AVIATION SAFETY

HEARING

BEFORE THE

SUBCOMMITTEE ON AERONAUTICS AND SPACE TECHNOLOGY

OF THE

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WITNESSES

AVIATION SAFETY

WEDNESDAY, JULY 31, 1974

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON AERONAUTICS AND SPACE TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:30 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 Subcommittee on Aeronautics and Space Technology has been holding a series of oversight hearings on aeronautical research and development, and today's session will be devoted to aviation safety.

There are many Federal agencies, both civilian and military, concerned with aviation safety, and we want to be sure that they speak with each other, and profit by the best thinking throughout the field and insure that the maximum benefits be made available to all the people in the Nation to protect everyone's safety in the air.

This committee is concerned, not only with how various safety programs are organized, but how technology on safety is developed, how it is communicated and transferred, and how to develop a nationally coordinated aviation safety policy, and how to generate and apply new techniques and ideas in aviation safety and development.

Our first witness today is Brig. Gen. Charles E. (Chuck) Yeager, Director of the Office of Aerospace Safety of the U.S. Air Force.

I would like to mention parenthetically that 17 Members of the House and Senate have introduced legislation to award the Medal of Honor to Chuck Yeager for his trail blazing exploit on October 14, 1947, in flying the Bell X–1, to become the first man in the world to fly faster than the speed of sound.

Later, he became the first man in world history to fly twice the speed of sound.

We are very honored to have General Yeager before the committee, and I am very pleased that our colleagues, Mr. Alphonzo Bell of California and Mr. Milford of Texas are also with us this morning to welcome General Yeager.

Mr. BELL. Mr. Chairman, I wanted also to lend my words to what you have been saying, how honored I am to be here listening to your comments.

And, General, I have been a great admirer of yours for years. I have been one of those who introduced legislation also that Ken is speaking of.

It is a real pleasure to meet you and be here with you.

General YEAGER. Thank you.

Mr. HECHLER. Thank you, Mr. Bell.

Mr. Milford?

Mr. MILFORD. Thank you very much for inviting me to participate with your committee.

Mr. BELL. I have another committee meeting I have to participate in, in a few minutes.

I appreciate being here.

Mr. HECHLER. I appreciate your contribution, Mr. Bell.

General Yeager, do you have a prepared statement you want to proceed with?

General YEAGER. Yes, sir, Mr. Chairman.

STATEMENT OF BRIG. GEN. CHARLES E. YEAGER, DIRECTOR OF AEROSPACE SAFETY FOR THE U.S. AIR FORCE

General YEAGER. Mr. Chairman and members of the committee, I appreciate the opportunity to appear before you and discuss aviation safety research and development.

I would like to start by showing you briefly what the Air Force did in aircraft accident prevention last year, calendar year 1973.

AIRCRAFT ACCIDENTS

	1972	1973
Major accidents	163	101
Minor accidents	52	43
Total accidents	215	144

Any accident of this type, is called a minor or major accident. For example if it requires more than 900 man-hours to repair on a complex airplane, that is a major aircraft accident. Or if we tear off any of the major components of an airplane, such as the tail, landing gear or wing regardless of how many man-hours it takes to fix it, that is a major aircraft accident.

You can see, in 1973, the Air Force experienced 101 major and 43 minor aircraft accidents for a total of 144.

This was a significant decline from the 1972 total of 215.

Next slide, please. [Slide—Table of Aircraft Accident Rates.]

Mr. HECHLER. Before you go off that slide, I wanted to ask whether or not this is a decreasing trend or just happened to be between those 2 years that you had a rather large decrease.

General YEAGER. Mr. Chairman, I will show that in the next slide.

Mr. HECHLER. If you are going to get to that——

General YEAGER. We can go back to the order of the slides.

The second slide. [Slide—Aircraft Accidents.]

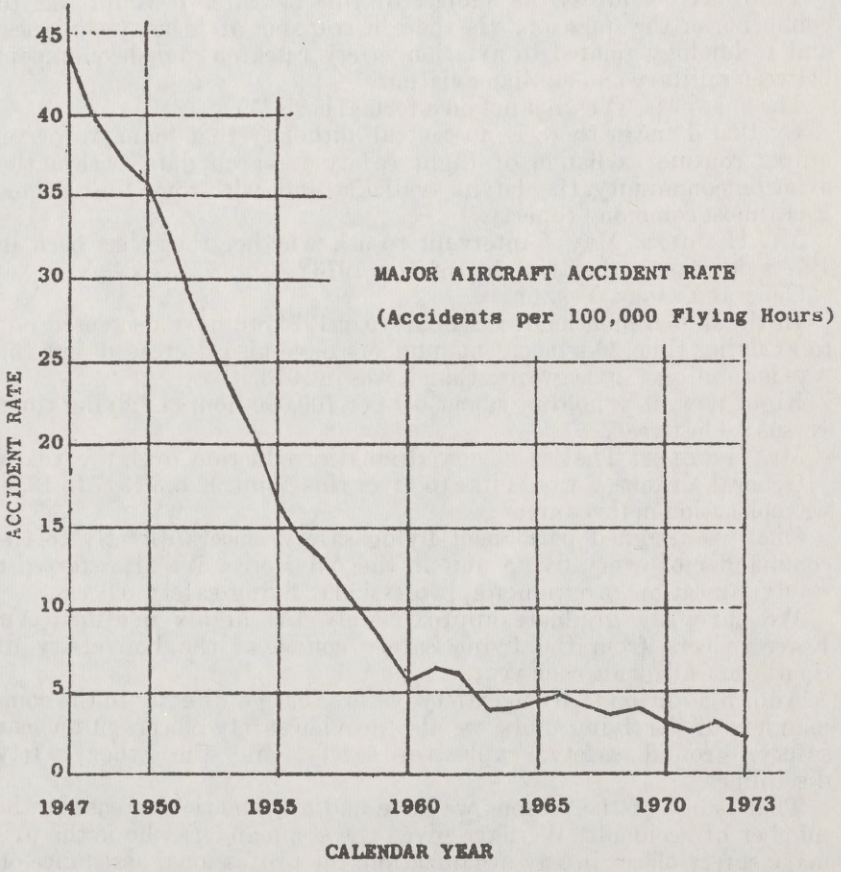
In 1973, the Air Force experienced 101 major and 43 minor aircraft accidents for a total of 144. This was a significant decline from the 1972 total of 215.

AIRCRAFT ACCIDENT RATE (ACCIDENTS PER 100,000 FLYING HOURS)

	1972	1973
Major accidents	3.0	2.3
Minor accidents	1.0	1.0
Total accidents	4.0	3.3

Despite a decrease of approximately 1 million flying hours in 1973, the accident rate still decreased as shown on this chart. The major accident rate decreased from 3 accidents per 100,000 flying hours in 1972 to 2.3 per 100,000 in 1973. The minor accident rate remained the same and the total rate dropped from 4.0 to 3.3.

