and catastrophic prime structure failure of the airframe occurs. The subcommittee would in the public interest do well to determine whether or not the airplane's fabrication alloys are becoming so exotic in composition that while they are strong enough to meet the current certification requirements, the question is are they strong enough for the life of the airframe and also are the current gust load strength formulas for certification adequate to minimize the possibility of an overload failure with catastrophic results?

The subcommittee is aware that in the past, after catastrophic accidents occur, the airliners are either "grounded" or flown with severe restrictions until they have their structural defects eliminated by reinforcements or improved design. These air transports have been certified to rules which reflect the current state of the art. Research and development studies to determine whether or not current regulations for airframe strength requirements and metal-fatigue-prevention requirements are adequate should be undertaken for today's fleet and apply all findings to future current airplanes as well as future airplanes.

Commendably one carrier is currently engaged in an extensive wing structural improvement to add strength and stamina to the large transport they are operating. With this recent development and those of the past, we consider this item of airframe strength and lifetime maintenance strengh falls within the scope of the hearing and is most worthy of the subcommittee's very serious and thorough review.

2. Avoidance of augmentation means for stability and control: Through research and development, aerodynamic means should determine the requirements for flight control of transport aircraft. The present trend of stability and control augmentation contaminates the flight control system and when malfunction occurs, a loss of control can result. Research and development should be conducted to determine the aerodynamic design needed for stability and control of a transport aircraft throughout the operating flight envelope without augmentation or a design so that when it fails, the pilot can safely hand-fly the airplane.

3. Catastrophic effects of turbine engine distintegration: The turbine engine has developed into a remarkably reliable powerplant for airline use. Its time between overhauls has reached undreamed of flight hours, 10,000 or more on some engines. However, turbine engines are composed of high speed rotating parts which upon distintegration have the force of a missile fired from a sizable cannon. The distintegration of only one or more of the major high speed rotating components of the turbine engine has the force of producing a catastrophic structural failure to the extent that the airplane is no longer controllable and a fatal crash results. We are at present flying approximately 2,000 airline aircraft with more to come that have turbine powerplants installed. Coordinated research and development is required to assure that when high speed rotating turbine engine parts disintegrate, that the parts will either be contained within the engine compartment, or deflected into the free air without striking the airplane and in addition a warning system of instrumentation be provided to warn the flight-crew in sufficient time so that the failing powerplant can be shut down before the destructive disintegration occurs. Warning means to the pilots to mechanically stop turbine rotation prior to disintegration may be a way to prevent the destructive effects of a failing turbine wheel or blades.

4. In-flight fire prevention and postcrash fire prevention: Commendable research has been done to minimize in-flight fire and postcrash fire. However, the research time and money spent has been somewhat of an exercise in futility. Namely, because this dynamic industry is advancing so rapidly in producing new advanced airline airplanes that we have not taken the time to incorporate all known means to minimize in-flight fire possibilities and since they can occur, positive fire extinguishing means should be developed. Commendable postcrash fire prevention research has been completed in regard to minimizing fuel spillage due to broken lines, torn tanks, water inerting of the powerplants, and undoubtedly some other detailed items. The record of catastrophic in-flight fires continues to increase and also catastrophic postcrash fires continue to occur. This is an area where coordinated research and development of hardware, promptly installed,

can minimize the continued loss of life and property due to the effects of aircraft fires either in flight or following a survivable accident.

5. Clear-air-turbulence instrumentation: Research and development should be expedited to produce clear-air-turbulence instrumentation which will enable flying a transport airplane without overstressing the airframe and also preventing passengers from becoming injured. Some research and development, including hardware, is presently being service tested. The subcommittee would do well to determine ways and means to expedite research and development, since this type of instrumentation is needed not only for the present airliners, but will be vitally needed for supersonic flights.

6. Sabotage prevention: The threat of some deranged person sabotaging an airplane is still with us. While extensive research and development has been conducted and is continuing, it would be well for the subcommittee to delve deeply into this area of continued accident exposure to determine if a suffiicent coordinated research and development effort is underway. In our opinion, with the airline aircraft continuously increasing in size, the exposure of losing a large airline airplane becomes greater.

7. Control of irrational passengers: A continuing problem the airline pilot faces is the control of irrational passengers. These may be passengers intent on sabotaging the airplane by shooting the flight-crew, hijacking, or becoming uncontrollable due to fright or other reasons. The record shows that to date we have not been successful in very rapidly incapacitating a person intent on pursuing any of the actions previously mentioned. A survey of the research and development status in regard to controlling irrational passengers should be undertaken so that a coordinated effort can be made to determine which is most promising of producing a desired result or expediting studies to accomplish the desired result.

8. Airplane noise reduction: Airplane noise has been a problem to the citizens living in the vicinity of the airports practically ever since the airline transport-type airplanes were used in scheduled air carrier operations. As the state of the art of aircraft and engine design advanced, the airplane noise problem grew proportionately. Citizens on the ground near the airport are really seriously affected by airplane noise and their complaints should not be disregarded. Minimizing airplane engine noise research is in progress. Installation of airplane engine noise suppression systems is in the test stages and some promise for relief is indicated. In some cases, engine noise can be alleviated by penalizing engine thrust. Therefore, the economics of the airplane may be adversely affected to the point perhaps where the amount of engine noise suppression required to satisfy the citizens will result in an airplane which is uneconomical to operate. The subcommittee should delve into this item deeply to determine where the compromises between the airplane engine noise suppression and the resultant loss of power versus controlling land use in the vicinity of the airport must balance. As the subcommittee requested, these hearings are scheduled to consider the required technology needs to meet the demands of the next decade and beyond. Since the transport airplane is increasing in size as well as the powerplants, the technology required to determine tolerable noise levels for the U.S. citizen is a vitally needed research area for improvement for today's aircraft and obviously a must for tomorrow's aircraft with their more powerful engines.

NAVIGATION OF AIRCRAFT

1. Air-traffic-control improvements: We foresee a continuing need for the research and development of an improved air-traffic-control system. Improvements in air traffic flow can be realized rapidly by an expedited airport development program since the airport is, and can become increasingly so, the bottleneck for the whole system.

Considerable research and development for improved air-traffic control has been completed and some new developments are now being introduced with more to come. However, more research is needed to provide efficient, safe, system capacity for present and future traffic requirements.

Today, we are seeing new concepts of navigation being installed in airline aircraft, pictorial area navigation as well as "off course" computers. There must be a continuing development of these capabilities to the point that they are foolproof enough that radar as we now use it will fall back into the category of a monitor type of equipment.

Frequency congestion as we know it today must be reduced. Toward this goal data-link forms of communication, such as a pictorial readout in the cockpit, must be developed and installed as rapidly as possible.

2. Collision avoidance system and proximity indicators: Even though we envision that some air traffic control improvements will be realized, a safe back-up for the ATC system is a way of providing the pilots on all airplanes with the means to receive collision warning and sufficient information to take the proper evasive action to prevent collision is needed. This is needed on all aircraft. Hardware must be developed that meets collision avoidance system criteria at a price that will permit mandatory installation requirements. Consequently, collision avoidance instrumentation suitable for all airplanes should be provided at the earliest possible date. An examination should be made of the current effort of research activity and also whether or not adequate funding has been provided to expedite these requirements.

3. Clear air turbulence forecasting: While aircraft instrumentation research and development must continue, there should be a paralleling research and development effort made for providing a clear air turbulence forecasting service for flight planning. Even though clear air turbulence detection instrumentation may be installed in the airliner, it is still desirable to avoid the turbulence in the first place by flying in areas where it will be nonexistent or minimized. To minimize the effects of clear air turbulence when it is detected by instrumentation will require the pilot to either slow down the aircraft, which is undesirable especially at high altitude, or make extensive en route deviations to avoid continued exposure. Either course of action is undersirable from the standpoint of safety and economics due to the additional requirement for either slow flight through the turbulence or detouring around it, as both are time consuming. While clear air turbulence detection instrumentation is vitally needed, research and development for forecasting clear air turbulence is also needed and will enable flight planning for maximum safety and maximum economics.

4. Airborne radar and weather improvements: Transport aircraft are being designed to fly at higher and higher altitudes; particular future aircraft being planned. High flying aircraft require radar which is capable of providing the pilot with information regarding the weather. Specifically, the need is to develop radar capable of functioning at high altitude where low moisture density exists.

An explanation of the foregoing appears pertinent. The present weather radar is really a storm detection device. Its principle of operation is based on energy transmitted being reflected back to the receiver by moisture particles associated with the storm area. The greater the moisture density, the better the picture on the radarscope.

In the lower levels, this is a very satisfactory system of storm detection, thus enabling the pilot to thread his way through or detour as required. As flight altitudes increase, the total moisture density decreases with a resultant loss of radar picture that enables the pilot to ascertain the severity of associated turbulence because at the higher altitudes the total moisture density in each cubic foot of airspace reduces materially.

Either further development of the present radar systems for weather avoidance purposes or improved or new development is indicated.

5. Standardization of all aircraft instrumentation and navigational facilities: Development of satisfactory testing equipment and calibration facilities are absolute essentials for flight instrumentation as well as navigational systems in order to provide accuracy of readouts on each aircraft in a type as well as type absolute essentials for flight instrumentation as well as navigational systems in all altitude references are accurate and identical, airspeed readings and mach meters are identical one to the other. Navigational systems must have the same relative relationship one to the other with respect to geographical position of all aircraft operating in the airspace.

The foregoing are simply examples of what must be done if we are to obtain economical use of the airspace with a high level of safety. Once system errors are compensated for with sophisticated checkout equipment, a longe stride will have been made in providing accuracy for records which report the various parameters they are designed to record.

Present aircraft and their associated navigational facilities and instrumentation are a far cry from what they should be in terms of accuracy and relationship one to another.

AIRPORTS

1. Airport development: We foresee a continuing need for the next 10 years and possibly beyond for research and development of our airport system. At the larger metropolitan areas this must also include the access and egress of people

and goods into and out of the airport, for continued safe and efficient movement of scheduled airline aircraft. We submit that there is very little need in the way of airport basic research. What is needed is recognition of the future needs and the money to realize these needs. Extensive documentation is available to the committee not only from this association, but also from other industry segments, as the problem has now become widely known and the foreseen "airport crisis" is now with us and will be for 10 years or more.

2. Fog dispersal for safer takeoffs and landings: The record will show that historically the Air Line Pilots Association has been actively participating in ways and means to accomplish all-weather flying. Certain times the ALPA groups of a particular air carrier have advocated lowering all minimums for a certain type of aircraft based on their collective experience relating to the handling of the airplane and the integrity of its instrumentation. At other times the pilot group of an airline have fought against lowering of minimums for certain types of airplanes, again based on their experience and not having the confidence needed for flying lower minimums. ALPA and its members also recognize the merits of automation, such as autopilots and automatic landing instrumentation. However, automatic equipment of all types are subject to tolerances and failures. In this regard for zero-zero takeoffs and landings, the ALPA urges expedited research and development to disperse fog of a sufficient distance from the threshold down the runway to the point where the pilot, in monitoring an automatic approach, can see enough to be sure that the automatic equipment will place him at the proper touchdown point for landing and continued high speed rollout or so that he can either take over and make a missed approach or take the proper corrective action to complete the landing by manual control. Such research and development is vitally needed and is in the best public interest for safe air carrier operation.

FLIGHT RECORDERS

1. In-flight recorder instrumentation for airplane airworthiness: The need for the airliner's flight crew being continually advised of the airplane's system, reliability, and other items while in flight becomes increasingly important as the air transports increase in size. Research and development for producing reliable flight recorder instrumentation will enable the flight crew to:

(*a*) Take the proper safety precautions to minimize the possibility of an accident;

(*b*) Conduct in-flight reporting to ground maintenance regarding a developing fault in the airplane's systems, and so forth, and thereby take appropriate action to reduce the "down time" of the revenue-producing airplane; and

(*c*) Keep an accurate log of repeated faults of the airplane's systems and, thereby, enable justifying research and development for improved design reliability of the airplane's components.

2. Flight and voice recorders for accident cause determination: The deficiencies of today's flight recorders for accident analysis are well known. Of concern is that the original flight recorder accuracy instrumentation must duplicate the accuracy of the instruments that are installed in the flight compartment. Additionally, there should be spot checking to assure that flight recorder accuracy is maintained. Since flight recorder use requires working with small-increments of time (seconds), it can be readily appreciated that there must be accuracy in the recorder's original installation as well as maintaining this accuracy.

The association has long stressed that flight recorders must always be recovered undamaged following the accident. The association has maintained that flight recorders for accident investigation must be capable of:

(*a*) Ejection upon impact so that it is away from the burning wreckage.

(*b*) Readily located by the means of a homing signal installed in the recorder.

(*c*) The ejected flight recorder should remain floating on the water surface.

In addition to the previously listed requirements, the parameters for recording information to analyze the cause of an accident should be increased from the present meager five plus a voice recorder to a sufficient number of parameters so that "the guessing" of what is happening to the airplane is reduced to the most practical minimum. Continued recorder accuracy is a prime necessity.

The state of the art of flight recorders is advancing rapidly. Expediting improved units for fleet installation of these sophisticated recorders, we will obtain the data to know the true cause of an accident. Immediate preventive measures can then be taken and also the data obtained can be studied to determine areas requiring research for prevention. The subcommittee should investigate whether additional research and development is necessary (or funding) for accomplishing the objectives for rapid and accurate accident cause determination by up-to-date flight recorder use.

CONCLUSION

It would be difficult to place a meaningful priority on the problem areas we have mentioned which the pilots, by the record, are exposed to in scheduled air carrier operations.

We are aware that the air carriers have placed recordbreaking orders for new aircraft. These orders are for aircraft that will closely resemble the design and operation of the current fleet of airliners. The present fleet and new orders for essentially the same type of airliner will be in service for approximately 20 years. Unless research and development occurs, the same type of fatal accidents which have occurred throughout the years will continue for the next 20 years.

We should carefully examine present "breakthroughs" of aviation research and development areas which prevent accidents from occurring and also examine ways and means to achieve future prevention of the accident type where no preventive "breakthrough" has occurred.

There are, no doubt, many other areas which would enhance safe and economical air carrier operations such as foolproof airplane assembly methods, improved inspection to minimize the possibility of losing an airplane due to a missing cotter pin, et cetera. However, we have tried to speak to the thrust of the hearings regarding the need for required technologies to meet the demands of the next decade and beyond and to direct examination of the adequacy of the national research and development effort in the field of aeronautics.

We have provided a condensed paper listing the items which are and will be of great concern to the airline pilots, to the carriers, and to the air traveling public. We are hopeful that our statement will be productive to assist in enhancing aeronautical research and development for manuafcturing and operating airline transports with increased efficiency and safety.

Description of Air Line Pilots Association, International: The Air Line Pilots Association, International is an association of the professional airline pilots of the scheduled U.S. air carriers. At present, it has a membership of over 27,000 active and inactive members employed by 49 certificated airlines. The association represents airline pilots in all aspects of their professional life. It is their bargaining agent under the Railway Labor Act, maintains an extensive air safety organization in 129 councils scattered throughout the United States and a number of foreign countries, and is spokesman for the airline pilot in his relationship with municipal, State, Federal, and international organizations.

ALPA's organization for safety: ALPA's organization for safety is composed of representatives of 129 councils located throughout the United States, its territories, and a number of foreign countries. Each council has an air safety committee composed of active airline pilots who are selected for their competence and interest in the air safety problems being encountered by their pilots. The chairman of all of the council air safety committees are organized into a central air safety committee which coordinates the safety activities of all of the pilots of the particular airline, subject to the authority of the master executive council which is their highest governing body and which is subject only to the board of directors which makes national policy for all pilot groups within the association. In addition, regional safety chairmen are appointed within five main geographic regions and with subregions. These pilots coordinate the safety activities which are primarily regional in character. Each pilot group designates accident investigation representatives who, along with regional accident representatives, participate in the investigation of all major air carrier accidents and report their findings to the president of the association. The activities of all of these safety representatives are coordinated by the international officers of the association and by a professional staff.

When specific problems require sustained study and representation, committees are created of pilots specializing in the particular subject and assisted by professional staff. For example, such committees in recent years have reported on such problems as new aircraft evaluation, training standards, collision avoidance, dangerous cargo, air traffic control, physical standards, and others.