[The accident rate chart for the years: 1947 through 1973, follows:]



General YEAGER. To show you where we've been and where we are now, this graph shows our aircraft accident rate since 1947. Last year, 1973, was the best year in aviation safety in the Air Force.

AIRCRAFT ACCIDENT COSTS

	1972	1973
Total aircraft destroyed	137	85
Total fatalities	163	90
Dollar cost (in millions)	$330	$293

I do not want to leave the impression that we've reached perfection in aviation safety. We haven't. Disregarding rates, this chart provides some idea of costs. As you can see, total aircraft destroyed, total fatalities, and dollar costs are all down, and we are pleased with that. Still, the costs are enormous in terms of money, hardware, and lives. Aviation safety is still an extremely profitable place to spend research dollars.

To directly address the subject of this hearing, I would like to comment on the question, "Is there a transfer of ideas, techniques, and technology related to aviation safety research and development between military and civilian aviation?"

The answer is, "Yes, but not on a formal basis."

By that I mean there is no central authority that manages or requires routine exchange of flight safety research data within the aviation community, the data is available, and, with some limitations, it is almost common property.

Mr. HECHLER. May I interrupt to ask whether there has been in 1974 a decrease in the flying hours from 1973?

General YEAGER. Yes, sir.

In the first 6 months of calendar year 1974 we have decreased our total flying time. Our accident numbers have also decreased, but the rate is running a little greater than it was in 1973.

Right now, it is holding about 3.0 per 100,000 hours of flying time, versus 2.3 last year.

Mr. HECHLER. That is a very dramatic reduction over the years.

General YEAGER. I would like to cover this point. From 1947 to 1950, we took action in three areas:

One, we assigned permanent flying safety officers directly to the commander of every flying unit in the Air Force. We also started a safety education program for professional flying safety officers.

We currently graduate approximately 150 highly qualified Air Force officers from the flying safety course at the University of Southern California each year.

And in addition to flying safety officers that go directly to the commanders of the flying units, we also provide safety officers in nuclear safety, ground safety, explosives safety, and the other safety disciplines.

That is one of the reasons we have had a dramatic decrease in the number of accidents. We have given the commander, who is the primary safety officer in any organization, the professional assistance on his staff.

Also, we have better systems safety, better equipment, better trained pilots, and better disciplined pilots.

Again, to directly address the subject of this hearing, I would like to comment on the question, "Is there a transfer of ideas, techniques, and technology related to aviation safety research and development between military and civilian aviation?"

The answer is: "Yes, but not on a formal basis." By that I mean there is no central authority that manages or requires routine exchange of flight safety research data within the aviation community.

The data is available and with some limitations it is almost common property.

I feel that I have full access to research data derived by NASA, the Federal Aviation Administration, the National Transportation Safety Board, any of the other military services, the major aircraft manufacturers, and the major air carriers. I must, however, know what to ask for, and I must know who has it.

To cite some examples of this type of data exchange, we use research from the FAA on runway grooving and runway markings.

NASA has done extensive research on comparison of aircraft and vehicle stopping performance—the objective being to measure a runway's slipperiness with a vehicle and thereby predict aircraft performance on landing.

NASA, in turn, uses a great deal of accident and incident experience furnished by the Air Force in developing their space shuttle design criteria.

General Electric's High Voltage Laboratory has furnished us with considerable research data on devices to protect aircraft from lightning strikes.

We, in turn, provide them with as much information about lightning-strike occurrences as we have available.

These are just examples. I would say that on any given day there is an exchange of some flight-safety data between the Air Force Directorate of Aerospace Safety and some agency outside the Air Force.

I stress, though that most of this exchange is on a demand basis. We either asked for the data, or we are answering another agency's request for data.

Another type of safety-research data exchange occurs at our Joint Services Aviation Safety Conference.

In April of this year, we, the Air Force, hosted the 13th of these conferences. For 13 years, the Army, Navy, Coast Guard, and Air Force have met to resolve common accident reporting and exchange flight-safety information.

The FAA has participated in all 13. NASA has participated in the last seven. The NTSB has participated in the last four; the Department of Defense in the last two; and the most recent conference included observers from the University of Southern California Safety Institute and the Canadian Armed Forces.

Next year's meeting will be hosted by the Navy, in Norfolk, and the trend is toward even wider participation. This year's agenda included such topics as:

Reporting of Thermal Exposures and Psychophysiologic Factors.

Standardized Strobe Light Installation Criteria.

Thermal Runaway of Nickel-Cadmium Batteries, which all three services are experiencing.

Selective Application of System Safety Analysis.

Helicopter Main Rotor Blade Failure/Inspection Criteria.

System Safety in Operational Flight Scheduling, and a report by NTSB on their Approach and Landing Accident Prevention Forum.

A third type of data exchange occurs during our participation in such symposiums as the Flight Safety Foundation, the Society of Air Safety Investigators, the System Safety Society, the Safe Flight Equipment Association, and numerous professional engineering and medical societies.

The benefits of this activity are difficult to assess. From the Air Force point of view, it is our opportunity to mingle with the civil aviation community, and learn of research projects that we might not hear of otherwise.

In summary, aviation safety research and technology are readily exchangeable within the aviation community. They are not routinely exchanged and, in my view, the sheer volume of available aviation research materiel makes this prohibitive. The weakness, as I see it, is the difficulty of determining what research has been done and who did it.

I suggest that if the available aviation safety technology were identified and catalogued, the problem of transferring it within the aviation community would be solved by the community members themselves.

Turning to the extent and nature of our organizational arrangements for coordination and cooperation, two features stand out:

First, for several years, the military services have been exchanging aircraft-accident and incident-message reports. That means that when the Navy has an A–7 accident, a copy of the messages from the scene comes to my office. I can follow the Navy's progress and apply the results to our A–7 or F–4 safety programs.

The Navy has full access to any data we have on the A–7 and vice versa. We have an identical relationship with the Army, because we both fly identical helicopters.

Second, the organization of the Directorate of Aerospace Safety includes permanent liaison personnel from several other agencies.

At the present time, the Naval Safety Center under Admiral Nelson, keeps a liaison officer at our safety center, as does the Federal Aviation Administration and seven of the major aircraft manufacturers.

The sole purpose of this liaison is to facilitate cooperation and coordination on all matters involving flight safety. This arrangement is of immense benefit to both the Air Force and the other agencies.

The third subject of this hearing deals with the extent to which there exists a national, coordinated aviation safety research-and-development program within the Federal Government.

Is there such a program?

No. Both NASA and the FAA have done some outstanding flight-safety research, but it is not their principal activitity; and it would be wrong to say that either represents a national, coordinated program.

Should there be such a program?

I will say, "Yes," with some reservations.

I mentioned earlier that it would be of considerable value to the aviation community to have a central repository of aviation safety-research data. This is not an original idea, and the fact that we do not have such a central repository may indicate the magnitude of the problem.