STATEMENT OF CHARLES H. RUBY, PRESIDENT, AIR LINE PILOTS ASSOCIATION, INTERNATIONAL, ACCOMPANIED BY CAPTAIN J. H. BARTLING (TWA), CHAIRMAN, AIR TRAFFIC CONTROL COMMITTEE, CAPTAIN J. W. MEEK (DELTA AIRLINES), VICE CHAIRMAN, AIRWORTHINESS AND PERFORMANCE COMMITTEE, THEODORE G. LINNERT, DIRECTOR, ENGINEERING AND AIR SAFETY, CAPTAIN HOWARD C. KELLY AND CAPTAIN WILLIAM H. JAY (EASTERN AIRLINES)

Mr. Ruby. I do not intend to read my statement. I believe it will be introduced into the record anyway. And I would like to preface this statement by a few remarks with regard to how we got from the beginning of this industry to where it is today, and the dilemma that we find ourselves in as of this point in time.

Essentially, this industry has grown like Topsy simply because it has some strong similarities to the automobile and its associated highway system.

I think we all know the problems of driving over a large segment of the country wherein there is different traffic rules in every city and town and county and State in the whole Nation. When the Federal highway system started, this was the first attempt to eliminate this problem with respect to somewhat long-distance driving.

We have witnessed what amounted to each individual municipality or State developing its own views on how it would handle automobile traffic. We simply cannot tolerate this in the aviation system, not only within the United States, but worldwide. And our biggest dilemma as of this point in time is the fact that the airports as such have been, for the most part, built and developed by local political agencies, and they range anything from port authorities to really privately owned airports and run the gamut between those extremes, with absolutely little or no thought of coordination between the air traffic control system and the airport.

This has brought on the difficulty of trying to produce a coordinated, efficient system with no basis of original design philosophy. And unless this country is in a position to take strong means to wipe away the mistakes of the past and develop the airport and the air traffic control as a common system, then we are headed for continued chaos.

I realize these are pretty strong terms, but we have got to face the facts if we ever intend to solve our problems.

Now, that is essentially the basics on how we got from an early beginning to where we are today. Admittedly, no one, us included, were able to accurately forecast the public demand for the use of air transportation, be it private flying or the use of commercial carriers. So it behooves us to try to eliminate the mistakes of the past and bury our political disagreements and try to develop an entire system that will serve the public as it should.

Now, we have tried to look into the needs of not only the present to some degree, but also the future, and if you take our paper, starting on the first page, in one, two, three order, we have listed the basic items that we think require not only immediate but coordinated research, development, and finalization into hardware or related end results.

The design requirements for the building of an airplane were developed back pre-DC–3 era. We have gotten into airplanes that are operating just barely subsonic today, and we are soon coming to the supersonic. The design criteria did not foresee this, and it is our judgment that the strength requirements under present design criteria are inadequate. And we deal with two basic premises: The unknowns of metal fatigue, on the one hand, and the exposure of the airframe to gust velocities that are in excess of what the design criteria visualizes the structure being able to withstand before it breaks.

Going to the second element, avoidance of augmentation means for stability and control. Well, as the airplane becomes bigger and faster, with the tendency to try to design without going to the requirement of testing and developing and making correction to the design, we have wound up with what we refer to as crutches in the system in that the basic control is one thing, but it has become powered or supplemented with augmentation devices to try to make the airplane fly as it should based on pure proper aerodynamic design and associated control systems.

Item No. 3, we are dealing with turbine engines today, at least in airline operations, and the engine is becoming a very large unit. And when we look at the diameter of the current engine and the engine that is just about to come into service, you can almost visualize a multibladed propeller that is housed in a cowling. The ability to retain this rotating mass without producing disaster if it comes apart in the airplane is something that is going to require considerable research and development to overcome. Either we have got to eliminate the possibility of these turbines disintegrating or find some method of containment in the event the blades begin to fly apart.

Item 4 is inflight fire prevention and postcrash fire prevention. There has been a substantial amount of research and development. We think it is on the verge now of being able to produce hardware that could go a long way toward minimizing the exposure in these two areas.

Item 5 is the clear air turbulence problem. As you probably know, the current weather radar is not a turbulence avoidance device directly. The airborne radar is a storm detection device, and when we encounter clear air turbulence we have no way of knowing it at the present time until we actually encounter it.

There is some R. & D. that has been done on clear air turbulence detection devices and cockpit readout that would hopefully aid the pilot in either avoidance or minimizing the exposure.

Item 6, we get into the sabotage prevention. That, gentlemen, is a cat with a very long tail. We have not licked it as yet. It is a very necessary problem to be accomplished. I look with horror on any possibility of even a stretched DC–8, much less a 747 or an SST becoming the victim of a saboteur, and last, but not least, even a hijacker.

Item 7 on page 2 gets into control of irrational passengers. This can and does happen on rare occasions. We have got to give some attention to this. We cannot afford to expose a large number of people to demented or irrational people.

Item 8 gets into the airplane noise reduction. Substantial research and development has been done on this subject in the past and is continuing. In order to make the current transportation system by air compatible with the public, we have got to develop sufficient capability to bring this noise problem into a level in which it is acceptable to the people on the ground and at the same time not destroying one of the main legs of the transportation system in this country, and in fact the world, today.

Now going down to the next item, under "Navigation of aircraft," item 1, air traffic control improvements. Obviously, this is needed. However, the basic problem today is the limitation of the airport. You can give a corollary, a double-track system in the railroads. How would you handle the trains, be it freight or passenger, if you still had just two tracks when you got into the station? You would have the same proposition. We have got multitracks as far as the air is concerned, and essentially no more than two tracks at the terminal.

This is a contributory factor to our basic problem, and I have observed a statement by one railroad man who looks with horror upon our philosophy on how to handle traffic. Many tracks, but only a minimum number when it comes to getting the airplanes in and getting rid of it.

Item 2 is a collision avoidance system and proximity indicators. There is development going on in this field today. Unfortunately, the system that looks like will probably wind up going at least aboard airline aircraft is too expensive for the private flyer to afford to buy. But we have not solved the problem unless we have a collision avoidance system that is aboard all airplanes and within the scope of either purchase or rent by the private flyer.

Item 3 gets into clear air turbulence forecasting. We hope for improvement there. At the present time there is no visible means on the horizon in which accurate, clear air-turbulence forecasting can be accomplished. But it is something that should be researched to determine whether it in the future would be possible to do this.

Item 4, airborne radar and weather improvements. I think it would be appropriate to outline the fact that the present weather radar responds to total moisture content in the atmosphere. As the airplane goes higher, the total moisture particles per cubic foot reduce themselves materially, and therefore, the effectiveness of the airborne weather radar for storm detection and therefore turbulence avoidance purposes is materially reduced. So some development or research should be done in this area to make high-altitude flying equally effective as far as weather radar is concerned as it is presently at lower levels.

Now item 5 I think is probably one of the major keys to a need for fast research and development, because we can have a manufacturer build altimeters, airspeed, indicators, mach meters, and any navigational equipment. They can be installed in any airplane and the reading that comes from this equipment is fraught with errors. And until we can get an altimeter that is installed in every airplane so that when the installation is made the corrective factors are made, everybody is flying at a fixed elevation with respect one to another—the same thing with mach meters and airspeed indicators, because some of the traffic separation is based on a constant fixed airspeed in the cruise flight regime. Navigational equipment, each aircraft that is in the airspace is going to have to have a direct relationship to each other in order to maintain proper separation. And you cannot depend on the ground-based radar to accomplish this. What we need is development in this area to do this job, and it is something that cannot be done overnight. But we are merely fooling ourselves if we don't set forth with a program to accomplish the problem. And with the increasing demands of the service, the need for accomplishing this end result becomes more critical every day.

The next item is the airports, which includes runways, and I think we have adequately covered that.

It is our view that further work should be done on fog dispersal for safer takeoffs and landings, because the theory that we can land and taxi an airplane into the terminal and taxi it out and take off without ever seeing the ground, in my judgment, gentlemen, is a long way off, and we should spend some time and effort in at least dispersing fog so that some visual reference can be accomplished at least at the terminal end of the flight and the departure end of it.

Now the last two items encompass flight recorders. The flight recorder readouts presently have the same errors and in some cases even more than the present instruments produce. So really, the flight recorder readouts are worthless until all the corrective factors are cranked into it; and you cannot provide complete correction when you don't know what the basis of error was to start with.

Now, the flight recorder gets into two elements. One is we would hope flight recorders can be developed that, for example, would be able to give the pilot information that the engine is beginning to become unusable and there is a possibility of it flying apart, so we should get enough warning to be able to shut it down before anything happens to it.

The other basis of flight recorders—and this is just one item within the requirements of flight recorders. The other is flight recorder data that would enable us to do an adequate job of accident investigation and subsequent prevention.

Now, these gentlemen here are all pretty expert in every field, and I would ask that each one of them, starting along here, if they have any suggestions or enlargements, please do so. At the same time, we will all be available for questions at any time anyone wishes to expound.

Mr. HECHLER. The committee is very interested in your statement, Mr. Ruby. And we are very anxious that this committee hear the best advice of those pilots who are actually utilizing the equipment and can see frequently what advanced research is needed in the future.

Mr. PELLY. I want to compliment you for a very fine extemporaneous presentation. I never heard anybody that summarized a difficult subject any more to the point than you have.

Have you had a regular opportunity to make these same suggestions to NASA and other organizations and have regular opportunities been afforded you to bring your needs to the attention of those that are engaged in research?

Mr. RUBY. Yes. But it is done on a piecemeal basis. And what we have done here is tried to assemble the whole package. We have not covered every single bracket of this, but most have been.

But as I say, it has been piecemeal, and there is a general lack of ability to bring all of the problems into one tent and then produce effective control on disseminating the effort and then bringing back the results and producing a final end result that solves the problem or determines that it is yet to be solved.

Mr. PELLY. We have had piecemeal testimony before our subcommittee in behalf of an authorization request for funds for research. I think this is very helpful. I feel that the next time witnesses come before us, I would want specifics on what was being done about these items.

You mentioned fog control. NASA showed us films as to what is being done in trying to diminish the dangers of fog, I thought it was practically solved.

I am very pleased, myself, with the fact that you have been here today.

Mr. HECHLER. Yes. Thank you, Mr. Pelly.

Let me just follow up with one question along the line that you were asking.

Has the FAA or NASA or any other agency ever given you the impression when you came forward with suggestions that you ought to go back to your business and not bother them, or have you found any resistance?

Mr. RUBY. Well, some years back I would say, and not critically, that we were probably looked upon as, well, boy, go away, don't bother me. But in probably the last 15 years or so that has not essentially been the case. And I think this area has been improving all along.

And I think Joe Meek here, for example, could address himself to the fog question and give you some idea on how this has been handled. Am I right, Joe?

Mr. MEEK. Well, I didn't want to speak specifically to the fog question, but Mr. Pelly raised a very good question of the difference between research and development and its final application.

In most of the meetings we attend, it is these meetings on the application of what research might be available. And I think there are many fine technical papers come out of NASA that never really get applied to the industry within the end result of the airplane.

Stability augmentation devices, for example, there have been several new papers out of NASA recently, but we still seemed to be arguing in developing rules for the use of stability augmentation devices years earlier than these recent papers came out. And I wonder sometimes if there isn't a gap someplace between the pure research organizations, which we see NASA as, and the final application of its research into use, which is primarily the FAA's point. And I think there is a problem in this area. And there are two ways to do research, as you are well aware: You can have an answer that you want and do the research to produce the substantiation for this answer that you already know, or you can do pure research and develop the facts that need to be developed.

Mr. HECHLER. On the other hand, I would just like to say in defense of NASA that there is a lot of work going on, for example, at the Electronics Research Center, which may be important, which you haven't mentioned here. For example, NASA is working on the whole question of power and how to develop a light power system for an airplane. I think you would concede this an area which might be of some great value and the research they are doing might produce some really outstanding results in the future, as David D. Thomas acknowledged in his testimony.

Mr. PELLY. Mr. Chairman, could I ask a question here?

Mr. HECHLER. Of course.

Mr. PELLY. You mentioned that the expected lifetime for aircraft currently being built is 20 years. Are the aircraft in service today being constantly supplied with the latest developments made available by research? Are these developments rapidly applied? Do you find that the aircraft manufacturers and the airline operators are taking advantage of all the research?

Mr. RUBY. Joe, do you want to field that question?

Mr. HECHLER. Captain Meek?

Mr. MEEK. It breaks down into two problems. The current airplane that is on the line that is flying today very seldom benefits from research that comes out, say, tomorrow. It might in some small technical—you might get a small improvement in instrumentation. But basic research, no.

The new manufactured airplane, sir, that will be produced, is going on the line next year, gets more advantage. But the trouble here is that this airplane was probably designed 6 years ago. There is such a lag between design, producing the airplane, getting it on the airline, and development, that the airplane we will be starting to fly next year will get some advantage of research done last year, but it is really a 6-year-old airplane already.

Mr. PELLY. It is obsolete when it comes off the production line.

Mr. MEEK. That is correct.

Mr. PELLY. That is a sign that science is moving ahead rapidly in this age. I don't think it should discourage us.

Mr. RUBY. No.

Mr. HECHLER. Mr. Ruby, do you think that the authority of the Department of Transportation, the FAA, and the supporting legislation is firm enough in areas such as collision avoidance and safety. We have had some legislation recently; for example, in the area of noise control, which has laid the foundation for trying to control the type of thing that you brought out. Do you think we will need some either additional legislation or tougher administrative authority in other areas aside from noise control?

Mr. RUBY. I think we are confronted with a downstream need for both.

As an example, the noise problem is not something that one particular item is going to produce a solution. Now, sure, there is a lot of work been going on to try to make a jet engine make less noise than it does today for a given number of pounds of thrust. But you simply cannot tippy-toe out of an airport with a 200,000- or 500,000-pound airplane. It just can't be done.

Now, we would like to tippy-toe out every time we go, and the same thing coming in, but we don't know how to do this. So there is going to have to be some compromises developed in terms of land-use planning and further work to try to make the engine quieter. And between the two we've got to reach a compromise that does the job.

Now, the legislation that covers the noise requirements for certification is one piece of it, but I don't know of anything yet that deals with the land-use planning requirements that has any teeth in it that gives anybody the authority to do it. But you've got to put the two pieces together, at least within the known state of the art today, if we are going to get anyplace. And we shouldn't fool ourselves into thinking that the absolutely quiet engine is just around the corner, because it isn't.

Mr. HECHLER. Well, what about other areas aside from noise? Do you or any of your associates want to comment on either the need for legislation or certification?

Mr. LINNERT. Congressman Hechler.

Mr. HECHLER. Mr. Linnert.

Mr. LINNERT. I would like to make some remarks here on item 4, in-flight fire prevention and postcrash fire prevention.

Fifteen years ago the NASA people, with some commendable scientific research, came forward with water inerting of powerplants to prevent the postcrash fire from occurring.

Mr. HECHLER. Could you speak up just a little bit, Mr. Linnert?

Mr. LINNERT. Yes. We witnessed films where these planes hit obstacles, and those that had water inerting of the powerplants did not catch fire, and those that did not have the water inerting of powerplants burst into flames immediately. This research was completed and hardware was developed, and the association tried very much to get regulation in this area for the next family of airplanes. I think about two families of airplanes passed through the drawing stages and flying, and this research was not applied.

We also have had for many years a research program which results in producing a tank design, a fuel tank design which minimizes the spillage of fuel which is the fire hazard. Also there has been development in lines and fittings. And I don't believe we have taken enough advantage of this research and actually put it in the airplanes as the new airplanes were being designed.

Mr. HECHLER. Well, who should do this? Whose responsibility is this?

Mr. LINNERT. Well, sir, I believe when we get to the point where research has solved the problem and we have virtually a known means of hardware that we can fasten these things on the airplanes and install them, then I think we should put regulation to the effect—objective regulation that a means of preventing postcrash fire to the powerplant area shall be provided. Let the engineer figure out the means, because the research has been completed, he then can design the fittings into the airframe.

Mr. PELLY. The chairman asked who should regulate it. You have said that somebody should regulate it, but you haven't indicated who.

Mr. LINNERT. All right.

The machinery set up for this is when we have passed the research point we can put out notice of proposed rulemakings to the industry and ask for this type of safety regulation as we have in the past as more and more research is completed.

I think in this area of fire protection, both in-flight and postcrash fire, I think we have to do more work.

Mr. PELLY. Would the rulemaking be made by CAB or FAA?

Mr. LINNERT. FAA would produce the notice. And the notice would usually be compiled as a result of industry conferences, and then when the notice went out, it would be pretty close to either adoption or rejection.

Mr. HECHLER. You made reference, Mr. Ruby, in your opening statement about the way in which airports are built by local decisions. And you gave the inference that there ought to be a move toward developing a truly national transportation system that fit in with the highway network and also developed in the national interest of passengers throughout the Nation.

Mr. RUBY. Yes.

Mr. HECHLER. Now, what recommendations do you have that would implement this?

Mr. RUBY. There are two very basic ones: No. 1, I think it will probably require legislation enabling the Federal Government to tie the airport and the air traffic control system together. If this is not done, we will continue to deal with loose bits and pieces rather than an entire system. And this is a big nut to crack, politically; I realize this. But, as I stated earlier, we are going to have to face up to the fact some day, and the longer we put it off the worse the problem is.

The second thing is this particular industry has grown up with the Federal Government, in fact, certificating the airworthiness of the airplane. They have done the same thing with respect to the airmen—and I am referring to airmen as mechanics, dispatchers, pilots, engineers, traffic controllers, et cetera. Today there is nothing that sets any specific requirement for an airport to meet any standard in terms of the type of aircraft that is to be operated on said airport.

Now, we are, I must say, not ones who are advocating great increases in power of the Federal Government. By the same token, how do you bring all of these things together into a cohesive system unless there is some orderly method of doing it? So we say that there has got to be a way of taking the airport system and the air traffic control system and putting it together as a cohesive element that is meshed instead of running the ends of the teeth against each other and knocking them off.

Mr. HECHLER. Do you want to identify yourself also?

Mr. BARTLING. My name is Bartling; I am chairman of the Air Traffic Control Committee.

I think one of the classic situations that everybody is fully aware of today is the situation of the high-density airports. And we have a situation, particularly in New York, where we have known for at least 10 to 15 years that we had to have another airport. We have reached the point now where we need two more airports. And yet, the people who have the responsibility, whoever they may be, for building the airport have been vacillating to the point where nothing has been done, and now it is going to be at least another 10 years.

And if you have read the Bloomquist report on the New Jersey jetport sites, you can see that probably by the time that one is built, if it ever gets built, there will probably still be a need for two more airports.

And I think that someplace here some of the responsibility for making these decisions must be centralized someplace to the point where when something is needed, that we don't quibble over it for 10 or 15 years deciding where it is going to be and who is going to pay for it and so on.

Mr. HECHLER. Well, isn't there something inherent in the way in which airports are financed by local bonds that makes this problem more serious?

Mr. BARTLING. We have been told—and I assume that this is true. We have been told by the ATA that where there is a need for an airport and it is demonstrated, that the airlines will underwrite the bond issue. And if this is the case, it would seem that it would take some of the pain out of the financing.

Mr. PELLY. Mr. Chairman, it seems to me that the highway trust fund referred to yesterday points up that if there is money available from a Federal trust fund, communities are going to fight among themselves to try to get some of it. We could provide airport specifications like we do for the highways.

Mr. HECHLER. Yes.

What is your reaction to this proposal which is pending in—I have a bill in the House, which Mr. Pelly has agreed to sponsor——

Mr. PELLY. I am one of your strongest supporters.

Mr. HECHLER. And Senator Randolph has a bill in the Senate to set up a type of trust fund that would help finance the development of airports in the future.

Does anyone else have any reactions along this line?

Mr. MEEK. You mentioned two questions; one was the trust fund and the other was the specifications of the airport.

Mr. HECHLER. Yes.

Mr. MEEK. I was going to speak strictly to the specifications.

Mr. HECHLER. Yes.

Mr. MEEK. The problem we have, for example, is one major city today that has just built a new runway, brandnew terminal building, they are now already in the process of going to tear down this brandnew terminal building to put another runway through its lobby, which we feel is a very wrong place to run it. They are going to put an additional runway where they should have put the new one to start with, and build a new terminal building. And we feel that the airport—as pilots, the airport will be more inadequate than it is today when it is completed.

I point this up only to say that there is no specification for building an airport. There are advisory circulars put out by the FAA that says you must have certain strength requirements in the runway, you must have certain width and certain length, minimum length. But there really is no specification for building an airport.

I have taken an airplane that is capable of weighing 317,000 pounds, I get a clearance in the cockpit that is figured down to the 1 pound. I look on a chart that figures out the runway length to 1 foot. I figure out my V1, V2 speeds to 1 knot, and I can operate it off of an asphalt runway, a concrete runway in any condition, no specifications; and it seems utterly ridiculous, because this is the whole crux of all this figuring, is to determine what this runway is. And I do everything to the fifth decimal place and then go out and do it to the closest hundredth.

Mr. PELLY. The Federal Interstate Highway System issues specifications for highways. As far as safety has gone, it has been very satisfactory.

Mr. MEEK. As far as safety is concerned, I would have to agree with that, the free speech aspect. When I am going down the runway with a load of people, I could care less. At this point I want safety. [Laughter.]

But it is disconcerting to us as pilots to have to fly these airplanes in all different types of weather, black runways in one place, runways marked different in another place, one runway that is beautiful, has signs along the edge telling me how many thousand feet I've got left, and I go into another ariport, I have no earthly idea.

There is no control over this. The Federal Government only says when they put funds in that if you build a runway of this thickness, this width and to this length, we will participate with the FAAP funds. But it doesn't determine whether the turnoffs are adequate for this type of airplane that is coming in; can we clear the runway in 15 seconds instead of 60 seconds by going all the way to the end? Do I get the whole use of the runway for takeoff—as several airports that I fly in where the runway entrance, taxi strip comes in 200 feet short of the end of the runway; the airplane I fly I can't turn around on that runway. So I have lost 200 feet of my fourth decimal place already. And there is no regulation that requires this.

I am against regulation, but in this area I think something is vitally needed. The runways should be certificated the same as the airplanes.

Mr. HECHLER. Has this suggestion of the pilots been passed on to the FAA? Is there a need for additional legislation, or is it your impression that this is just a philosophy that dominates our entire system that prevents any action in this area?

Mr. MEEK. It has been passed on. We have proposed this now—I am trying to think—at least 6 years that I can remember we have been proposing this, both in writing and at meetings. Of course the real problem we get into, this is the largest political can of worms I think you could ever open. And these airports are owned by the individual municipalities, they are managed by local people. And to bring all of this under one control and to certificate this would—I don't know how you would ever do it without some massive bleeding on the part of a lot of people.

Mr. HECHLER. We are dealing with the lives of people, though, and I think we ought to try seriously to see what solution can be achieved.

Mr. PELLY. Are there any airport owners who don't desire Federal assistance for safety? If you had a provision that required airports to incorporate certain standardized safety requirements, it should be simple for the Federal Government to include that requirement into appropriation legislation.

Mr. MEEK. This is what we would propose and like to see: That the airports should be certified and maintained.

Now we not only certificate the airplane to an A–1 condition when it is new, but we must maintain it if we operate it in airline service to the same conditions. And it is both the original certification and maintaining that is vital.

Mr. HECHLER. Mr. Kelly?

Mr. KELLY. I would like to add something to Mr. Meek's statement there in regard to the one municipality we were talking about: That throwing in one thing to start with, there are certain guidelines that the FAA does lay down, has laid down in the past on runway construction—I am thinking of separation at this point. But the days that it was laid down was in the days of the DC–3, and this type of equipment certainly don't have anything to do with what we are flying today, but they are still building airports along this same guideline.

This one municipality that we are talking about, before they built the runway—and I was very interested in the gentleman's statement from PATCO about how little the people come to the people who are doing the work to ask them, "What the devil do you think about it?" We went on our own and told them, "If you put this runway where you are putting it, it is not going to do you any good because we are not going to fly it the way you figure we're going to fly it"; and to date we haven't flown it.

Now they are getting ready to put in these two additional runways, and the pilots have gone to them already and said "You build that airport and you just got yourself two runways that are never going to be used," and yet they are going ahead with the same identical situation.

This again is one place that the FAA should update, and update quite rapidly, their guidelines for the building of an airport.

Mr. HECHLER. I didn't quite understand. To whom did you go? The community, or the FAA?

Mr. KELLY. The community and the FAA. They didn't have any guidelines at this point. We had our own standards of separation. But the FAA finally came and changed their minds and went with the ALPA separations and the runway separation for this particular thing of parallel approaches. The city refused to go along with it. Today they've got primarily a single runway system with two beautiful runways sitting there.

Mr. HECHLER. We are getting pretty close to operational problems outside our jurisdiction. The testimony should be related to what we need to do in advanced aeronautical research with reference to airports in order to put this within the context of the hearing? Captain Jay?

Mr. JAY. There is one area I think we certainly need some research in, would be in the financing of these airports.

Every community and authority that operates the airports seem to have their own guidelines, and we recently came across a case where the new construction would be financed by charges added on to a ticket. And quite a few of the local operators with, say, fares over 100, 200 miles, in the neighborhood of $10, $15, now this $4 fare added on that would certainly change your passenger's mind. He might take the Greyhound bus or maybe he wouldn't make the trip. But now if that fare were transcontinental and if this particular airport—at this particular airport there are transcontinental flights, it wouldn't make too much difference. But there is certainly an area for considerable research in this field.

Mr. HECHLER. Aren't we going to have to come to something like this—not $4 a head for a hundred miles, but aren't we going to have to come to something like this to help finance airport construction?

Mr. JAY. Yes.

Mr. HECHLER. I paid a head tax when I left Czechoslovakia and I was very pleased that I could do that the day before the Russians came in.

Mr. Lukens, do you have any questions?

Mr. LUKENS. Thank you, Mr. Chairman.

Do you gentlemen have any additional suggestions as to alternative means of financing besides the user tax?

I might add, Mr. Chairman, I also paid that tax and was just as happy as you were to pay it. I was there the day after the Russians came in.

Do you have any suggestions besides a straight user tax as a source of revenue?

Mr. RUBY. I will tell you, we are in a very poor position to get into the methods of financing, because we as employees of carriers generally are not the victims of how financing is done. And I am sure that many people would take a dim view of us making suggestions of how money should be extracted from someone else's pocket.

Mr. PELLY. Except the Federal Government's pocket.

Mr. RUBY. Yes.

If we would say that, I am sure they would be happy. By the same token, we do feel that our knowledge of what is required is such that if we stay within the technical field of responsibility of producing a safe operating system and participating in it, it is probably better answered by those who are expert in the field of finance—and we don't profess to be expert in that field at all. Technically we are better prepared than we are in the field of finance.

Mr. HECHLER. Did you have some other question? I wanted to intervene.

Mr. LUKENS. No; please do.

Mr. HECHLER. Mr. Ruby, you mentioned a few minutes ago that the members of the panel here had some additional suggestions perhaps that they wanted to make. I would like to give them an opportunity before we proceed with other questions to see if they had other areas of research that they thought ought to be emphasized or what priorities we need for the 1980's.

Mr. RUBY. I would say Joe Bartling has been very deep in the air traffic control areas, which, of course, in a way includes airports. If he has got anything he would like to add, this would be a mighty nice time to do it, I think.

Mr. HECHLER. Captain Bartling?

Mr. BARTLING. Thank you.

I would like to suggest that we need a great deal of research in how to keep aircraft apart without depending on radar. This is probably the most basic research that we could do today, because if we continue with our present air traffic control system, it is not only going to be the airport that is the limiting factor but how many men could you put around a radar scope. And we do know there are means today where by using techniques that are presently available, it is possible for each pilot to go back to the old "see and be seen" concept, because he will be able to detect other aircraft in his area who might be on collision courses with him. We know that this is being worked on. We know also, as President Ruby said a few minutes ago, that it is going to be presently so expensive that only the airlines will probably—and perhaps some of the corporate aircraft operators will probably be the only ones able to buy it.

And there are some other developments of a far less expensive nature that need research and development, and in many cases only need the financing to permit the research and development.

Unfortunately, our collision avoidance committee chairman is not here today, but I happen to know that he is working with one small company who has been trying to get funds for quite some time just to buy some basic equipment that they need to test this equipment.

Mr. HECHLER. Has any approach, do you know, been made to the Federal Government to try to see if they could undertake this type of research?

Mr. BARTLING. The approach has been made. I don't know whether there was any success. Unfortunately, we don't have the gentleman here today. But I do know that the approach has been made. I don't think it has been very successful, but I would not like to be quoted on that.

Another area that we could get into would be the area of this proximity warning device. We have been told that it is possible in certain areas to use equipment that is presently on board the aircraft to separate aircraft by themselves—in other words, each aircraft will provide its own separation from the man in front of him, and in other words, would be able to string himself out in a line of aircraft and maintain his distance from the aircraft ahead of him. This we understand is a very inexpensive thing. And we have been trying both internationally and locally, domestically, to get this system put into an aircraft, or into several aircraft and evaluate it.

It has already been evaluated by the FAA and we have their report on it. It says that it works. And yet we cannot get the equipment put into regular line aircraft to even try it out and see what happens.

Mr. HECHLER. Also in addition to that, isn't one of your big problems the fact that the smaller general aviation aircraft which may contribute to some of the accidents cannot afford to have this equipment aboard?

Mr. BARTLING. Well, this particular equipment that I am referring to probably would be within the capability of—at least half of the system would be within the capability and is probably already installed in most light aircraft. All it would require would be a DME receiver—distance measuring equipment receiver, which most of them already have.

Mr. LUKENS. Mr. Chairman, if I could ask a follow-on question: Obviously what is needed is a test period with large aircraft operators before we could possibly apply the equipment logically and practicably to the smaller aircraft?

Mr. BARTLING. That is correct.

And we understand it is a very inexpensive modification on the aircraft.

Mr. LUKENS. Captain Bartling, to follow this to the next step, what is needed, therefore, at this stage is simply administrative approval; namely, from FAA?

Mr. BARTLING. I think probably even as much or more than that would be someone to say, all right, let's put it on the airplane. It only costs a thousand dollars, say, whatever the cost is: let's put it on the airplane and try it.

Mr. LUKENS. Has any major user requested this permission?

Mr. BARTLING. So far as I know; no.

Mr. LUKENS. So the initiative is still with private industry?

Mr. BARTLING. I think so.

Mr. PELLY. Do you have cockpit control now in maintaining distance?

Mr. BARTLING. We do not, because we have no means of doing it except visually. And if we are talking about jet aircraft, I would say that this does not apply for jet aircraft visually even, because in the positive control of air space we must have some other form of separation.

Mr. KELLY. Mr. Chairman.

Mr. HECHLER. Mr. Kelly.

Mr. KELLY. One more point to the gentleman's question there that kind of brings it up. Around the first of the year the FAA had a notice of proposed rulemaking that all air carrier aircraft would be completely IFR under the control of the air traffic control system from the time the wheels are off the ground until they are back on the ground. It sounded very good. They eventually withdrew it a couple of days ago because of the comments, because it developed the only thing we were doing was protecting ourselves from each other. We weren't getting any protection from the light aircraft or anything else. And this is what we are getting into if we don't have a compatible system built into this that will cover every aircraft. We are depending on ATC to keep us away from others now. They are doing a pretty good job of it. But at the same time, it is still not going to answer the problem.

Mr. LUKENS. Mr. Chairman.

Mr. HECHLER. Mr. Lukens.

Mr. LUKENS. I would like to ask your opinion on STOL or short-range aircraft and the on-board landing system that Eastern is beginning to use with some success. What is the professional pilot's opinion of this system, and the real possibility of increasing the use of the system? Do any of the gentlemen on this panel want to comment?

Mr. HECHLER. Captain Bartling?

Mr. BARTLING. Thank you, Mr. Chairman. I would like to comment on that.

We have been trying both as ALPA and as the International Federation of Air Line Pilot Associations for at least 15 years to get this very system tried. This is one of our problems:

We recognize a good thing when we see it, and yet we can't get anybody to try it, just as we were talking about.

Now they have finally come around to trying it, and they find that it is a great system. And we think it is a great system, too.

Mr. HECHLER. Who is blocking you? Who are these "they" that keep coming up?

Mr. BARTLING. Sometimes I wish we could find out. [Laughter.]

It is a very difficult thing. We know it is economics, part of it is economics. Part of it is inertia, and part of it I don't really know what it is, but we find that it is very difficult to get any kind of application of a proven device.