I believe that it can be done best by a Federal organization, and I believe that the long-range benefits of managing the information we already have would exceed the benefits of an equivalent effort devoted to reseach projects.

My instincts tell me to do research; but my brain tells me that I can't do it all myself, and I had better learn to keep track of what others are doing.

Beyond that there are some common aviation problems that probably deserve a nationally coordinated research program.

Bird strikes—not only protection from, but avoidance of; collision avoidance; lightning-strike research; runway construction; severe-weather prediction. Those are just a few.

On the other hand, I do not believe that a Federal program should attempt to coordinate all or even a large part of the avaiation safety research that takes place in this country.

To begin with, the term, "Aviation Safety Research and Development," covers a lot of ground. I do not believe that a definition could be written which would clearly distinguish aviation safety research from other forms of aeronautical research.

In many cases, aviation safety research is part of some other aeronautical research program. Since operational need is the driving force behind most research in this country, I do not believe it would be advantageous to hang a "safety" label on a program and coordinate it at the Federal level just because safety is heavily involved.

Finally, a considerable amount of research and development involving aviation safety tends to be system—or agency—unique. Each military service has problems not shared by the other services or the civil aviation community, and we need the research capability to pursue those problems.

Even among problems we share with others in the community, our view of their criticality is likely to be tempered by our current posture and our national commitments. We need the capability to establish our own priorities and apply research where we need it; not where the aviation community as a whole needs it.

In short, the bulk of aviation safety research needs to be responsive to problems, and I see no way to nationally coordinate this without adding an unnecessary management level and delaying the solution.

In conclusion, I will comment on new ideas and approaches to aviation safety research and development. This could be the subject of a separate hearing; so I will just briefly mention what I consider to be the three most significant recent developments in aviation safety.

First is computer technology. I do not believe that aviation safety and safety research have more than scratched the surface of the capabilities of the computer. We are now storing, retrieving, and correlating enormous amounts of data—usually after something happens.

I look forward to the day when we, in aviation safety, learn to use the computer as a predictive and diagnostic tool—before something happens.

Second is system safety engineering. This is a relatively new field; and, in my opinion, it is still in the developmental stage as a discipline.

There is no doubt in my mind that it is cheaper and better to design safety into an airplane than to try and add safety afterwards.

Now, that sounds simple, but the process of doing it and, equally important, being sure you've done it, is quite complex. It involves a lot of research and analysis, but the benefits are enormous.

The third significant new development, in my view, is the flight simulator. It used to be that simulators were training devices and not very good ones at that. They've come of age, though, and NASA has been a leader in their development.

Aside from improved training, which is a matter of some interest to flight safety, simulators are now considered research devices which can be used to accurately predict aircraft response. Moreover, some simulators can now be programed to refly an actual accident mission based on recorded data. It is becoming a recognized research tool for accident investigators. We are using it a great deal lately.

I could mention other ideas and developments; but, as I'm sure this committee realizes, the scope of aeronautical research and development is almost without limit. The rate of change of aeronautical technology is breathtaking.

Looking back, I guess that constant change and improvement in aviation has been one of the most satisfying and enjoyable aspects of my career. Yesterday's airplanes were great; today's are terrific; but tomorow's are going to be even better.

Mr. Chairman, it has been a privilege and an honor to appear before this committee. I'll be happy to answer any questions you may have.

Mr. HECHLER. Thank you very much, General Yeager, for a very penetrating and imaginative statement.

The Chair recognizes Mr. Wydler.

Mr. WYDLER. Well, I too enjoyed the statement and it is a good one, the kind I guess we would expect to get from you, General.

I can't let this opportunity pass without saying that as a member of this subcommittee, I am most honored to have you here today.

During World War II, I was in the then-Army Air Corps, and stationed far away from Europe. I was over in the CBI, but I remember in those days reading about your exploits in Europe.

You were one of our aces, one of our heroes, and, of course, you are the man that has done one of the milestones in aviation itself by breaking the sound barrier, about 25 years ago——

General YEAGER. Twenty-seven years ago, October 14.

Mr. WYDLER. I understand at that time—I was in government fairly young—there was some speculation that anybody who tried to do that would fly to pieces—everything would fall apart; a person was going to be killed—this type of thinking.

We found out, of course, it wasn't so. You were the man who did it.

This committee is very proud and honored to have you here today as a person that has always been leading the way in aviation, and its development.

I think probably what you have put forth to us in the statement you have given us indicates you are going to keep right on doing that now in the field of aviation safety.

I would like to get, if I could, some reaction from you on a question like this:

How do you trade-off, in the military, the question of aviation safety?

By that, I mean this: Obviously, you want to get the plane back. It is a big investment. It is an important weapon. It is part of the planes you maintain. You want to get the pilot back because he is also a very big investment in time and effort.

Yet I am sure you have to somewhere trade-off the performance of the plane from all the possible safety devices that could be installed in it.

Is there any standard you use in trying to make those trade-offs?

General YEAGER. I assume you mean, if you are involved in a research program, you have to weigh the risk factor against the data that you are after and come up with a happy medium.

Things have changed in the years since I was involved in research. I suppose, before my time, you tied a white scarf around your neck and flew airplanes until they came apart. That was back in 1943, when the Air Force had over 20,000 major aircraft accidents in 1 year.

That attitude probably contributed a lot to that accident rate. Things have changed a lot.

With the X–1 program in 1947, there was a large risk factor involved, but the data that we were to get made that risk worth the effort.

Today, things have advanced to the point where, if a new airplane is involved in research flying, we use all of the computers and simulators available, to predict at what point we begin running into a higher rise in the risk factor. These things are predictable today.

When a new airplane makes it first flight, for instance, there is a First Flight Safety Review Board that analyzes all of the factors involved. Today this subject that you bring up of the risk factor versus the data you are after can really be worked very close together.

And I am happy to say that we have been very successful in predicting where failure takes place in most research vehicles, so that we stop within a degree of that point.

Mr. WYDLER. Of course, I come from Long Island. We are building the F–14 out there. This is an important plane, not only from the standpoint of our economy, but, of course, from the standpoint of our national security.

It is one of our current mainstays. It all strikes me whenever we have an accident, which seems to be with any newly developed aircraft, the first reaction of the public is always the plane is no darned good; forget about it—that type of thing.

I wonder, is it humanly possible to build a brand-new aircraft without any kind of malfunctions, mistakes, accidents?

General YEAGER. Not as long as there are humans involved in it, sir.

Mr. WYDLER. You think it can be done on a computer, theoretically there would be no way, there could still be a mistake made in how a plane is put together?

General YEAGER. I think you can build an airplane that is perfect but you will not advance the technology of that airplane's capabilities in it.

That is where we get in trouble. If we come out with an F–14 or 15 which operates in a new environment or new concept where we have to advance the capabilities of that airplane, then that amount we advance is where we run into the risk factor.

This is where systems safety comes into account. We go through the new systems that are incorporated in the airplane to see that there is no way that that system, because of its design and the capability that it gives the new airplane, is fallible to either human error or material failure.