Mr. HECHLER. Mr. Ruby, on that point, have you talked to the Air Transport Association people on things like this to see if there is some way you can speed up the progress of the application?

Mr. RUBY. Oh, yes. This is done frequently. But it gets down to again the problem of getting everyone that is involved in the industry agreeing to go along the same line. And we are certainly not advocating the expansion of controversy. On the contrary, we would like to see agreement reached.

Now, as Captain Bartling said, this "they" business gets a little hard for us at times, because our Ouija board is no more successful than many others in trying to identify the resistance area. And in a free country, it is impractical to become too rule conscious or too obstreperous, generally speaking, and we are certainly not advocating that.

On the other hand, if sufficient effort were forthcoming and we were able to spend the money—and I go back to the collision avoidance system as an example. The present philosophy apparently is that it will run between $30,000 and $50,000 to install a collision avoidance system aboard an airplane. We all know the private flyer cannot afford this, and we would be crazy to think that we would be advocating that he had to have such a device at this price. So what we've got to find is a way to produce a satisfactory collision avoidance system that can either be purchased within a price range that the private flyer can afford, or, on the other hand, his equipment wired and prepared so that he could rent the unit when it became necessary for him to do so.

These are the kind of imaginative approaches that have got to be taken, because just defending one type of aircraft from collision with one another isn't going to solve our problem. We have to look at the whole industry, the big one and the little one. So we can't get so selective as to who is able to afford this equipment that we don't solve the problem.

Mr. HECHLER. Have you or any of your representatives ever visited the Electronics Research Center at Cambridge? I think you would be really interested in the progress of the NASA development of a warning indicator so that the pilot of a larger plane can detect the approach of a small plane and vice versa.

Mr. LINNERT. Congressman Hechler, if I may.

Mr. HECHLER. Yes, Mr. Linnert.

Mr. LINNERT. I am on a NASA advisory committee on operating problems, and about 4 years ago I initiated the need for the partial protection. This was before the breakthrough of the more sophisticated collision warning devices, and collision avoidance devices. I was one member of a three-man ad hoc committee and we went to Cambridge and also Langley, and they are at the point now where at Langley they have two installations in C–54's which they hope to test in about 3 months or so. I feel somewhere along the line that there should be broader research; that not only NASA should be doing these things, but I believe there are a lot of electronic brains working on the space program, and so forth, and also very knowledgeable electronic producing companies, that we could expand this effort of R. & D. And I believe our item here on this subject speaks to this point.

Mr. HECHLER. Yes, I appreciate that suggestion. I think this is a useful suggestion.

There is a good deal of applicability of the things that we are learning in space to aeronautics. I think the NASA people at Cambridge are trying more and more to try and utilize what we are learning in space to apply to aeronautics.

Mr. LINNERT. That is true.

I think your point is extremely well taken, that we ought to utilize more of the electronics expertise in this area.

Mr. KELLY. Mr. Chairman.

Mr. HECHLER. Mr. Kelly.

Mr. KELLY. I would like to get back—I believe it is Mr. Lukens was talking about the navigation system that has been tried out in the STOL's. It was also tried by Eastern on the shuttle service for the past 6 or 8 months. It is also being installed in a local service carrier in New York State. American Airlines is putting it in on their Chicago-New York shuttles. This is how it is coming about. I mean it is picking up.

But we feel strongly enough on this particular thing, which is area navigation, that we just cannot see how we are going to be able to fly the airplanes of the future without it. And it is not going to be a cure-all, but we feel strongly enough on it we want to see it developed to the point that radar will become secondary, it will just be a safety monitor.

I think the gentleman from PATCO mentioned that this morning, that this is the state they would like to get into. We feel very strongly on that.

There is one other thing I would like to mention; that is the frequency congestion that we are encountering today in the air traffic system. What we want on this thing—and there is very little development work being done on it; there has been some—what we call the data link communications system, which will give us a pictorial readout in the cockpit, printed one way or the other, we don't care. You can even run it on a TV tube if you want to, like they do the advertisements, but as long as we can have a hard copy after it is over, after we are finished. But this is going to be a vital means of communication in the future, and as I say, I don't think there has been too much done to this point and we would like to see that started and worked on real good.

Mr. HECHLER. Captain Bartling?

Mr. BARTLING. Mr. Chairman, there is one point I would like to comment on here. One of the problems that we have run into time after time when we go to these various manufacturers and so on to check the possibilities of working with their equipment, is that if they hold a patent on a part of it or the total system, the only way they can get money to develop the idea is to give the patents to the FAA to get the money to further the development. In other words, they no longer control the patents, as I understand it. And many of these people refuse to give up their patent rights on these things just to get the research money—or the development money to go ahead with it. And yet they are stymied for lack of cash to proceed.

And perhaps there is some way around this particular impasse that Congress could look into and see if there is a way of getting around this difficult problem.

Mr. Hechler. Unfortunately, Mr. Daddario, a member of our full committee, our expert on patents, is not here. I could never fully understand this subject. I always defer to him.

Mr. Pelly. It should be stated that the Science and Astronautics Committee has interested itself a great deal in the matter of patents. I think Mr. Daddario will be quite interested in your statement.

Mr. Hechler. Yes. I would like very much to see that you can get together with him personally.

Mr. Lukens, did you have some comments?

Mr. Lukens. Yes, sir; Mr. Chairman.

I am a member of the subcommittee which has gone into the patent field, as it applies to science and technology. I will see that the word is passed on to Mr. Daddario.

I would like to go back to Mr. Kelly. Is it your opinion that the STOL or onboard navigation concept offers the only practicable immediate relief from congestion? Do you see anything else in the immediate future that we can apply right away which will relieve any of the traffic congestion?

Mr. Kelly. Personnally I do not. Of course, I would like to divorce the STOL from it. It just happens this is the type of equipment that they have installed since they have been testing on our DC–9's.

Mr. Lukens. We are talking about onboard guidance and control? Is that what the system is called?

Mr. Kelly. No, it is area navigation. It is in the cockpit and there is a map keeps unrolling all the time with a stylus tracing it out. There are predrawn tracks and you can set these tracks up just as far as you can get them. And over-traffic for New York, for example, would never have to go for a navigation fix in the New York area. They could bypass it and know exactly where they are all the time.

Mr. Lukens. You simply match where you are with where you should be on a preset visual presentation?

Mr. Kelly. Right. It constantly tracks your route on this roll as the map unrolls.

Mr. Ruby. You can build your own map by offset computers so you don't have to fly the specific radial of any "VOR" station, and this is how he says you can bypass an area that is congested.

Mr. Lukens. And relieve the traffic congestion.

Mr. Ruby. Yes. And this is the way we can do it properly.

Mr. Lukens. I gathered that this is an onboard equipment capabiltiy to map out an alternative route at any time so that a pilot is not confined to one route.

Mr. Kelly. Yes, this is true. We see it for thunderstorm avoidance as probably the only way out, and we are being tied down real hard with this thunderstorm avoidance now.

Mr. Lukens. Tied in with data link, in an inexpensive system of collision avoidance, this package could be of immense immediate practicability.

Mr. Kelly. This is our whole concept: The collision avoidance system, the pictorial off-course or analog computer type of navigation, and tied in with the data link communications, we feel at this point is about the closest solution we can get to the air traffic system.

Mr. Lukens. The major stumbling block appears to be sufficient research funds and development funds?

Mr. KELLY. Well, part of it is already researched, and that is your area navigation concept. It is in use, as I said, and proved at this point. The other two things is what is holding up the complete package, the data link and the collision avoidance system.

Mr. LUKENS. Thank you, Mr. Chairman.

Mr. HECHLER. I would like to raise another question about general aviation.

It is obvious in the next decade that we are going to have a tremendous growth in the number of general aviation aircraft just as well as in the number of commerical airline passengers.

With relation to the development of airports, I wonder if you are familiar with the Minneapolis-St. Paul example of how they have been able to build an airport there primarily for commercial airline flights, ringed by a series of satellite airports. I wonder if any of you had any suggestions as to how to solve the crisis of the tremendous number of general aviation aircraft with relation to the development of airports in the future.

Mr. RUBY. Well, I can comment there, and it is fairly simple. It works, so if other people could duplicate what has been done in the Minneapolis-St. Paul area, it will work there, too.

Mr. HECHLER. I asked Secretary Boyd about that, and he said, "Well, that is a good example of hardheaded local vision." But there is a—what do you call it now, Mr. Lukens? Is that a vision gap?

Mr. LUKENS. It is usually a communications gap.

Mr. HECHLER. Well, there is something missing here, obviously.

Mr. RUBY. Right.

Mr. HECHLER. I wondered if you had any suggestion as to what research is necessary to alert the great traffic jam that general aviation is going to cause.

Mr. RUBY. I think this really gets back to the basic discussion we had earlier wherein someone has got to begin to produce a menage between the air traffic control systems and the airports with authority to do this. Persuasion is insufficient to accomplish the job.

I really reluctantly use the word "compulsion," but it is obvious persuasion hasn't done it, so I suppose—how do you solve lack of persuasion? I suppose compulsion is the next answer. It is a very reprehensible situation, but do we wish to live with chaos forever, or do we want to be realistic and get compelled to do a few things?

And we are not advocating running general aviation out of the sky. There has got to be a place for them, and there should be. And Minneapolis-St. Paul is a good example of how they made provision for everybody.

Mr. HECHLER. Is there any other area of research on the design of future airports, in the way in which general aviation is to be taken care of, that you could suggest to the committee?

Mr. RUBY. I think there is one area at least, and I think maybe some of these other people can maybe answer even better than I. When an exercise is run by the FAA with the air traffic control system with respect to airport locations, they are having to determine what their problems are with respect to air congestion and handling traffic in and out of specific airports. When you plan on building a new airport you should run this exercise in an attempt to attain the most efficiency with a minimum of accident risk.

Now, this would have a very saluatory effect on what the end result is, obviously. And this would encompass not only the big major terminal, but also the so-called satellite airport as well.

Now, here is where the DOT has got to get into the picture, because you are not going to have satellite airports that are acceptable to the private flyer if he has to get to town on a bicycle or thumb rides. You've got to deal with the ground transport system as well, not only for the major terminal, but for all the satellites, too. And I cannot conceive of handling, for example, two 747's on the ground at the same time. Some airports could handle it if everything else were kept out of the way, but what is the highway system going to do? What are the buses going to do? What is the capacity of buses to haul people? If you are going to haul everybody away from there in a taxicab from a 747, Lord look after us, because the highways better be piggy-backed, or we are going to get in trouble there.

So we've got a great big ball of wax here, and we better start trying to sift it out.

I am broad brushing this, but it is a true statement of the basic problem. The general aviation cannot be shoved off and said "Go away, boy, don't bother me." There are a lot of people who travel this way too. And they should be interested in safety, and I am sure they are. They don't want to get run into or run into somebody and get killed.

So there are solutions, but we've got to face up to the necessity of doing the job even, as I say, if it gets a little beyond the powers of persuasion.

Mr. Lukens. Mr. Chairman.

Mr. Hechler. Mr. Lukens.

Mr. Lukens. Could I interrupt for another question here?

Mr. Hechler. Yes.

Mr. Lukens. From what source do gentlemen such as yourself who are interested in the profession of aviation, obtain blueprints, programs, or projections for future airways systems and airports from coast to coast? Where is there any coordination? Is there sufficient coordination on which to base your own projections in your own planning?

Mr. Ruby. Well, in our own organization we've got a lot of pretty dedicated people that spend most, if not all, of their days off in this dreamboat trying to figure a better way to do the job. And this is not a pure U.S. problem any more, and hasn't been for some years. The International Federation of Air Line Pilots Association meets annually, and through ours and input from the pilots of other countries, assembling once a year, we try to reach among ourselves agreement what constitutes, for example, standardized navigational equipment that is carried aboard an airplane. And this means it has got to be compatible with the ground-based facilities such as radios, et cetera. And we like to standardize the airport lighting and the approach patterns and all this system.

If you didn't do this, you could haul no passengers. You would be hauling the necessary equipment aboard the airplane to be compatible with each particular country in the world's own ideas on how they should have their country equipped.

So this is how we ourselves put this ball together. But admittedly, we are not completely successful in every country in the world, but we try.

Mr. LUKENS. The general thrust of my question is that there is, no adequate source of general coordination or information on national planning? I realize it is still an international problem. There is no general source of information?

Mr. RUBY. Not that we are aware of.

Mr. KELLY. The FAA used to put out a 10-year forecast of the airway system on this type of stuff, but I don't think I have seen one in 10 years.

Mr. LINNERT. It needs updating.

Mr. KELLY. Because they put it out and it wound up so wrong after it was all over I think they just gave up on it. Now this is my personal opinion, certainly not anybody else's opinion.

Mr. HECHLER. I just want to say on behalf of the committee that this testimony this morning, Mr. Ruby, by you and your associates has been extremely helpful to the committee.

I am sure that we will have other questions that we would like to submit to you for the record. If you have other information along the lines of the questions that we have asked that you would like to supply to the committee, we would certainly welcome it.

Mr. RUBY. All right, sir.

Mr. HECHLER. We congratulate you for bringing such a star-studded array of talent here this morning. If there are no further questions by members of the committee, the committee will stand in recess.

(The subcommittee recessed from 11.10 to 11:18 a.m.)

Mr. HECHLER. The committee will be in order.

We are very honored this morning to have with us Lt. Gen. Elwood R. Quesada, an old friend of the committee. In fact, I understand you appeared before our committee in 1960.

General QUESADA. And before, I think.

Mr. HECHLER. At the time you were Administrator of what was then the Federal Aviation Agency.

We appreciate very much your giving us the benefit of your experience. This committee has been trying to look into the future of this Nation's needs in aeronautical research and development. The basic thrust of these hearings is devoted toward how we can focus national interest on what needs to be done in aeronautical research and development in order to strengthen the Nation in the future.

And within that very broad context, we would be interested in any general observations that you care to make as to why aeronautics is important for the national strength and what priorities or what emphasis needs to be placed on our aeronautical research for the 1980's.

(The biography of Gen. Elwood R. Quesada follows:)

GEN. ELWOOD R. QUESADA

E. R. (Pete) Quesada was appointed by the President of the United States as the first Administrator of the Federal Aviation Agency on November 5, 1958. At the time of his appointment Mr. Quesada was Aviation Advisor to the President, Chairman of the Air Coordinating Committee and Chairman of the Airways Modernization Board. As Administrator of the FAA, Mr. Quesada was responsible for modernizing the federal airways system, directing air traffic control of civil and military aircraft, controlling the allocation of the diminishing airspace and both issuing and enforcing air safety rules.

Mr. Quesada was born in Washington, D.C. on April 13, 1904. He attended District of Columbia grade and high schools, the University of Maryland and Georgetown University.

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In 1924 Mr. Quesada enlisted in the Army and in the ensuing years rose from private to Second Lieutenant to three star General.

Early in his flying career (1928) Mr. Quesada took an active part in the dramatic rescue of the crew of the BREMEN, a German aircraft forced down off the coast of Labrador after completing the first successful east-west crossing of the Atlantic by air. He was also on board the famed QUESTION MARK when it remained aloft the entire first week of January 1929, establishing a world's record for endurance and proving the efficacy of aerial refueling. During the period in 1933–34 when the Army flew the air mail, Mr. Quesada was chief pilot on the New York-Cleveland route, personally flying the round trip on alternate nights.

During World War II, Mr. Quesada served as Commanding General of the 12th Fighter Command and Deputy Commander of the Northwest African Coastal Air Force. As Commanding General of the 9th Fighter Command, he directed the American air effort prior to and during the invasion of Normandy, and directed a tactical operation in conjunction with the Army during the Allied sweep across Europe. He participated in more than 90 combat missions.

From 1949–51 he was in command of Joint Task Force Three, representing the Army, Navy, Air Force, and Atomic Energy Commission, which organized and carried out Operation Greenhouse, a series of tests which included the detonation of the world's first thermo-nuclear device.

Mr. Quesada holds the Distinguished Service Medal with Oak Leaf Cluster; Distinguished Flying Cross; Legion of Merit; Air Medal with two Silver Oak Leaf Clusters and Purple Heart. His foreign awards include the British Order of the Bath; Commander of the British Empire; French Legion of Honor; French Croix de Guerre with Palm; Luxembourg Croix de Guerre, Order of Adolph of Nassau; Belgium Order of the Couronne with Aviation Palm, and Belgium Croix de Guerre with Aviation Palm.