Mr. WYDLER. At one point there was a story—I don't remember the details of it—but something to the effect that the F–14, in some test, shot itself down.

Does that ring a bill? If so, could you explain that, General?

General YEAGER. The first story, was back in about 1952—the first aircraft which shot itself down, as I recall, was an F–8 Crusader. The pilot was doing air-to-air gunnery or firing the guns on a test at the Naval Air Test Station at China Lake at about 40,000 feet. He fired the guns on his airplane. He kept the airplane in a dive at supersonic speed. The bullets are going to slow to subsonic speed as they get into the 18,000 to 20,000 foot level, especially if fired at very high altitude.

The airplane maintained supersonic speed and he ingested some projectiles and shot himself down.

Mr. WYDLER. That is supposed to do——

General YEAGER. Yes, sir, at supersonic speeds, the projectiles will slow down to subsonic speeds, having no propulsion.

It is really not a very healthy thing or very wise thing to do. There is no reason to get yourself involved in something like that.

Mr. WYDLER. Thank you, Mr. Chairman.

Mr. HECHLER. We have several pilots on the committee, and one of them, our colleague, Congressman Parris of Virginia, I recognize Mr. Parris.

Mr. PARRIS. Thank you very much, Mr. Chairman.

Let me apologize for being late. I had to leave the luncheon early yesterday and I am late this morning.

It is not a traditional course of conduct. I do apologize.

Let me just take one moment of the committee's time to suggest that back in 1950, when I was going through Air Force flying school, I think Major Yeager at that point was a household word around with the guys who were trying to keep from getting air sick and learn how to fly formation.

Several years before that, he had, as we all know, done these tremendous things with the X–1—things that no one had ever done before.

I think it is only fair to say that I certainly share the thinking I am sure all of my colleagues on this committee share my thinking when I say how much respect for the contributions that you have made, General, to aviation history. I mean that sincerely.

I congratulate you for what you have done. We are delighted to have you with us this morning.

General YEAGER. Thank you, Mr. Parris.

Mr. HECHLER. Thank you, Mr. Parris.

Mr. Milford, do you care to ask any questions or add anything?

Mr. MILFORD. Thank you, Mr. Chairman.

I would like to develop one or two points.

First, I would like the committee to be aware of the fact that actually, you have not been calling Colonel Yeager by his proper rank, because he is a colonel in the Confederate Air Force, the real Air Force, where I am happy to also be one of his comrades.

Mr. WYDLER. I didn't know you had an air force.

Mr. HECHLER. Will you explain what the Confederate Air Force is?

Mr. MILFORD. Don't let that get to the paymaster.

Mr. PARRIS. They are paid in Confederate dollars.

Mr. MILFORD. The Confederate Air Force flies real airplanes. It has a flying museum located in south Texas, where we have restored one of each type of World War II aircraft. It is a type of museum where, instead of the people going to the museum, the museum goes to the people.

Colonel Yeager is one of our proud members. We take issue with him in flying some of these Yankee gliders. They are bound to be gliders because they have no propellers.

At any rate, on behalf of our illustrious witness, Colonel Yeager——

Mr. HECHLER. Is he eligible for promotion?

Mr. MILFORD. No. In the Confederate Air Force, we took a lesson from World War II; we allow no rank, so everybody is "colonel."

Mr. HECHLER. You are demoted temporarily.

Mr. MILFORD. Colonel Yeager, I would like to get into an area that you are very familiar with, and I think has a little bit of a spillover into civil accident investigation.

I direct your attention to your Accident Investigation Board.

I would like to ask you a few questions about it, if I could, sir.

Am I correct that your Accident Investigation Board is very similar to our NTSB investigation in that you set up teams after a major accident to investigate it?

And am I also correct that this team would contain members of the manufacturers of the engine, the airframe: avionics, civil members that would be on the Board?

General YEAGER. With one exception, sir.

I am the Director of Aerospace Safety, but normally I do not run the accident investigating board. Usually, we charge the major commander or the major command who had that accident with running the investigation. I maintain the authority under regulation to move in and take over a board if it is important enough.

Also, we have the technical capability within either our Air Force depots or the safety center at Norton, to send in if necessary. If we require assistance from a contractor, we have contractor liaison at our center.

Mr. MILFORD. I was thinking primarily of the makeup of the boards and membership itself.

General YEAGER. Yes, sir.

Mr. MILFORD. It would be various teams that would go to the actual site and at a subsequent time investigate each system, each—such as the engines, avionics, to make a determination.

Are the work products, records, the notes, deliberations, of these various teams and members of those teams—is that data available to the public?

General YEAGER. No, sir. An accident report has privileged status because of the system we use in accident prevention. When we get testimony from individuals who are involved in an accident, or the maintenance of the airplane prior to the accident, we promise them immunity from prosecution so the accident report is privileged status information.

It is not open to the public itself. We do put out a statement of facts about the accident that does not cover the causes or the recommendations. This is one area that is being jeopardized in our accident investigations today.

Mr. Milford, this one thing that many lawyers, if they can get their hands on an accident report, have a readymade case for liability against either the manufacturer of the aircraft or some individual because of admitted guilt, if you want to call it that, involved in that accident. And this is one thing that we are very worried about, because more and more of our accident reports are being released in the privileged status. The subject of privileged status, which is a nasty word, anyhow, is being jeopardized.

Mr. HECHLER. Would the gentleman yield?

Mr. MILFORD. Yes.

Mr. HECHLER. What are the advantages of withholding an accident report and giving it privileged status?

General YEAGER. Within the Air Force, I know somewhere between 60 and 70 percent of all aircraft accidents have human elements involved; either the pilot, supervision, or maintenance.

After an accident, if there is maintenance involved, we go to the individual and if he testifies before the accident board, then his testimony is used only for accident prevention or safety.

It cannot be used against him in a collateral or liability investigation. This way he will sit down and freely tell you the things he has done wrong, and we find out what he did wrong.

Then we can train other individuals better, and uncover the weak areas in our safety and accident prevention programs. Otherwise with the large amount of human error involved in accidents, we are closing up that source of information to prevent future accidents. Once that is used against an individual, he will take the fifth amendment; he will never admit that he did anything wrong.

Mr. HECHLER. You don't learn a lesson then.

General YEAGER. No, sir.

Mr. MILFORD. General, to what extent is civil litigation getting involved in military accidents?

General YEAGER. I don't know the exact numbers.

Mr. MILFORD. Do you know the number of suits we have had?

General YEAGER. Just generally.

Mr. MILFORD. Are you involved in civil litigation?

General YEAGER. Yes, sir. There have been quite a few within the last couple of years. An accident report is a readymade case for a lawyer. It goes through and lists the direct causes. Especially in one case—I use this as an example—I think the last case we lost was the F–111 that was finally settled out of court, where you might blame the aircraft manufacturer for some of the discrepancies that were found.