Mr. Quesada retired from the Air Force in 1951 with the rank of Lieutenant General. He is now associated with private industry in Washington, D.C. and elsewhere.

STATEMENT OF LT. GEN. ELWOOD R. QUESADA, FORMER ADMINISTRATOR, FAA

General QUESADA. Mr. Chairman, I am flattered that you would even ask me to appear before your committee. I have an abiding interest in aviation and in air transportation in a more narrow sense. I have no official role, so what I say is my opinion and is born of long experience. What importance you might want to attach to my experience is a subject the committee will have to determine for itself.

I want to make sure that the committee knows that I am a director of one of our large airlines. I am a director of American Airlines. I think I am able to separate my vested interest, if you wish to call it that, from my personal views as a director. And if there is any doubt in your mind, I will try to eliminate it right now. What I am going to advocate at this moment is something that American Airlines, per se, is not particularly fond of.

You made reference to the long-term requirements of aviation and air transportation, particularly as applied to research and development. I think it is undeniable that air transportation is a significant element of our transportation system today. And it is a large element, much larger than any of us forecast; certainly larger than I was bold enough to forecast.

But the fact remains it is a significant element and a great deal must, by necessity, be done.

Now, if that is so—and I think most of you agree that it is so—you might be interested in an observation that is mine, and mine alone.

The stepchild of air transportation, in my opinion, is an efficient short haul system that is able to connect city pairs that are close to each other. As an example, I mean New York and Washington, I mean Washington and Pittsburgh, Pittsburgh and New York, Pittsburgh and Cleveland, Cleveland and Detroit, Detroit and Chicago—that type of city pairs, which, incidentally, provides something around 30 percent of the total air traffic, which is a very large segment of the whole.

Now, the aircraft industry and the air transportation industry have been very successful in providing extremely efficient air transportation on the long haul segments from New York to San Francisco, from New York to Los Angeles, New York to Chicago, Boston to Dallas, Washington to San Antonio. That element of air transportation is extraordinarily efficient and it competes most favorably with all other forms. It competes most favorably and it has little competition. But for some strange reason that I think I understand, the aircraft industry has never really been interested in using its extraordinary talent in producing an equally efficient airplane for the short haul or the city pairs that constitute a very large percentage of our air transportation needs.

The aircraft industry has been obsessed with a faster airplane and a bigger airplane, influenced largely by the fact that those two elements reduce the seat cost. And that is undeniable. And they have done that extremely well.

However, I would say that economic necessity has caused them to neglect using their extraordinary talent in producing an airplane that could go from downtown Washington to downtown New York, or from downtown Pittsburgh to downtown Cleveland, or from downtown Detroit to downtown Chicago.

Mr. Chairman, there isn't any way I could exaggerate the tremendous volume that exists between the city pair of Detroit and Chicago. It is unbelievably large. But the fact remains that the people who wish to travel between that city pair, in order to do so have to go to airports far removed from the center of the population and consume a great deal of time on each end and then get into an airplane that admittedly travels extraordinarily fast. But it would be more efficient if they could start from downtown and go to an airport that is downtown and get into an airplane that is not necessarily extraordinarily fast, but is reasonably fast, and could use short runways that are in the downtown area of each city.

The aircraft industry has the capability of devising means where high-performance airplanes can achieve low-performance characteristics in landing and takeoff. And for reasons that I have never been sympathetic to, the industry has essentially ignored this potential, influenced by a desire to build a faster and a bigger airplane. It isn't sexy to build a slower airplane. It is, however, a need that has been not fulfilled.

Mr. HECHLER. Does this mean, then, you feel that additional research of a concentrated variety, perhaps by NASA, ought to be carried on concerning short takeoff and landing planes?

General QUESADA. In the area of air transportation I don't think there is any endeavor that could be more productive on the part of NASA, than in the short takeoff and landing area. Of all the areas that are devoted to air transportation, I think the NASA could make its greatest contribution if it focused on this area.

Mr. HECHLER. Mr. Pelly?

Mr. PELLY. I am interested in your advocating the use of a relatively slow aircraft that leaves from one center of population and goes to another center of population. This is not going to be popular with the people on account of noise, as you know. Isn't it possible to have a different system such as a monorail or other form of rapid transportation leaving the downtown areas and going out to airports with a quick turnaround and which could accomplish the same objective without causing a disruption to the business centers?

General QUESADA. Certainly, sir, it is possible. But I don't think it is ever going to be as productive and as efficient as having the ability to connect certain city pairs that are within, say, 300 miles of each other—let's take that as an arbitrary unit of measure—and providing a slower airplane from a downtown area.

In most cities, sir, I think you will find that airstrips, or air facilities such as I have attempted to describe, could be provided with a minimum effect in terms of noise.

Most cities are on water. And let's take, as a hypothetical situation, connecting Pittsburgh to New York. I don't think American Airlines connects Pittsburgh to New York, so I am free to use this one. High-speed rail transportation connecting those city pairs is almost impossible. I don't think it is possible in the next century to provide a high-speed surface transportation between Pittsburgh and New York, if for no reason other than terrain. You just can't bore a hole in the mountains for 100 or 200 miles and expect to come out with an economic roadbed.

So I think that distance and that terrain excludes surface transportation being competitive with air.

It just so happens that the city of Pittsburgh and the city of New York are both on bodies of water. And it also happens that bodies of water present a fairly convenient platform for a short-haul type of airdrome or air terminal that I think must necessarily serve a service such as I am attempting to describe. And admittedly, if someone would attempt to convert Central Park into such a facility, it would attract universal opposition. It would certainly attract mine. And I don't think anybody would be for it except the people who wish to make a quick buck out of it.

But the fact remains that the top of docks lend themselves to this type of terminal facilities, as a single example.

Mr. PELLY. Certainly there is no fixed pattern that could meet the needs of these cities located on water and those not so located.

We know the Japanese are using a monorail from downtown Tokyo to Haneda Airport. Certainly that is one way of helping to solve the air traffic problem.

General QUESADA. It certainly is. There is no question, sir, but fast transportation from the downtown big cities to the airports that serve them, whether they are for short haul or long haul, would make a great contribution.

Mr. PELLY. You have to solve the long-haul problem by developing means of getting people quickly to and from the airports in large groups.

We heard from one witness earlier this morning who indicated that today two Boeing 747's couldn't land within minutes of each other at any airport. That would bring a thousand people at one time into an airport. There are not enough taxicabs nor enough highway space to move those people quickly out of the airport area. So there has to be a lot of different approaches used to solve this problem.

General QUESADA. If two 747's landed at Pittsburgh or New York, or anyplace else, within 15 minutes of each others, which we should anticipate, chaos is obviously going to occur, because you are putting into this confined area maybe as many as 600 or 700 people. We must lend encouragement to the concept of getting these people out, not only by conventional means, which are bus, taxi, private car, and so forth, but by mass means such as high-speed surface transportation.

I think you can't deny that we must look to high-speed surface transportation.

Mr. PELLY. When you say "surface," you don't mean necessarily on top of the ground, do you?

General QUESADA. Or submerged. It doesn't make any difference.

Mr. PELLY. Air cushion is another approach?

General QUESADA. Another possibility. There is no doubt about that. And it is an area that is being explored.

Mr. PELLY. We have been told that none of these problems would have occurred today if there had been adequate research 10 to 20 years ago, that nobody anticipated them. You said you didn't anticipate them.

The purpose of this hearing is to try to ascertain the research needs for the future. As you say, there are going to be tremendous developments with Boeing 747's landing every 15 minutes and these developments will create problems that require a lot of research now, not later.

General QUESADA. And if it isn't done now, I can assure you what is going to happen later. It is going to be chaos.

Mr. PELLY. Which is the proper agency to do research for locating airports and tying together all of the different studies on handling people and traffic?

General QUESADA. The research that I think you refer to when you talk of transportation, whether it is on the ground or below the ground, that would connect a city—the downtown area of a city to its airports, I think is the role of the Department of Transportation. I don't think that is the type of research and development that I was referring to when I described this short-takeoff airplane.

Mr. PELLY. Can it be done if we don't put all that research under one roof?

General QUESADA. Yes; I think so. I think the Department of Transportation could coordinate with NASA a research program that would embrace the type of research that I have attempted to describe, to connect city pairs by air. Because there is a possible relationship between connecting city pairs by air—you are referring to connecting a downtown district with its airport.

Mr. PELLY. Right.

General QUESADA. Whereas I was referring to connecting two separate city pairs. I would not encourage excluding from the subject, your concern, that is, connecting a downtown area of a large city to its airport by air, because that might be a convenient way to do it. I certainly would not want to exclude connecting a downtown area by a surface transportation system, because I think that in the final analysis would be more efficient, because it can carry so many people.

But I was attempting to describe a vacuum that exists, at least in my opinion, of connecting large city pairs between which there is tremendous traffic, in which air transportation, in my opinion, offers the most potential.

Mr. PELLY. The Secretary of Transportation was before this subcommittee earlier this week. Subsequent witnesses have agreed with him that funds presently available for research in all these fields is inadequate. And I think you would agree with that.

General QUESADA. I think there is ample proof of that, sir, in that we now have a crisis. Not only are they inadequate now, but they have been inadequate over the decades. As you say, we have failed, as we so often do, to forecast the future with accuracy. We often have a tendency when a request for funds comes before you to say: "Well, that is the great wild blue yonder; the future will take care of that." But that isn't so.

My wife is very successful in solving her problems this way. She can solve almost any problem by ignoring it. [Laughter.]

Mr. PELLY. We didn't do the research, apparently, on intercity surface transportation with regard to fast train service between Boston and New York. We were told that we would build a train that was a great advance in the state of the art. Now we apparently have to do more research after we have built our cars.

General QUESADA. That is often the case, I am sorry to say. Research funds are very difficult funds to put a handle on. When I try to put myself in the shoes that you are in, I often wonder how you understand what we are asking for.

Mr. PELLY. Well, that is one of the problems I have, too.

General QUESADA. Right. It is awfully difficult. And I am in sympathy with your problem.

All I can say, those people who have devoted themselves to the future of aviation have characteristically undershot their requirements rather than overshot them. They have underestimated what they could do, rather than overestimated what they could do. The "wild blue yonder," at least the forecasts of the future that are often referred to as the "wild blue yonder" turn out to be reality much sooner than most people ever forecast.

And I would urge your committee to encourage research and development in these areas, knowing that some of it is going to be nonproductive. It is erroneous to think that the results of every research and development effort will turn out to be positive in its results. It is just as important, often, to prove that it is negative; proving something is wrong is often just as important as proving something is right.

With the United States holding supremacy at least for the present, in the field of air transport, the importance of our aircraft sales overseas to the balance of payments situation, it is important too that we work on standards governing the use of these planes wherever they are used in connection with trade and the transportation of passengers.

If we didn't have a standardization procedure and if that procedure was not efficient and effective—let's say more effective than efficient—international air travel would be anarchy. They would speak one language in Portugal, another in Switzerland. They would have one frequency for air traffic control in one country that is not usable in another. The navigational aids would not be compatible with the airplanes that use them. It would be anarchy if such a standardization did not exist. And I assure you that it does exist.

It doesn't exist to the degree that many would like to have it. But that is true of all walks of life.

Mr. PELLY. Thank you, Mr. Chairman.

Mr. HECHLER. I recognize Mr. Hunt for 10 uninterrupted minutes.

Mr. HUNT. Thank you, Mr. Chairman. I don't think I will take the 10 minutes.

I recognize the General's position here. I would like your opinion on a few things that I have gathered from your presentation this morning.

Actually, aren't we talking in essence about two systems of air transportation: one the short haul and the other, the long haul?

General QUESADA. In essence we are. And I am attempting to say the short haul is a neglected area, and the long haul is the dynamic area.

Mr. HUNT. I agree with you. Short-haul traffic is now estimated to be about 34 percent of the total traffic. This includes the commuting executives, the commuting salesmen, and the people who make short trips to and from the suburbs or their places of business. This is the projection that you have outlined with regard to downtown-to-downtown operations.

The other is the long-haul traffic which will be operating out of our major airports which presently are stifled to a great extent by lack of adequate and fast ground transportation. Is that not so?

General QUESADA. That is so. Contributing to the stifling is the fact that those long-haul airports often have to handle the 33 percent to which you and I have referred. If you could take that 33 percent away from the big jetports and put them in other areas, the congestion at the big jet airports would be lessened.

Mr. HUNT. I read a very interesting article on congestion of airports about 6 months ago. It said that each passenger departing on, or arriving from, long-distance flights on scheduled or charter airplanes, usually attract to the airport not less than 3½ persons per family; these are children, wives, mothers-in-law, fathers-in-law, uncles, aunts, all pouring into the airport either to wish the passenger bon voyage or to welcome him back. The article went on to say that this would become a major problem when the Boeing 747 went into regular service. We would have a tremendous congestion of ground traffic at each airport. This is a problem that we are going to have to research.

General QUESADA. We certainly will, and the time has passed when we should have had a solution to it.

Mr. HUNT. In other words, what is happening is that there are more sightseers at the airports and air terminals than there are passengers. And this is creating a severe bottleneck.

I wonder if there is any research being done on this?

General QUESADA. I would doubt it.

Mr. HUNT. We have the same problem on our highways during rush hours. There was a survey made a short time ago on one of our major bridges connecting New Jersey and Philadelphia. I was amazed to find that 85.4 percent of the cars crossing that bridge had exactly one passenger, the driver. We are running into the same problem in our airports with people.

Do you agree if we do get into a system of STOL operations on a downtown-to-downtown basis, that we will alleviate some of our difficulties insofar as scheduling at our present airports is concerned where we have overlapping schedules at peak hours? Do you agree that today, STOL research should be accelerated so that we might soon get the benefit of that technology?

General QUESADA. I can't think of anything that would contribute as much to the solution to the basic problem that will confront us for the next decade, as research and development money that would eventually result in an acceptable, usable, and economic air transportation system connecting city pairs of short length. It would do a great deal to alleviate the tendency of peaking the load on all of our airports.

If such a system could become effective, the frequency could be every 15 minutes or every 10 minutes. And there isn't anything that would contribute more to avoiding this tremendous tendency of peaking the demand on airport facilities between 8 and 10 and then doing the same thing from 4 to 6. This would bring a tremendous relief to that problem.

Mr. HUNT. As an aside, I can readily visualize the Madison Avenue boys producing a slogan such as—"Do you want to travel from boondock to boondock, or do you want to travel from office to office?"

General QUESADA. Right.

Mr. HUNT. This is our major problem. Commuting needs for business people are increasing rapidly. We have a crying need for a compatible dual system capability, one from downtown to downtown, and the other, the long haul from large jetports which will require rapid transit surface systems. And, of course, how are we going to control the well-wishers who clog up the airports as well as the vendors in the airports?

People are going there just to look around and see aircraft land and take off. It is getting to be a major problem.

General QUESADA. This is a problem that is primarily addressed by airport design.

Mr. HUNT. Right.

General QUESADA. In the case of Dulles, as a single example, there was one feature installed in that airport—and I cite it, on one hand with embarrassment, because the concept came out of my insistence, and the other is pride. The airport at Dulles has two basic levels, and these people who are departing from Dulles by air use one of them and those people who are arriving by air use the other. And that makes it extraordinarily efficient. They don't bump into each other. The people who are arriving by air and going away by some surface transportation, our studies indicated only buy 7 percent of the merchandise that are sold in the area. They just can't wait to get away.

Mr. HUNT. That is exactly my point. I think that portion of research and development is vital at the present time to long-range planning.

General QUESADA. It is.

Mr. HUNT. I am hopeful it will be taken into consideration.

General QUESADA. Airport design has still got a lot to accomplish.

Mr. HUNT. Thank you, General.

Mr. HECHLER. Mr. Hunt, do you have any further questions?

Mr. HUNT. No, sir. Thank you.

Mr. HECHLER. We certainly appreciate your coming to appear before the committee, General Quesada.

General QUESADA. Thank you very much, sir.

(Whereupon, at 11:55 a.m., the subcommittee was adjourned.)

APPENDIX A

Comments on the Hearing and Additional Material for the Record

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF SCIENCE AND TECHNOLOGY,
Washington, D.C., October 4, 1968.