This is a readymade case for a lawyer for a liability suit. I would say within the last couple of years, there have been no more than four accident reports released through court order to a court.

Mr. MILFORD. Do you find that manufacturers speak more freely to you, particularly where there might have been a flaw in their own product, if they are assured of this type of confidentiality?

General YEAGER. Definitely; yes, sir.

Mr. MILFORD. Do you expect they would speak as frankly if this should ever become public?

General YEAGER. No, sir.

Mr. MILFORD. Do you feel this would have any effect on future designs of aircraft or changes or their willingness to freely make changes if these reports were ever made public?

General YEAGER. I will say that it would make accident prevention a lot harder.

Mr. MILFORD. Would it have any effect in advancing the state of the art?

General YEAGER. No, sir; I do not think it would have any effect.

Mr. MILFORD. Thank you, Mr. Chairman.

Mr. HECHLER. We have several more witnesses this morning and one or two more questions I wanted to pose.

The National Transportation Safety Board had done a breakdown on civil airline accidents over a period of years and has made a percentage breakdown as to the causes and nature.

Their figures show approach and landing accidents, 46 percent; enroute, 19 percent; takeoff and climb, 25 percent. That is just a general breakdown but has the Air Force made any similar type of breakdown?

General YEAGER. We have had a couple of other categories in addition to takeoff, climb, normal flight, and landing.

No. 1: for comparison roughly one-third of the accidents in the Air Force occur in either the instrument approach, takeoff, or landing. In the routine area of the flight or en route, we also have about another one-third, or 31 percent involved. Eleven percent of our accidents occur in the takeoff and climb phase of the flight.

We have two other major areas we lose aircraft in. One is air combat maneuvering or dogfighting.

For example, because of the F–4 characteristic of pitching up as you achieve maximum angle of attack, and entering a spin, and the inability of the aircraft to recover once in a steady state spin, some 15 percent of our accidents occur in the area of dogfighting, or air combat maneuver training.

We also lose an additional 10 percent in the air to ground gunnery phase of training. Those are the two additional phases. We have lost a little less in the takeoff and climb and more in the routine phase than civil aviation has.

Mr. HECHLER. You mentioned in your testimony that there is no central authority managing or requiring the exchange of flight safety research data. You have to know what to ask for and who has it. You discuss this further in your testimony.

Do you have any advice to the committee on how we can make it a little bit easier to interchange these data, make sure that you don't

have to just think of precisely what you need and precisely where it is located?

General YEAGER. Mr. Chairman, I personally think that we have within our Government today, with the NTSB, FAA, Air Force, Navy, Coast Guard, and NASA, we have the people and the means. It just means expanding, in my opinion. Something like our triservice conference that we have each year.

We could have a committee that meets once a month, to screen out or project new research in aviation safety. But, I would rather expand our triservice safety conference.

Next year the Navy is hosting the conference. We have found that because of the complexity of some of the weapons systems—a good example is our missile systems—that industrial safety is having a great effect on the flight safety aspect of the system. Consequently in next year's triservice conference, in Norfolk, we are going to expand our conference to include the other safety disciplines, such as ground safety, explosives safety, and nuclear safety. Today they are playing a big part in aviation safety and must be discussed. The same rules apply to those disciplines of safety that apply to flight safety.

And I think I would like to see our conferences expanded to include more participation by all of the agencies involved. And maybe have a smaller committee that meets once a month to discuss the R. & D. aspect of safety.

Mr. HECHLER. The subject is so important to the lives of individuals, both in the military and throughout the Nation, that I am hopeful that jurisdiction jealousies won't interfere and full exchange of data and central approach of solving problems of aviation safety will come about.

Mr. Parris?

Mr. PARRIS. Very briefly, you mentioned, General, on page 10, your brief outline of the three most recent significant developments in aviation safety.

Among those, you listed systems safety engineering, and you make the statement that it is better to design safety into the airplane than to add it later, or whatever. Now, we are all familiar, even the old-age boys, of the backup, redundancies, pumps to take over from others' failure—that type nonsense.

For my edification, what do you mean by systems safety engineering?

General YEAGER. In the old F–84 there were many lines that had common fittings, that were interchangeable.

The airman who worked on that airplane, who was probably looking a mule in the fanny 6 months before he was working on those lines——

Mr. PARRIS. And 6 months afterwards——

General YEAGER. Yes, sir.

He puts them on wrong. It is Murphy's Law.

When we look at the design of a new aircraft we try to simplify it. If something can be hooked up wrong, it will be hooked up wrong.

We have to design systems in our aircraft so there is no way to make a maintenance error on it.

We have to design it so all of the life support equipment, ejection seats and all, are tied in with and compatible with the mission of the

aircraft. So the average individual can work on it, fly it, and maintain it.

This is systems safety. Anything that you have uncovered in the past, in an old straight-wing F–84 or 104, where a system caused an accident because of its design, then we redesign it so that it is compatible with the aircraft. You can't make a mistake with it. This is what we mean by systems safety.

Mr. PARRIS. That is basically in the maintenance and design phase rather than in the operational phase?

General YEAGER. It goes all the way through the aircraft into the operational phase: The weapons systems that are aboard, the switches, switchology—you remember the mistakes you used to make hitting the wrong switch, losing a drop tank or bomb on an F–84. Now, the systems are designed so that can't happen.

The safety people are getting more and more into this field. When we talk about trying to shred out safety research and development, it means let's go the way we are going today. The engineers that design this system are safety oriented.

Mr. PARRIS. Thank you very much.

Mr. HECHLER. Mr. Milford?

Mr. MILFORD. I just have to ask one more question, Colonel: Out of all of the airplanes you have known, can you truly say that there are many of them better than our P–51?

General YEAGER. If they ask you to haul a load of manure some place you don't take a sports car to do it with. It is the mission of the aircraft. I would say the best airplane that I have ever flown, the most pleasurable airplane, is the F–5.

Mr. PARRIS. Did you ever fly a Great Lakes trainer?

General YEAGER. Yes, sir; I have had that privilege.

Mr. PARRIS. That is the best one I have ever flown. I have got one. You can fly it any time you would like.

Mr. HECHLER. Mr. Wells?

Mr. WELLS. General Yeager, you mentioned in your statement a number of problems that might be susceptible to some kind of a national coordinated basis, rather than some grand overall management plan.

Yet there might be problems that could be looked at, such as lightning strike, and perhaps not now, but perhaps you could give us your thoughts subsequently for the record as to some ideas as to how we might go about setting up such a system for across-the-board examination of specific problems on some kind of systematic basis, rather than waiting until they somehow emerge.

I think the example of the F–4 spin problem is one of these that emerged finally, after a number of years, and as I recall an enormous number of airplanes, approaching 100 airplanes were involved, before it finally became obvious to the Department of Defense that something was drastically wrong and a crash program was started to find out what was going on; whereas, if there had been some kind of way of identifying the problem earlier, perhaps the solutions might have been achieved earlier.