Hon. KEN HECHLER,
Chairman, Subcommittee on Advanced Research and Technology, Committee on Science and Astronautics, U.S. House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am submitting the attached statement in accordance with my letter to you of September 18, 1968, and in lieu of my appearance as a witness at the Subcommittee hearings on aeronautical research and development. I have been closely following the progress of these hearings and believe they have developed an interesting and productive set of views on our future needs in this area. Since you have received a comprehensive discussion of possible R&D programs in a number of specific areas I have chosen to focus upon aspects of our aeronautical effort which seem to apply generally and will deserve increasing consideration in our approach to these future programs.

Sincerely yours,

DONALD F. HORNIG, *Director.*

Attachment.

STATEMENT BY DR. DONALD F. HORNIG, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY FOR THE ADVANCED RESEARCH AND TECHNOLOGY SUBCOMMITTEE OF THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS, OCTOBER 4, 1968

Mr. Chairman and Members of the Subcommittee, I welcome the opportunity to provide a statement for the record in connection with your hearings on "the adequacy of the national research and development effort in the field of aeronautics." These hearings are both timely and useful in focussing on an area that perhaps has languished in the shadows in the last ten years while the spotlight was on space.

In this statement I would like to mention some of my concerns about the content of future R&D programs in aeronautics and upon the government role in fostering or supporting aeronautical research programs. I will not attempt to be exhaustive in suggesting areas for emphasis; rather I will discuss those areas which appear to have reached inadequate attention in the past or where there has been an inadequate appreciation of the impact of a particular new technology on the directions of aeronautical research and development. In so doing, I do not imply that other areas are less important or should receive less support.

I recognize, for example, the need for greater understanding of the relationship between the federal investment in aeronautical R&D and the benefits which accrue from this investment and to whom they accrue. This understanding is obviously a very significant component of the answer to the question—"Is our present level of investment adequate?" I will not attempt to answer this question, but let me point out that even if one concludes that the answer is "no", requesting or appropriating additional funds is still not a satisfactory solution. First, as in other areas where we face complex problems, we would have to identify rather specifically what is to be done with those funds. A set of priorities must be established based upon an objective assessment of the technological opportunities, our needs and our deficiencies. We have only an imperfect view of these needs at present and for this reason I support, as a step in the right direction, the recently agreed joint study by the NASA and the DOT which is to examine "the appropriate role of government support for aeronautical R&D." I plan to maintain close and continuing contact with this study as it matures to insure that it addresses the fundamental issues in this area.

It is clear from testimony you have received as well as from many other sources that there are some problems for which such studies are unnecessary. These problems are widely recognized as requiring federal R&D attention. Foremost among these are: (1) problems of greater congestion approaching immobilization at times in our major terminal areas, both in the air and at the interface between the air and ground links, (2) the airport and all of its functions from cargo handling to passengers and aircraft maintenance, (3) aircraft noise near airports, (4) sonic boom, and (5) aviation safety.

Stimulated by World War II, and sustained by continuing DOD, NACA and NASA investments, aeronautical research and development made possible an explosive growth in air commerce in the past several decades. In addition this R&D activity has contributed to the national security, to the efficiency of commerce on a national and international scale, to our balance of payments, to employment, recreation, personal mobility and other well recognized needs and demands of our society. At the same time, however, our society is becoming increasingly aware of the progressive degradation of the environment. Because our environment is becoming increasingly polluted, at least in part by our misuse of the fruits of our research and development activity, we are beginning to redirect this effort to include the alleviation of the undesirable side effects of our use of advancing technology. This is, of course, the case for aircraft noise, sonic boom and air traffic congestion. In the future, therefore, aeronautical research and development must be broadened to include a multitude of technological objectives, objectives that are interrelated in ways that we are only beginning to understand. This recognition of the complex interrelationship of technological progress with other values and problems of our society has received Congressional attention in a recent Seminar on Technology Assessment.

I believe that technology assessment has been inadequately appreciated up to now but that it should receive our greater attention as we face the future. One clear and current example of a failure to assess adequately the complete impact of a new development upon our environment is related to the introduction of large turbojet air carrier aircraft into our air transportation system. In addition to the significant beneficial impact that reduced transcontinental and transoceanic travel times has had upon the growth of air travel and upon the traveling habits of the population, the growth of air traffic has produced congestion of the airways and serious adverse public reaction as a result of the noise generated by this traffic. Appreciation of the serious nature of the noise problem would not, however, have kept us from developing turbojet transport aircraft, just as appreciation of the air pollution characteristics of the automobile would not have delayed the introduction and growth of this technology. But it is conceivable that, given sufficient foresight and an adequate assessment of the impact of the technology, early development of turbojet engines could have included low noise as an important part of the design criteria in addition to efficiency, reliability and other obvious factors. We are now, of course, proceeding with a program which rather belatedly recognizes this aspect of aircraft engine development. Remedial programs of this nature are both very expensive and lengthy.

I should point out that transportation is not the sole area in which we have had difficulty in assessing the consequences of our technological progress—nuclear fall-out, insecticides, new drugs, power plant sitings, waste management and environmental pollution from many sources are all well known problems that attest to this difficulty. I do not profess to know a single panacea that can prevent undesirable consequences from developing in the future. In any case it is not clear that being able to produce such an assessment would lead to appropriate investments to support adequate preventive action before significant public impact had occurred. Nevertheless, it appears to me that one of the significant challenges for our future R&D aeronautics, as in other areas, will be in the recognition and the broad assessment of the impact of new developments upon the environment and upon the society as a whole.

This assessment need not inhibit the development of new technologies; indeed it can serve to stimulate innovative approaches to potential problems and certainly would serve to reduce subsequent costly corrective measures.

Another well recognized area in which aeronautics has a significant perturbing effect upon the environment is sonic boom. A major thrust of our efforts in aeronautics has been toward larger aircraft and increasing airspeeds. In our air transport industry, I see the trend continuing. NASA has supported a research program in hypersonic aircraft technology for several years and proposes to continue with this program. For many reasons, I support such forward-looking NASA effort, but I believe it is essential that in the future NASA also conduct an in-depth assessment of the consequences of this development at appropriate points in its evolution. I have no doubt that the technology leading to an operational hypersonic aircraft will eventually be developed, but I am less convinced of the commercial or military utility of such aircraft without this continuing assessment to assist in molding the program. The research objectives in this area, therefore, should recognize explicitly the need for concurrent technology assessment as part of the program.

Similar problems exist for the present SST designs—both U.S. and foreign. The noise generated by SST aircraft on takeoff and on landing and the sonic boom generated in flight create serious problems. There are severe economic penalties associated with these problems, since in my view there is plenty of evidence that the public will not tolerate large numbers of flights over populated areas by any SST's we can now foresee. For this reason a high priority for future R&D in this area will be closely tied to the alleviation of sonic boom and noise effects as well as to the further development of materials and structures technologies, control systems, avionics, detection and prevention of the detrimental effects of clear air turbulence and the improved determination of very high altitude radiation environments.

The development and introduction of V/STOL air carrier aircraft would also introduce a new set of problems, many of which affect the environment, the structure of the city and the air traffic control system.

Thus, the general applicability of environmental considerations pervades a broad range of aeronautical research and development. In the next decade this awareness of the effects of our advancing technology upon the environment will be an increasingly significant new factor which will influence our R&D decisions.

I have characterized aeronautical R&D as contributing to a number of objectives or needs of the society. In civil aviation, where spectacular growth has occurred in the previous decade, the principal impact has been derived from introduction of the turbojet aircraft, and the wide acceptance of U.S. manufactured aircraft in the world market. The current value of this export market is over $1 billion annually or about 3% of all U.S. exports. This competitive position is not without challenge, however, and it is this challenge which should provide a corresponding impetus to our future activity. Although we enjoy a very strong competitive position in the international commercial aircraft market, it is perhaps significant to note that we have frequently not been the first to anticipate new technologies or to promote new developments—such as introduction of the turboprop transport, the large all-jet transport, commercial V/STOL aircraft and, it would appear, a commercial SST. In several of these areas, the U.S. has been able to capitalize upon DOD sponsored developments, unforeseen difficulties encountered by foreign competitors, and upon superior large-scale production techniques to recoup a strong market position.

What are the implications for future aeronautical R&D which are imposed by the threat of foreign competition? There are two points that seem to emerge clearly. First, the U.S. must pursue a research program in the basic aeronautical sciences such as the mechanics of fluid flow, structures and materials characteristics, detailed understanding of gas turbine engine combuster and compressor mechanics, and in the basic exploration of broad new areas such as the hypersonic regime in order to have the tools and the understanding to open these new areas to further exploitation. Second, in appropriate cases we must pursue the development of vehicles and subsystems which are experimental in nature but which will serve to demonstrate the feasibility of a particular set of new technologies. This latter activity, which has been widely discussed in connection with our aeronautical R&D posture, is expensive and presents one of our major policy problems.

In the DOD, we have followed a path in which government funding is applied to support the entire R&D spectrum, from concept studies, through system and subsystem R&D, to prototype construction, test and eventual production. In the past, because of a great deal of commonality between DOD air transport requirements and those of the air carriers, the DOD funding policies served the civil aviation industry as well. The examples of this transfer from DoD to civil use are many and are well known to you. You are also familiar with the fact that this transfer is becoming a less effective mechanism for the support of civil aviation development because of the increasing complexities and the higher degree of system integration that is occurring in both civil and military aircraft. It is precisely this point that is of concern today, for this is an area in which the role of the government is poorly defined. No other major industry has depended as exclusively on federally financed R&D programs.

Historically, the aviation industry has generally assumed the costs and responsibility for proceeding from developed military aircraft or subsystems and NASA research findings to the development of commercially useful aircraft types. In the case of the SST, however, the government has gone still further and chosen to underwrite a large fraction of the total funding to develop a commercially useful aircraft, to adjudge the acceptability of the design and generally to operate in a manner closely parallel to the DOD in forwarding the construction of a developmental prototype. Funding arrangements for the production phase of the SST have as yet to be finally determined; nevertheless, in the SST program the government has established a new level of involvement with civil aviation development, and in so doing has established an interesting new precedent for future development programs. Just as with the nuclear energy industry our national policy may be evolving toward a position which includes government support for development efforts which are so large that the resources required exceed the privately available risk capital and where the development in question is in the national interest. I have stated previously before your committee that I view such a policy as both reasonable and necessary. But I am not encouraging or supporting unnecessary federal involvement in the development of aircraft for use in civil aviation. In any event, major development efforts on a scale comparable to the SST are likely to occur infrequently, and will undoubtedly be subject to extensive public debate, so I do not view such programs as being the real problem from a policy standpoint.

What I do foresee, however, is an ever increasing need to define the mechanisms for bridging the gap between concept and operational use, particularly in our transportation industry. I see no alternative to greater government involvement in this area, at least under a combination of conditions where market forces are insufficient to force innovative technological solutions. A significant challenge for our program of aeronautical research will be to build the firm foundation upon which both major program decisions such as the SST and decisions on the direction to proceed in supporting demonstration systems or vehicles can be made. This is not an easy task, as our current difficulties with the SST design and high speed ground transport will attest, but it is one that should be pursued vigorously.

Government involvement in such demonstration or prototype programs on a smaller scale than our support of the SST has been suggested for NASA through use of the "proof-of-concept" approach. I believe this is an area in which we should move very cautiously. I do not, therefore, endorse NASA's conduct of "proof-of-concept" programs as a general mode of operation for the agency. Rather, I see "proof-of-concept" as a useful option which should be pursued in selected areas, particularly those in which the national interest requires demonstration of a set of technologies and where the economic incentives for such a demonstration are lacking or where the risk factor is so high that private capital finds such a risk unacceptable. There is a timely and excellent example of a program which satisfies this criteria—the NASA quiet engine project. This is basically an engine demonstration program. It is a costly effort, one in which there are adequate profit incentives to bring about timely development by industry, but a development which is clearly in the national interest because of its applicability to the alleviation of aircraft noise. Other valid applications of the "proof-of-concept" approach appears to be likely, particularly in those areas where, as I pointed out earlier, undesirable social consequences of advancing technology are identified which require remedial action in conflict with economc forces. There is a danger however that I believe we should guard against—that is, creating an in-house R&D capability that is self-propagating and competitive with industry. This is a problem that I shall watch very closely.

As my final point, I wish to touch very briefly upon the subject of reliability and maintainability. As we have progressed in developing aeronautical and space vehicles we have rapidly moved into a regime which typically involves a new and increased level of complexity and interdependence between various elements or components of the overall system. This has occurred naturally as a consequence of our push toward higher performance and better economics. In general, we have achieved reliability through redundancy, thus exacerbating the problems associated with increasing complexity. We have accepted this greater complexity in spite of increasing problems with system maintainability because the performance achievements have far outweighed the problems that were encountered. But we are rapidly approaching the point where maintenance is a significant factor. For example, maintenance costs for our commercial air carrier fleet are rising, with over $1 billion spent on engineering and maintenance effort during 1967. As aircraft unit costs rise, the economic penalties which accrue when the aircraft is out-of-service for maintenance become a significant part of total operating cost.

Reliability and maintainability are factors that are most efficiently pursued as part of the initial design of a system. We have learned in Apollo and in other programs that system modifications to achieve satisfactory levels of reliability can be an expensive and lengthy process. It is also clear that periodic maintenance or servicing is not a cure for poor reliability in the case of complex systems. Experience has shown that the process of disassembly and assembly which accompanies such maintenance or servicing leads to significantly higher failure rates.

I see, therefore, a need to give greater emphasis in our future research to an appreciation of the various contributors to system reliability and to orient our development efforts toward greater recognition of the need for maintainability.

In summary, as I look into the future, I can anticipate a series of important and challenging problems which will require intensive research and development in the field of aeronautics. Our approach to these tasks requires a new dimension of technological sophistication, we must perform the technology assessment function, we must seek effective mechanisms for the translation of concepts to operational systems together with a continuing critical examination of the government role in support of aeronautical R&D, and we must recognize explicitly new aspects of old concepts which our advancing technology has exposed—such as reliability and maintainability.

UNITED STATES SENATE,
COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES,
Washington, D.C., October 11, 1968.

Hon. KEN HECHLER,
House of Representatives,
Washington, D.C.

DEAR KEN: As you know, the Senate Committee on Aeronautical and Space Sciences has for some time been concerned with the adequacy of the level of aeronautical research and development in the United States. Our aeronautical system contributes significantly to our nation's transportation capability, employment, the Gross National Product, and accounts for a large percentage of our favorable balance of trade (44% in 1967). It is imperative therefore that NASA's aeronautical R&D effort follow a policy and operate at a level that will assure the continuation of these benefits to our economy.

Naturally, then, I was quite interested when you wrote to me earlier this year telling me of the hearings that your Subcommittee intended to hold. The professional staff of the Committee has followed those hearings closely and I was delighted to learn that your approach and your interests so closely paralleled those of the Senate Committee on Aeronautical and Space Sciences. I want to congratulate you on a fine job. The joint efforts of the House and Senate Committees are complementary in helping to help a still better aeronautical research and development policy for our country.

With warm regards, I am

Sincerely yours,

CLINTON P. ANDERSON, *Chairman.*

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.,
Washington, D.C., October 16, 1968.

Hon. KEN HECHLER,
Chairman, Subcommittee on Advanced Research and Technology,
Committee on Science and Astronautics,
U.S. House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN HECHLER: On behalf of the Aerospace Industries Association, I submit the enclosed statement of its views on the future requirements of aeronautical research and development and respectfully request that it be included with the written record of your hearings on this matter.

If you have any further questions we would be happy to assist.

Yours very truly,

KARL G. HARR, Jr.

Enclosure.

STATEMENT OF KARL G. HARR, JR., PRESIDENT OF THE AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC. ON FUTURE REQUIREMENTS OF AERONAUTICAL RESEARCH AND DEVELOPMENT

The Aerospace Industries Association, representing the principal manufacturers of aircraft, missiles and spacecraft and their components, appreciates this opportunity to place in the record its views on the subject presently under consideration by this subcommittee: Whether or not aeronautical research and development activities are adequate to meet the present and future needs of this nation. The subject is naturally a matter of intense concern to the aerospace industry.

Other witnesses have outlined the complex and interrelated nature of research and development activities in government, industry and the academic community. The sum of their testimony has been that our aeronautical research and development activities are inadeqaute to meet the needs of today, let alone tomorrow. We agree.