As I recall, NASA was brought into the problem on the F–4 rather late in the process. What I am really getting at is how do we some-

how identify these problems earlier and get the attention they ought to have before we have major catastrophies.

General YEAGER. In the case of the F–4, whether people come in late or early, there is no way you can recover an F–4 from a spin without a major redesign of the aircraft.

We, in the safety business, and I probably take a narrow view of this, Mr. Wells, normally you would ask me in the Air Force—I am in charge of the safety program—how much of your effort is devoted to R. & D. and safety? Off the top of my hat, I would say 30 percent.

You say, give me 30 percent of your manpower positions. We will pool that with the Navy, Army, so you make up your own organization.

I lost that capability. If you lok around today. I suppose Chuck Miller, of the NTSB, knows more about what is going on in research and safety than any other individual I know of.

If we could get an organization together made up of people like him, or, let us say, we put it under the control of the NTSB, which would have to be expanded—where are you going to get the people to expand it?

That bothers me. You get people like Chuck Miller; he is aware of what is going on in research and safety. I would like to have a catalog of what is being done in all of those areas. If I can get the data to apply to my safety program in the Air Force that would be the clean and effective way of going about it.

Mr. WELLS. That is exactly the kind of advice we are looking for.

Thank you, Mr. Chairman.

Mr. HECHLER. Thank you, Mr. Wells.

Any further questions by members of the committee?

Mr. MILFORD. No, sir.

Mr. HECHLER. Without objection, I would like to put General Yeager's official biography into the record.

[A biographical sketch of General Yeager follows:]

BRIG. GEN. CHARLES E. YEAGER

Brigadier General Charles E. (Chuck) Yeager is the Director of Aerospace Safety for the Air Force Inspection and Safety Center, a separate operating agency located at Norton Air Force Base, San Bernardino, Calif. The Center is a function of the Air Force Inspector General's office in the Pentagon.

General Yeager became the Director on June 1, 1973 after having reported to the Center on March 16, 1973 from Islamabad, Pakistan where he had been the United States Defense Representative to the Pakistani government.

The general has worldwide supervisory responsibility for the development and implementation of policies, standards, and procedures for Air Force flight, ground, missile, space, explosives, and system safety engineering programs. His directorate's mission is to help conserve the nation's aerospace resources by preventing and reducing accidents through global programs of safety education, accident investigation and analysis, human factors research, and safety inspections.

He was born February 13, 1923 in Myra, W. Va., and is a graduate of Hamlin, W. Va., High School. He enlisted in the Army Air Corps in September 1941, was accepted for pilot training under the flying sergeant program in July 1942, and received his pilot wings and appointment as a flight officer in March 1943 at Luke Field, Ariz.

During World War II, General Yeager distinguished himself in aerial combat over France and Germany during the years 1943–1945 by shooting down 13 enemy aircraft, five on one mission, including one of Germany's first jet fighters. On March 5, 1944 he was shot down over German-occupied France but escaped capture when elements of the French Marquis helped him to reach the safety of the Spanish border.

He returned to the United States in February 1945 to attend the instructor pilot course after which he served as an instructor pilot. In July 1945 he went to Wright Field, Ohio, where he received his first taste of experimental flight test work. His assignment there led to his selection as pilot of the nation's first research rocket aircraft, the Bell X–1 at Edwards Air Force Base, Calif., where he served from 1949 to 1954.

General Yeager made world history on October 14, 1947, when he became the first man to fly faster than the speed of sound. During his nine-year assignment as the nation's leading test pilot, he also became the first man to fly more than twice the speed of sound, flying the Bell X–1A on December 12, 1953. During 1952 he attended the Air Command and Staff School.

He returned to Europe in October 1954 and became Commander of the 417th Fighter Squadron at Hahn Air Base, Germany in May 1955. He remained in that position when his squadron was reassigned to Toul-Rosieres Air Base, France in April 1956.

Upon his return to the United States in September 1957, he was assigned to the 413th Fighter Wing at George Air Force Base, Calif., and in April 1958 became Commander of the 1st Fighter Squadron. In April 1958 he went with the 1st Tactical Fighter Squadron to Moron Air Base, Spain, where he remained until November 1958. He returned to George Air Force Base with the same unit which was later redesignated the 306th Tactical Fighter Squadron.

General Yeager was graduated from the Air War College, Maxwell Air Force Base, Ala., in June 1961 and became Commandant of the Aerospace Research Pilot School, where all military astronauts are trained, in July 1962.

In July 1966 he assumed command of the 405th Fighter Wing at Clark Air Base, Republic of the Philippines. While Commander of the 405th Fighter Wing, he flew 127 missions in South Vietnam.

General Yeager assumed command of the 4th Tactical Fighter Wing at Seymour Johnson Air Force Base, N.C., in February 1968 and went with the wing to Korea during the Pueblo crisis. In July 1969 he became Vice Commander, 17th Air Force, with headquarters at Ramstein Air Base, Germany.

His military decorations include the Distinguished Service Medal, Silver Star with one oak leaf cluster (OLC), Legion of Merit with one OLC, Distinguished Flying Cross with two OLCs, Bronze Star Medal with "V" device, Air Medal with 10 OLCs, Air Force Commendation Medal, and Purple Heart. He is a command pilot and has flown more than 10,000 hours in 155 different types of military aircraft.

General Yeager's exploits have made him one of America's most honored fliers of the century. He has received all of this country's top awards for permanent contributions to the history of flight, including the Collier and MacKay Trophies in 1948 and the Harmon International Trophy in 1954. On December 14, 1973 at the age of 50, he became the first military person on active duty as well as the youngest person ever to be enshrined in the Aviation Hall of Fame at Dayton, Ohio.

General Yeager was awarded an honorary doctor of science degree from West Virginia University in 1948 and an honorary doctor of science degree from Marshall University of Huntington, W.Va., in 1969.

General Yeager is married to the former Glennis Faye Dickhouse of Grass Valley, Calif., and they reside in quarters at Norton Air Force Base. They have two sons, Donald C. and Michael D. Yeager; and two daughters, Mrs. Sharon C. (Steven) Wren and Susan F. Yeager. They also have two grandchildren.

Mr. HECHLER. It is so studded with feats and accomplishments, that I won't go into it in full detail, but I should mention, of course, in addition to the trailblazing flight of October 14, 1947, General Yeager has received all of this country's top awards for permanent contributions to the history of flight.

Many people in the field of aviation feel that the work that he did with the Bell X–1 and its successors is comparable to the development of the science of aviation, which was contributed by the flight of the Wright brothers.

He has been awarded the Collier and MacKay Trophies in 1948, Harmon International Trophy in 1954. On December 14, 1973, at the age of 50, he became the first military person on active duty, as well as

the youngest person ever to be enshrined in the Aviation Hall of Fame at Dayton, Ohio.

Up to this point, I have resisted the mention of the fact that next to the black diamonds in the mountains of West Virginia, Chuck Yeager is West Virginia's greatest resource.

Now, with the permission of the members of the committee, I am going to do something rather unusual this morning: I waive all of the rules of the committee, and I am going to ask General Yeager to come up to the table here, and to make such observations or comments as he cares to on the questions and testimony of other witnesses. Essentially our committee is interested in trying to develop a record here on how we can contribute toward improvement of aviation safety.

I might say, if any of the other witnesses care to share that privilege, I would also waive the rules, but you know, I always heard that in political science courses that committee chairmen had absolute prerogatives of seniority; so I will exercise them this morning.

General Yeager, if you will come up here, I would appreciate having you as a member of the committee this morning.

General YEAGER. Thank you, Mr. Chairman.

Mr. HECHLER. Our next witness this morning will be Comdr. M. L. Johnson, Chairman of the Joint Technical Coordinating Group, Department of Defense.

Commander Johnson, it is good to have you with us before the committee.

Do you have a prepared statement you would care to make?

Commander JOHNSON. Yes, sir, I do.

STATEMENT OF MERLIN L. JOHNSON COMMANDER, U.S. NAVY, CHAIRMAN, JOINT TECHNICAL COORDINATING GROUP ON AIRCRAFT SURVIVABILITY

Commander JOHNSON. Mr. Chairman, members of the committee, General-Colonel Yeager is going to be a hard act to follow.

Mr. MILFORD. Colonel-General.

Commander JOHNSON. Colonel-General; yes, sir. Being from the South, I agree with you.

Mr. Chairman, members of the committee, as Chairman of the Joint Technical Coordinating Group on Aircraft Survivability, it is indeed an honor for me to be here and I welcome your invitation to tell you about the operations, experience, and success of a joint group effort and program in line with the interests of this committee.

The Joint Technical Coordinating Group on Aircraft Survivability—JTCG/AS—experienced some growing pains and other difficulties, but we have developed into a creditable and productive organization. We have found that there are many advantages associated with a joint group, for example: Personnel and facilities can be utilized to their best advantage; costly duplication can be recognized and avoided; communication becomes easier and a free flow of technical information is timely and R. & D. efforts become synergistic; a focal point exists for coordinating, proposing, and conducting R. & D.; existing boundaries assume a much lower profile.

By having a recognized and formalized organization there is a cadre of talent and expertise available to assist the aero community.

The joint group recently completed the A–7/A–10 vulnerability assessment for D.D.T. & E. and the congressional hearing on those aircraft.

General Brown, then Chief of Staff for the U.S. Air Force, specifically requested the joint group to do this assessment to avoid any implication of parochialism or in-house favoritism, hence this adds the flavor of joint concurrence and professionalism.

We found that technology is not an entity unto itself. It requires a technological forecast and technological assessment to provide guidance and validate its application. Joint programs have a tendency to have these checks and balances built into them and helps preclude any one organization from becoming an empire of authority.

The joint group has the capability of seeing the whole forest while still being able to identify and look at the individual trees. It keeps the relative order of priorities in keeping with the objectives and goals, whereas uncontrolled or fractured efforts have a tendency to take the priority of the salesman or the pet project of that agency. A joint program has recognition because the entire community of experts and organizations have in some way blessed the objectives and goals of such a joint program.

There are also disadvantages: Frequently your delegated authority and responsibility is questioned or remains undefined; omnipotence can become a prevailing belief in the group; usurpation of parent agencies' authority, responsibility, and dollars can be attributed to your group.

It has been found that for a joint group to be effective, it must have four salient features: Authority, responsibility, permanent staff, dollars.

Fundamental reasons for the success of the JTCG/AS are:

a. It is formally chartered and supported by the Joint Logistics Commanders—JLC's:

1. The JLC's encourage active participation of R. & D. organizations under their command and make all facilities and personnel accessible to JTCG/AS.

2. The JLC's approve the JTCG/AS program plan and therefore provide a check and balance in the system.

3. The JTCG/AS is their organization doing a highly necessary job for them. It was not superimposed by an outside agency.

4. The Chairman has direct access to the JLC's.

b. A small, highly motivated, highly qualified permanent Central Office Staff is manned by personnel who are members of the chartering commands.

c. The overall plan is prepared and executed by personnel belonging to the participating commands.

d. All projects are conducted within or under contract to the R. & D. organizations belonging to the Joint Logistics Commanders.

e. Funds are provided to the Central office for the execution of the plan:

1. The power to control the flow of funds to the R. & D. organizations charged with the responsibility of performing the projects has enabled this Joint Group to insure that the actual conduct of the projects is done in a way that will support the overall goals of JTCG/AS and not be altered to support other programs.

2. The funding, though limited, has been sacrosanct and has allowed the execution of a well-coordinated integrated plan at a relatively constant level of effort. This minimized the impact of the JTCG/AS projects on existing, ongoing service programs and allowed the commanders of R. & D. organization to better plan for future requirements.

The creation and chartering of a joint Group takes time and patence. For example, the JTCG/AS took 3 years to develop and receive a charter. In 1968, Dr. John Foster, Director of Defense Research and Engineering, established the focal point for all aircraft survivability within D.D.R. & E. In an effort to get the group started and perform some urgently needed test and evaluation, the Group was funded by General Starbird of D.D.T. & E. for the initial 3 years of the program.

There is a program going on now until 1980, that will be funded by the services.

We had problems because we were new and using a new approach, but they were not insurmountable. We can influence but we cannot force compliance and our responsibilities are broadly defined in the charter. We have established our credentials to meet the services' requirements.

Change has become an American way of life that seems to be driven in some ways by technology advances. Organizations seem to respond to these advances rather than be managing them or guiding them.

Another problem I have always felt existed is the large gap between our R. & D. efforts and what I call "Application Engineering," that is: getting the results of R. & D. effort into proper use. A method is needed to overcome the "Not invented here," "We didn't originate it," or "It's not managed here or our responsibility" syndrome that exists. We have found that our joint efforts and programs help break down these barriers.

In the JTCG/AS we are conducting 38 separate and distinct technical programs concerned with improving aircraft survivability. We have over 150 individuals directly connected with this program that come from 20 different laboratories and represent all the military services, NASA and industry. The management tasks frequently appear to be overwhelming, but close coordination and communication resolve this task.

Communication and coordination is a relatively simple matter because all the experts in this discipline are participating closely in our group's programs. Frequent meetings encourage an interchange of ideas and programs, and a free flow of technology results. These meetings are more than just talk sessions or meetings of the clan because they are essential to the completion of funded joint efforts which comprise the heart of the triservice aircraft survivability program. Communications are therefore sanctioned on a formal and informal basis.

For example, JACG/AS is conducting at least 15 programs that have potential applications to both military and civil aircraft. I will discuss several of these programs. We are communicating with NASA and the FAA on these programs.

I found that an organizational upheaval was not necessary to establish a joint effort. I'm reminded of what was once attributed to Petronius, proconsul and consul of Bithynia.