America's aggressive efforts in aeronautical research and development in the past have made us the preeminent world leader in military and civil aviation. While we still retain this position, our continued leadership is by no means assured.

We are being seriously challenged today in both military and civilian aviation. How these challenges are met will have a profound effect on our military posture, the efficiency of our total transportation system and, indeed, the viability of our economy. One need only look to the expansive efforts of Russia's Aeroflot, its SST development work, and the appearance of its MIG-23 for sobering examples. In the VTOL area, Russia is flying helicopters that are twice the size and lift and equal in speed to our largest helicopters.

The nature and scope of the challenges we face are enormously complex. One example is the crisis reached this summer in the saturation of our major airports.

That crisis was the direct result of a growing imbalance between the efficiency of commercial air vehicles and the airline operators, on the one hand, and the lack of a concomitant improvement of the system in which these vehicles must operate. Whereas it is this very efficiency which has made air travel increasingly economical and, therefore, attractive, commercial air travel is being slowed down to accommodate the archaic system, and not the reverse. The traveling public is being asked to share this inefficiency in terms of both added costs and delays.

There are other serious problems affecting our total transportation system.

What is clearly needed is a reappraisal of the total problem, a reappraisal which demands a systems analysis and systems approach on a scale which only the Federal government can undertake, drawing to the maximum extent possible on the resources of industry.

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To underscore this need, a recent study of the air transportation system shows that substantial growth can be expected if such growth can be accommodated efficiently in the operating environment—principally airports and airways. The study indicated that with growth unrestrained the airlines will generate 300 billion revenue passenger miles by 1980. However, if congestion continues to grow and airline operations should be restrained to 1967 levels, this estimate drops to 160 billion revenue passenger miles by 1980.

The adverse economic impact on the nation in the 1968 through 1980 period if such should occur is substantial:

National, state and local governments would lose $31.2 billion in tax revenue from industries and individuals engaged in or supporting the air transport industry.

Aircraft manufacturers would lose $13.2 billion.

Airline revenues would be lower by $7 billion.

Disposable income of those employed in the air transport industry would be reduced by $18.4 billion.

Loss to airports would be $3.06 billion.

We believe these figures, which are predicated on only the air carrier segment of the total system, dramatically demonstrate both the need for and potential benefits from R&D efforts to reduce constraints on air commerce.

Working with industry, the Federal government must arrive at a new sense of national direction and establish a system of goals and priorities consistent with the needs of the public and the economic well-being of industry. Important to industry and public alike are adequate profit levels to assure aggressive competition and the maintenance, in being, of a broad technological base, skilled manpower pools and a wide spectrum of technical facilities.

Where, on the one hand, industry looks primarily to government for the basic research and development effort in areas of deficiency, government should look to industry to the maximum extent possible for their application to systems of new technical knowledge identified as needed by rational requirements.

In short, such an effort must be a joint, reciprocal one. Planning goals should be established by a top-level government-industry advisory group. Because of the range of agencies affected by such an effort, there should be clearly designated, central points in government with overall review responsibility. In the civil aviation area, for example, the Department of Transportation should perform this responsibility, while continuing to utilize the research capability in being in NASA and the Department of Defense.

Clearly, in any order of priority, the need for intensive aeronautical research and development is urgent in the civil area. At the same time, military R&D must continue minimally at present levels. While the value of military R&D may be less immediately apparent, the fallout to the civilian sector will continue to be great in such areas as STOL, V/STOL and hypersonic vehicles, noise elimination and suppression, exotic materials, propulsion research, avionics, weather forecasting, satellite communications and automatic landing systems, to name just some major areas.

Future military programs will probably not provide the base they have in the past for spin-off to the civil aviation sector as the difference between civil and military requirements increases. Some of the gap can be bridged by the development and construction of carefully selected experimental hardware aimed at civil applications. This is equipment that proves the feasibility of a new concept and provides confidence that the several technologies involved in a total system will work together.

In the area of civil aviation and the relationship of government and industry, special mention should be made of the study titled, "Civil Aviation Research and Development: An Assessment of Federal Government Involvement," carried out by the National Academy of Engineering's Aeronautics and Space Engineering Board (ASEB). In this comprehensive analysis, which has AIA's full support, ASEB isolated airport and support facilities, noise and air traffic control as the three factors most inhibiting to civil aviation's growth.

In these areas, AIA here offers these additional comments from the manufacturers' viewpoint:

First, our airways demand an effort on the most urgent scale if research and development is to head off what threatens to be a worldwide breakdown in the movement of people and goods by air. The problems of air traffic control, en route and in terminal areas, have already been exhaustively explored before this subcommittee, as have the ancillary problems of improved weather forecasting—particularly the problem of clear air turbulence—and collision avoidance. The jumbo jets are virtually here, and the supersonic transport is not far away. If the benefits which they promise are to be realized while sharing a common air space with military and general aviation aircraft operating across an extreme range of speeds and altitudes, both VFR and IFR improvements must be orders of magnitude beyond the present system. Research and development lead time for such improvements must not be lost sight of now.

Within the terminals themselves, the need for massive research and development is equally urgent in the efficiency with which passengers, baggage, cargo and aircraft are processed. No air traveler in America needs to be told that the speed potential of an airliner today is of small comfort if the time saved in the air is cancelled out either going to or coming from the airport, or if the aircraft itself cannot operate efficiently because of deficiencies inherent in the airways system.

The broadest possible systems approach must be directed toward optimizing each interlinked element involved in the total transportation mix, and the scope of the problem is such that only the Federal government can address it.

Working closely with government toward that goal, industry is confident that it can innovate new vehicles adapted to emerging needs. A greatly expanded effort must be made throughout the speed spectrum, particularly in the V/STOL and hypersonic regimes. Basic and applied research must yield continuing improvements in aerodynamic efficiencies, better materials, in greatly improved avionics, in flight safety and survivability.

Much greater efficiencies are still to be realized in propulsion systems, while a parallel effort must be made to mute the problem of noise propagation at its source. While no easy breakthroughs are at hand in solving the noise problem, complementary efforts must go forward in propulsion unit design, in improved operational concepts, and in more enlightened land use philosophies accompanied by architectural design that acknowledges the coexistence of man and machine.

The aerospace industry stands ready to support, and help lead, such an all-out total effort.

RESEARCH AND DEVELOPMENT PROGRAM TO IMPROVE GENERAL AVIATION SAFETY AND UTILITY BY THE AIRCRAFT OWNERS AND PILOTS ASSOCIATION, WASHINGTON, D.C., OCTOBER 16, 1968

This paper presents the views of the Aircraft Owners and Pilots Association (AOPA) regarding an aeronautical research and development program to meet the present and future needs of the nation with respect to general aviation. These views result from the complaints of AOPA members, a review of the accident record and the observations of AOPA's professional staff.

AOPA members buy the major portion of the U.S. general aviation product. As users and consumers of this product, they have acquired some definite reactions to it and some observations about the process by which it comes into being and is used—and this includes aeronautical research and development.

DESCRIPTION OF AOPA

Since AOPA does not regularly appear before this committee, a brief description may be helpful. AOPA was formed in 1939 to provide a vehicle through which individual pilots and aircraft owners could channel their efforts to make flying safer, more useful, more economical and more pleasant. AOPA's membership of over 147,000 individuals includes some 30% of the active civil pilots and the ownership of about 70% of the nation's active general aviation aircraft. AOPA is the largest aviation organization of this kind in the world. AOPA employs a staff of about 135 people to serve its members. The professional members of this staff are acknowledged experts in their various fields of specialization.

BACKGROUND

To avoid the errors and failures of the past, some historical perspective is needed. From official publications we have abstracted some information which may be helpful in achieving this perspective.

Aircraft Production.—One of the several clear obectives of the Federal Government, as spelled out in the Federal Aviation Act and its predecessor, was the "promotion, encouragement and development of civil aeronautics." It does not appear that we have done too well for aircraft production has not matched expectation.

Since powered flight began, the U.S. has been producing aircraft. Now, almost 66 years later, we have yet to build our 250,000th civil aircraft. Even counting military aircraft production, the total U.S. output of aircraft in this period amounts to only some 600,000 aircraft. Records began in 1913. Our average is less than 4,000 aircraft per year.

Recent years show some slight improvement. In the last 10 years we have produced 92,000 civil aircraft; an average of 9,200 per year. Only 3% of these aircraft were transports. Another 3% were rotorcraft. The remaining 94% were general aviation types.

This Lilliputian performance may be compared with the automobile, born about the same time, which we now produce at the rate of 200,000 or more per week. In three weeks we build more autos than we have ever built airplanes. Compare this also with the situation in boating; pleasure boat dealers sell over 250,000 boats a year.

Following World War II, while unit production remained low, aircraft prices went up. The average cost of a general aviation airplane soared from $3,700 in 1947 to almost $32,000 in 1966. Far from becoming a machine to broaden the horizons of the average man, the new airplane has become instead the tool of the businessman who can justify it as a part of the cost of doing business. The majority of those who fly for personal or pleasure purposes are using machines over five years old.

Aircraft Exports.—Aircraft have always been an export commodity. Not until 1925, two decades after the first flight, did we build and keep more aircraft than we exported. It's impossible to distinguish definitely between civil and military exports for all years but it appears that civil aircraft shipments account for most of the exports. On this basis, over the years, we have exported 45% of our civil production. If considered on the basis of civil and military production, the number exported still totals over 18%.

Following World War II, general aviation aircraft exports slumped sharply in numbers but the percentage of total production exported generally remained in the range of 17–25%. By now, numbers have almost quadrupled and the percentage exported remains within this range, currently standing at better than 18%.

Aircraft Fleet.—The number of aircraft on the U.S. Registry is now in the vicinity of 160,000 but due to the frailties of the record keeping system this number is somewhat meaningless. It is generally ignored in favor of "active" or "eligible" figures which reflect a positive knowledge of some kind of recent use. Only 116,000 aircraft were considered active last year and 114,000 of these were in the general aviation category.

Here again is evidence of retarded aviation development. In 1946 Congress enacted the Federal Airport Act in anticipation that the private airplane would assume the same kind of development that the automobile had taken after World War I. Congress then expected that within 10 years or less there would be 500,000 private airplanes. More than twice that time has passed and the actual number is barely a fifth of that expected. By contrast, pleasure boat registrations stood at almost 4,500,000 and it is estimated that over 8,000,000 boats are in use on U.S. waters. By contrast also, automobile registrations are now in the vicinity of 100,000,000.

Airmen.—We are primarily interested in pilots. The number of pilots remained at a low level until World War II carried it over the 100,000 mark. Since then it has grown fairly consistently to over 600,000 at present. Here again is still more evidence of retarded development for by comparison there are over 100,000,000 licensed drivers of motor vehicles and 50,000,000 persons participating in boating.

Airports.—It didn't take much to make an airport in the early days. At one time or another some barnstormer made an airport out of almost every usable meadow or pasture in the country. But the number of registered airports has grown very slowly from slightly over 1,000 in 1927 to about 10,000 in 1968. This seems a little odd in a country with over 18,000 incorporated communities, all of which should want to participate in the benefits of air commerce.

The growth of improved airports has been much slower. Only 2,235 are paved and lighted; 874 are paved but unlighted; 914 are lighted but unpaved; and 6,103 are neither paved nor lighted. The legislative history of the Federal Airport Act reveals that the Congressional objective was the provision of 6,000 publicly owned improved airports within seven years. Contrast this with the present case where only 3,830 of our airports are publicly owned and only some 2,200 have received Federal aid. The other 6,296 airports were established by private interests. Half of these are open for public use.

Flying Activity.—The number of take offs and landings counted by FAA towers has more than doubled in the last decade but this growth is more apparent than real. The number of towers has increased by 62% while the average volume of traffic per tower has increased only 26%. While the total volume of traffic has increased, towers are counting a given flight at both ends of the trip instead of just one more often than before. Taken as a whole, general aviation accounts for 75% of the operations at these tower controlled airports and close to 100% of the operations at all the rest of the nation's civil airports. The significant fact is that if general aviation were eliminated from these tower controlled airports, only 77% would qualify for tower service under present criteria.

Instrument operations comprise only about 22% of the total operations at tower controlled fields and weather conditions requiring instrument operations will prevail at any given location only 10–15% of the time.

An indicator of the impact on interstate commerce is provided by noting the relationship of "itinerant" as distinguished from "local" operations. A decade ago the number of itinerant operations was about the same for both general aviation and air carriers but now the number for general aviation is more than double that for the airlines.

Flying hours for general aviation in 1967 was over 22 million; almost four times that of the airlines. It is our feeling that general aviation hours may actually be much greater than the 22 million the FAA reports. If this time were divided only among the general aviation flights reported at tower controlled fields, the average flight would last only 1:15 and this does not seem realistic. A similar calculation using only itinerant operations reported by towers results in an average field time of 2:21. Since only 3% of the fields have towers to count traffic, some caution in using hours flown as a basis for decision making is indicated.

Economic Impact.—Sales of new general aviation aircraft now amount to over a half a billion dollars. Manufacture of these aircraft provides employment for over 31,000 people. We estimate that approximately 5,000 business concerns are directly involved in providing or supporting general aviation activities in one fashion or another. By providing air transportation to connect the thousands of communities without airline service with the 600 odd that do, general aviation has become an integral part of the air commerce system. Flight operations in support of industrial, construction, agricultural, and resource development activities has become essential and adds incalculable sums to the gross national product. Flying for pleasure has resulted in the development and expansion of new recreational businesses.

These developments are not usually or widely recognized by the general public or its political leadership, but when they are, the results are astounding. The Mayor of St. Paul, Minnesota, has reported that each thousand dollars of tax money invested in general aviation facilities in that city has produced new business in excess of two million dollars a year.

It would seem from this, that greater attention to the needs of general aviation for aeronautical research and development support would bear great fruit.

CONSIDERATIONS

Before proceeding to a discussion R&D requirements, it is necessary to comment on some related considerations.

Financing.—Presently, there is much pressure from various sources for selective taxes to support particular programs. Currently, aviation programs are the principal target and the taxes are usually referred to as "user charges".

AOPA is opposed to user charges for a number of reasons which we have spelled out elsewhere. Therefore, we would oppose any Federally enacted aeronautical research and development program presented upon the basis that the costs of the program were to be recovered from selected users through new or special taxes, fees or charges. It is our contention that aviation will develop naturally in due course. If the general public, acting through its Congress, wishes to accelerate that development, it should pay the cost of that acceleration, not load it on a few selected participants who are helping to achieve what the public wants accomplished.

AOPA is of the opinion that general tax funds can be fruitfully used for aeronautical research and development and that it is in the public interest and beneficial to the public welfare to do so.

Essentially, the problem resolves to one of determining whether or not a given program is of such merit that it warrants support from the general tax funds presently available or which can be made available. If it is, the program should be enacted. If it is not, the program should be left to the mercies of those interested enough to voluntarily bear its cost. In no case, should a select few be required to pay for a program desired by the general public but for which that public is unwilling to pay.

Spinoffs.—We have noted the tendency in recent years to justify research and development programs on the basis that unknown and unexpected payoffs may accrue. It is our view that the primary objective should provide adequate justification. It is a specious logic that holds that something not worth doing for the primary purpose is nevertheless worth doing for other reasons.

Research and Development Scope.—In previous years AOPA has supported the view that Federal efforts in civil aeronautics research and development should be limited to the basic areas of physics and chemistry as they relate to aeronautics. The continued failure to bridge the gap between basic research and application to the products of the market place has forced us to change our view. The attitudes of the Federal agencies involved and the aviation community must change if substantial improvement at earlier points in time are to be achieved. The current approach is too limited.

Federal aeronautical research and development needs to venture into areas beyond that of pure physics and chemistry. It must investigate and find practical solutions for problems involving what are now classified as human factors, economics, fabrication, application—in other words, the associated areas of development that bridge the gap between knowledge and practical economic production. It is no longer sufficient to limit the Federal interest to aeronautical research and development in the problems of simple mechanical and technical feasibility. If we are to have greater safety and utility at an earlier point in time, these problems must have greater attention.

Research versus Development.—Related to the previous item is the relative emphasis in the program structure to research as contrasted with development. The file drawers are full of research results. Transformation into application lags. The time has come to reappraise the research and development effort with a focus upon the constraints that surround any such effort in current times. Almost invariably, agencies that have tried to make a giant step in research expenditures have wasted money and obtained disappointing results. Highly qualified manpower for research and development work is severely limited. Industry has found that $5–15 of new capital is required to exploit a dollar's worth of new product research, with the result that the investment cost quite often can easily exceed the financial resources available to exploit the products of research.

There is considerable evidence suggesting that returns from increased research expenditures are shrinking. In fine, the research administrator must consider many factors besides technical feasibility before undertaking a proposed research project. It is our impression that greater emphasis needs to be laid upon the development rather than the research aspect of the venture. This is a logical and natural application and extension of the "proof of concept" idea.

Research and Development Direction.—Some years ago we favored a great expansion of funds for aviation research and development. Now we have learned. Great sums of money do not guarantee success or accomplishment. We had hoped for programs which would enlarge freedom of use of the airspace for all. Instead we got programs which nibbled away a part of what freedom we had and promise to take still more. If things continue in this fashion, each aircraft will be goose-stepping its way about in a totally controlled environment that serves the needs of the "system" beautifully but forgets that the objective was the service of the desires of people.

To a great extent, research and development programs have fallen into the hands of technicians who are so entranced with exploring the possibilities within the state of the art that they have lost or cannot see the implications for the taxpayer or the system participant. Not having the profit objective, they have found it impossible to find the will or the talent to make the hard, economically sound decisions which are so necessary for the productive use of available funds.

It seems to us that selection of projects for support should be done by decision of a committee in which no one interest, including the Government agencies involved, wields a majority or even a heavy plurality of power and influence. We think there must be substantial—perhaps two-thirds or three-fourths—and relatively free agreement arrived at over a reasonable period of time for consideration. Certainly, such a committee should contain a fair representation of users who will buy and use the products or services which ultimately will be produced.

Above all, research direction requires leadership sensitive to the untapped capabilities of the existing aviation system. A little exploration with practical rather than theoretical users of the system will reveal practical opportunities for improving system capability and capacity—provided we are willing to demand a little self-reliance on the part of system participants. We can also profit by remembering the techniques tried and proven in less sophisticated times and consider how they might be adapted to current needs rather than ignored completely.

Objectives.—Sometimes it has seemed that the valid objectives of Federal research and development have been overlooked or ignored. The fundamental objective is not simply knowledge, but knowledge applied. Money spent for research and development is fruitless unless the results are applied within a reasonable time period. Moreover, the development phase must be advanced far enough that those downstream who will use the results can do so with a reasonable degree of confidence in the results they will obtain.

Another fundamental objective is the improvement of the lives of the nation's citizens. This means the consumer must gain some satisfaction from the results of research and development.

Still another objective is the development of an aviation system that meets the needs of all the people—both the trained and the untrained. Our population is a passing parade of people—not an isolated audience. It will always have students who are learning, private pilots of varying degrees of competence and professional pilots who are highly skilled. Planning and development must encompass the whole range of needs.

In sorting out the objectives, the distinction between people and aircraft must be carefully observed. While the purpose is to serve people, certain parts of our airports and all of our airspace and air traffic control system must deal with aircraft. This difference has often been ignored in the past.

PROGRAM

Some degree of research and development for general aviation would be useful in several areas.

Information.—One of the great deficiencies is a lack of complete, consistent and reliable data upon which decisions can be based. The Civil Aeronautics Board collects and publishes a host of official statistics for the airline industry. Similar data on general aviation are not available. This void needs to be filled.

Airports with towers have only approximate traffic counts. Most others have none at all. Some economic and reliable device for providing this information is needed.

Recording tachometers are subject to failure and change. Engine hour meters count ground running time and can be left on inadvertently. Some independent and reliable meter of flying time is needed.

Airports.—Our airport system is incomplete and generally inadequate. Development attention should be focused upon optimum designs of airports for both single and multiple use by various functional users. Construction methods and techniques must be improved to provide airports more swiftly and less expensively.

Parallel runway spacing requirements for both visual and instrument operations should be reappraised to see if safe reductions can be made.

Construction of airstrips double decked over freeways offers the possibility of more landing places in metropolitan areas for general aviation, STOL operations and similar feeder activities. The technical and operational feasibility of this needs practical exploration at once. If it will work, it will provide more air service to more people in more locations at a fraction of the cost otherwise required.

One omnipresent aspect of airport design has had little attention: What is the optimum layout for servicing aircraft? No one seems to know and the layouts in use are endless in variety. Few work well.

Airport markings for guidance of pilots should be improved. This sounds simple but is not. The sea of blue taxi lights can be very confusing and turnoffs are hard to locate. The welter of runways and taxiways on a large airport requires the strange pilot to resort to airport diagrams or request detailed guidance if a tower is available. Neither should be necessary.

Weather.—Adverse weather has been a factor in about 30% of the general aviation's fatal accidents. Thus, any improvement in weather conditions or information is likely to be reflected directly in an improved fatality record.

The primary requirement is for the pilot to know what the weather is in more places on a more timely basis. The Weather Bureau has not been able to develop a satisfactory automatic weather observing station, yet this seems the only way around the manpower problem. Perhaps NASA can help get the job done.

Distribution of weather information is the next pressing problem. The requirement for weather information is so universal and so continuous that the feasibility of a synchronous satellite weather broadcasting station should be explored. It should broadcast on one of the educational television channels and be receivable on any television receiver any place in the country at any time of day. We must find effective ways to make wholesale distribution of weather information.

The methods of measuring weather need refinement.

Air travel has become so fast that for practical purposes in many cases present weather along the route and at destination is more important and significant than forecast weather which has a built-in time delay. It appears that emphasis should be shifted from improvement of forecasts to improvement of weather observations, observation amendments, reporting and distribution techniques.

Air Traffic Control.—The present air traffic control system is unable to handle the full existing demand for service under instrument weather conditions. This demand is less than 20% of the total traffic. Under visual weather conditions and using visual flight rule techniques, air traffic suffers no significant delay at any airport. The fundamental objective of an air traffic system should be to enable the pilot to do under instrument weather conditions what he can do in visual weather conditions. He must be able to navigate, avoid other aircraft, and avoid collision with the ground independent of external control or guidance. Such a system appears to be the only one which will accommodate the large numbers of aircraft which are anticipated.

We think low-cost inertial guidance, procedural traffic techniques, and collision avoidance or proximity warning devices will have to replace most if not all of our present air traffic control system. Intensive effort to resolve the problems which prevent widespread use of these things should have the highest priority.

The long run value of data links, in view of the above, should be explored.

Engines.—We need quieter engines, both for those inside the airplane and those outside.

Small turbines have not been developed as rapidly as desired. It would seem that general aviation applications would provide one of the best and quickest methods of proving reliability and utility. Cheaper alloys suitable for the purpose would help. Present costs are too high for general aviation.

Aircraft.—Noise is a nuisance and an irritant to both those inside and outside the airplane. While most general aviation aircraft are not critical in this respect, the business jets are, and there is no good reason why all aircraft noise should not be reduced to pleasant levels. If we can do it with automobiles and ventilating fans, we should be able to do it with airplanes and helicopters and still produce a useful product.

Accident statistics show that a large number of accidents result from forced landings caused by fuel mismanagement. The pilot crashed after running out of gas even though he still had gas on board. This is generally classified as an error in pilot judgment. In fact, it's a problem in faulty design where the pilot must compensate for the fact that the aircraft has a complex fuel system. Research and development to remedy this problem is nonexistent. We now have provisions for complex fuel systems built into the airworthiness regulations which govern aircraft production. The example is not isolated.

If large numbers of people are to operate airplanes, more attention must be given to development of automatics for aircraft operation. Aircraft should largely fly themselves with the pilot doing only a monitoring job. The pilot should not have to be highly trained and skilled to compensate for the deficiencies of the aircraft and the air traffic system. Just as self starters, automatic transmissions, and power devices of one kind or another have made the automobile a common conveyance, so similar developments will make the aircraft more useful to more people. To this end, we envision autopilots, navigation couplers, inertial or doppler guidance systems and proximity warning or collision avoidance devices as standard equipment on future aircraft.

Development should be carried to the extent that redundant systems are unnecessary for reasonable safety.

Short and vertical takeoff and landing developments should be accelerated to provide lower landing speeds and permit smaller landing areas.

Pressurization problems for general aviation aircraft need more attention. This will improve safety by facilitating operation above adverse weather.

Boundary layer control holds the promise of greater utility, efficiency and safety. Applications for general aviation aircraft are needed.

Plastic construction of aircraft has had only a fraction of the attention warranted. Applicable developments could substantially reduce aircraft production costs.

Along with more automated aircraft and less skilled pilots will come a need for maintenance recorders suitable for general aviation aircraft applications. These will help minimize maintenance costs and improve safety.

CONCLUSION

The present and potential size of the general aviation aircraft fleet suggests that the balance of research and development support for the various kinds of aeronautical development needs readjustment. Less than one percent of the NASA 1959 budget application for work in aeronautics was allocated to general aviation aircraft. If our society is to reap the social and economic benefits which personal air transportation on a large scale can make possible within a reasonable time period, projects designed to aid development of general aviation will have to comprise a much larger share of the program.

EXCERPTS FROM A SPEECH DELIVERED BY ROBERT W. MARTIN, CHIEF, AIR TRAFFIC CONTROL OPERATIONS AND PROCEDURES DIVISION, AIR TRAFFIC SERVICE, FAA—BEFORE THE RTCA 1968 ANNUAL ASSEMBLY MEETING, SEPTEMBER 25, 1968

Area Navigation

Throughout the history of aviation, one basic problem has plagued planners and users of our National airspace. That problem is how to provide sufficient usable airspace to accommodate the ever-increasing user demands.

The evolution of navigational aids dramatizes this quest for more and more usable airspace. Homing beacons gave way to low-frequency ranges because more accurate positioning allowed more aircraft to be safely separated. VHF omnirange (VOR) stations have replaced low-frequency ranges and opened more airspace by providing more routes, reliability and accuracy. The addition of distance measuring equipment (DME) to the VHF system has provided additional flexibility and position fixing accuracy.

Despite the improvements represented by the present VHF airway system over the old low-frequency system, there are still serious limitations which must be overcome if we are to meet the forecasted demand on the ATC system.

The main limitation is the fact that the present navigational methods result in routes or airways which are either directly toward or away from the station. This creates a convergence or funneling of air traffic and results in a severe limitation on the configuration and the number of routes available between two points.

The same deficiency takes on even more importance when you consider that arrival and departure procedures are based, in large measure, on the same ground stations as our en route structure. This means the funneling effect is compounded by altitude changes for transitioning traffic. That is, the constantly changing altitudes of arriving and departing aircraft make the controller's job more difficult than in the en route environment where altitude changes are less frequent.

The next logical step towards providing more airspace and reducing traffic congestion is the development of a navigational capability that permits accurate route definition on an area basis without the constraints of site location or course alignment.

This capability is commonly termed "area navigation" which could be defined as navigation not confined to flying a radial or track toward or away from the ground station providing the navigational guidance.

Several airborne systems have been developed which put area navigation capability and responsibility in the cockpit, where it rightly belongs. Among these are the course line computer/pictorial display equipment used in conjunction with VOR/DME/TACAN ground facilities. By definition the Pictorial Display (PD) is an airborne equipment that displays to the pilot a continuous visual cockpit presentation of the geographical position of the aircraft, on a chart, with respect to the navigational environment. The Course Line Computer (CLC) is an airborne equipment that computes bearing and distance information from airborne receivers and presents it for flight course guidance to any selected destination within the range of the ground station supplying the bearing and distance information.

In effect, the azimuth and distance information generated by the present VOR-DME system is processed by an airborne computer and used as the basis of an area navigation system. It has the advantage of being a system which is presently in place and can be used by aircraft equipped with the present RHO THETA navigational equipment as well as those equipped with area navigation capability.

Area navigation techniques hold promise of improvement for both pilots and controllers in all phases of flight activity. To illustrate this, let's look at some of the possible applications.

The most immediate possibility is the establishment of area navigation airways. These airways will probably be charted and flight checked in much the same manner as our existing vector and jet routes.

Parallel and one-way routes can be established to reduce the congestion on our heavily traveled airways. En route traffic can be routed clear of congested terminal areas. Multiple parallel routes may be established between major terminals to permit segregation by aircraft speed and/or arrival airport. Each of these parallel routes could transition directly to the approach aids without converging at some primary navigation aid. Even in areas where congestion is not a problem, routes can be established along the shortest and most convenient paths without regard for the constraints of navigation aid location. Many of the present dog legs could be eliminated.

By the same token, site selection for initial placement or relocation of navigation aids can be based on accessibility, favorable terrain and least interference, instead of the more limited objective of meeting one or more procedural requirements. Terminal area applications promise to be as beneficial as those for en route operations. Here too, the initial effort will probably be to establish published and flight checked routes as opposed to random routes. Departure routes can be designed to proceed directly from the runway to the appropriate parallel airway without radar vectoring or passing over primary navigation aids. Parallel departure routes can be established to alleviate speed differential problems.

Arrival routes can be designed to transition traffic directly from en route airways to arrival routes without proceeding over an approach NAVAID or requiring radar vectors. Instrument approach procedures can be shortened, because area navigation provides continuous position information to the pilot and does away with the need to fly over the station and solve time/distance problems.

Instrument approach procedures can be established for many airports that do not have approach NAVAIDS. This has not been possible in the past because these airports have insufficient traffic to warrant the cost of NAVAID installation and maintenance. Now, they can be served by area navigation approaches based on nearby NAVAIDS. Of course, the minimums for these approaches cannot be as low as those based on precision aids, such as ILS, but they will be a significant improvement over the service available to these airports today.

By lifting the constraints of NAVAID locations, better noise abatement procedures can be defined. Shorter approach procedures will mean less low altitude flying time and a proportionate decrease in noise problems.

Holding patterns, in our terminal areas, can be more efficiently placed and more accurately flown. They too have been dependent, in the past, on NAVAID location and course alignment. With area navigation, they can be aligned for expeditious transition to approach routes.

Development and implementation of such a system is not an easy task; nor should this system be construed to be a panacea of all the ills that plague the air traffic control system.

Many problems remain to be solved. Several projects, in cooperation with private industry, are underway to find solutions to these problems and explore ways of developing the full potential of the system.

Currently in progress is an airline evaluation called the "Northeast Corridor Project." Airline pilots are employing area navigation equipment and techniques on regularly scheduled flights. These flights are, of course, provided the safeguards of ATC radar monitoring as well as having conventional VOR/DME capabilities in the aircraft. The purpose of this evaluation is to examine the feasibility of using area navigation in an operational environment.

This project is limited to examination of only the en route environment, since traffic densities in our northeastern terminals seldom permit the handling of special flights that do not conform to general traffic flow. Even in the en route environment, heavy traffic often forces these evaluation flights to remain on conventional routes. This is unfortunate but it does serve to emphasize the importance of careful procedure development. We must develop not only full-scale area navigation procedures but we must also provide for the ever changing ratio of equipped to nonequipped aircraft.

The "Northeast Corridor" project is providing valuable data to the airlines and equipment manufacturers as well as the FAA. The airlines are able to develop pilot procedures and technique while seeing for themselves the advantages to be realized from such a system.

The equipment manufacturers are provided the best possible test-bed for their products. By seeing their equipment used in an operational environment, they are better able to anticipate what will be expected by the users.

Several recommended equipment design changes have already been incorporated as a result of this project.

Another airline evaluation is in progress using area navigation routes between Chicago and New York. It is proposed that eventually these routes be extended to the West Coast to be used by Transcontinental flights. This would provide a good look at the system under a broad range of conditions.

Another evaluation is underway by the flight standards service of the FAA. Area navigation equipment has been installed in FAA aircraft to provide a test-bed that is not limited to scheduled times and routes. These flights are designed to include a very broad range of operations. The objectives are to determine potential application, technical standards, and system accuracy.

The findings from all the evaluations will be the basis on which the FAA will develop separation standards, weather minimums, equipment standards, and operating procedures for pilots and controllers.

In conclusion, area navigation, though not the answer to all our problems, does promise to be a significant step toward better service to the flying public.

Only a few of the problems and plans have been mentioned to illustrate the work yet to be done. No matter how desirable this system seems, or the advantages it appears to offer, it cannot be implemented overnight.

Through the continued cooperation of private industry and the FAA, we will, in the not too distant future, have the answers to these questions and open the way to bigger and better things in our vital aviation industry.

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