We tried hard, but it seemed that every time we were beginning to form up into effective teams, we would be reorganized, I was to learn that later in life we tend to meet any new situation by reorganizing, and a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralization.

JTCG/AS PROGRAMS WITH CIVIL APPLICATION

TEAS	Title	Lab	Objective
5.1.1.7	Advanced firefighting agent	AFAPL	Develop an improved firefighting agent.
5.1.1.10	Void filler foams	NASA/NWC	Develop void filler foams and reticulated foams for fire prevention.
5.1.1.11	Hydraulic ram	NWC	Develop theory for predicting fluid pressures and hydraulic ram damage.
5.1.1.12	Airflow effects on fuel tank fires	AFFDL	Establish design principals to minimize airflow effects on fuel tank fires.
5.1.2.6	Small engine combustor damage	BRL	Minimize damage effects and perforation.
5.1.2.7	Large engine combustor damage	AFAPL/NAPTC	
5.1.2.9	Fan and turbine blade damage	NAPTC	Develop damage and performance criteria for material selection.

VIEWGRAPH 1

5.1.2.11	Improved bearing thermal environment.	BRL	Develop model to predict critical bearing failure criteria.
5.1.2.12	Transmission and drive train	BRL	Develop fail safe nonlubricated drive trains and transmissions.
5.1.2.14	Compartmented lubrication system	AFAPL	Develop compartmented system for turbine engines.
5.1.2.16	Engine bay fire prevention	NWC/FAA	Determine factors which contribute to ignition and sustinance of fire.
5.1.3.1	Extension of NASA transparent matls to aircraft canopies.	NASA	Tailor NASA matl to use as canopy with improved crash and fire resistance.
5.1.3.2	Improved transparent surfaces	NASA/AMRDL	Improve reliability, maintainability, and impact protection.
5.1.3.5	Damage tolerant wing structures	NWC	Examine conventional and composite matls to develop damage tolerant structures.
5.1.4.1	Backup flight control system	NAVAIR	Develop a minimum backup flight control system.

VIEWGRAPH 2

Gentlemen, there is a breakdown by program plan with the title, "Laboratory," doing it, along with the objective.

You can see here where there is a commonality, with civil aviation, particularly in the engine bay fire prevention.

We have been instrumental in development of the paint that is now in the C–10 engine bay.

There is an informal communications between us. There is no formalized line, Mr. Chairman.

I think also the back-up flight control is of prime interest for us.

Is there any question on this?

Mr. HECHLER. General Yeager?

General YEAGER. Is that the fly-by-wire system?

Commander JOHNSON. That is included.

That is not the only system in there, General.

Our joint effort did not require a new massive organization or reorganization to establish the group because it capitalizes on the talent and facilities of existing organizations. All it needed was a small working staff.

In conclusion, we found that our joint efforts served to solve the coordination problems, eliminate the fragmented efforts, and provide the cooperative approaches needed. Our technical research capabilities are excellent, but we established positive guidelines to enable us to focus

attention on critical problems. The key for our success was a unified approach which attacked common problems, provided coordinated solutions, and across-the-board application engineering.

Thank you, gentlemen.

Mr. HECHLER. Petronius is certainly using modern phraseology.

Commander JOHNSON. Yes, sir.

Mr. HECHLER. Reminds me of a story Senator Dirksen used to tell.

He would say, "This is sort of like the fellow that went into the restaurant and asked the waiter, 'What is the soup de jour today?'

"And the waiter said, 'Oxtail soup.'

"And the man then said, 'Must you go back that far?' "

You may proceed.

Commander JOHNSON. Thank you.

He got pretty far back in the soup list.

Thank you. I have concluded.

Mr. HECHLER. We have more pilots than professors in this committee this morning.

I have just been advised that our colleague from Massachusetts, Mr. Cronin, is also an accomplished licensed pilot, flies back and forth to his district all the time.

Mr. CRONIN. Licensed doesn't mean accomplished, Mr. Chairman.

Mr. HECHLER. Thank you. That's right.

General YEAGER. You had better talk to the FAA about that.

Mr. HECHLER. Mr. Milford?

Mr. MILFORD. I have no questions.

Mr. HECHLER. Mr. Cronin?

Mr. CRONIN. Commander, what do you think some of the payoffs have been and are going to be from the program that you are sharing?

Commander JOHNSON. I think we are really beginning to see one of the first and foremost payoffs that I have found very gratifying and that is the interest from the users.

The problems of survivability in combat have always been there. It is the method of doing something about it that they seem to like.

They can see not only solving today's problem, but a projected program looking at what we might anticipate in future problems.

This may be the laser threat, sir. Over all and above the advantages, I cited earlier, one of the things that comes to mind is that over 50 percent of the crash fatalities in helicopters were attributed to fires.

When the Army developed the crash-worthy fuel system for the Huey, there has not been one thermal fatality in helicopter crashes since then.

There are other payoffs, sir, like establishing common terminology, between various engineering disciplines.

This helps in the engineering communities and appears in the contracts.

This assists us in many ways.

All the reporting I require is documented and this insures a much wider distribution of the reports, rather than the reports going to the initiating agency and someone's file cabinet.

I have always requested and insured that all of my engineers include assumptions in their assessments so that the rest of the world will know what they are talking about.

I tried to standardize testing. Laboratory testing of a nonflammable material with a bunsen burner, may not burn, but when you burn

them in their environment and they burn instantaneously. This is not valid testing.

I would like this for the record and, if I could, read the summary of this report to you, Mr. Chairman. This is a report from U.S. Army Foreign Science and Technology Center on fire safety aspects of polymeric materials, dated April 1, 1974.

Mr. HECHLER. How long is it?

Commander JOHNSON. It is just one page.

Mr. HECHLER. Fine. Without objection, it will be included.

Commander JOHNSON. Thank you, sir.

The combustion of organic polymeric materials presents serious fire, smoke, and toxic-vapor hazards.

The growing use of these materials in all segments of our society has resulted in a heightened concern for the safety of human life and property.

Scientific solutions to the problem rest on improving present fire, smoke, and toxic-vapor testing methods.

These solutions, coupled with a fuller understanding of the dynamics of burning, will lead to the development of organic materials that, as a result of composition and design, pose fewer and less severe combustion hazards.

At this time, the technically advanced nations do not possess the necessary technology to accomplish this end.

Nevertheless, scientists in these countries realize the situation and are striving to remedy it.

Analysis of foreign efforts indicates that they coincide, both in scope and intensity, with those of the United States.

The stated deficiencies of current fire, smoke, and toxic-vapor testing methods have been realized by all concerned. It appears that the remedy should involve a research approach to develop scientifically sound and reliable tests that can predict the behavior of a material in an actual fire.

The standardization of reliable tests will follow, and this standardization will be most effective if it eventually attains international recognition.

This, of course, necessitates worldwide cooperation, which at this time is only just beginning.

A complete understanding of the dynamics of fire also must include a research approach and lead to the ability to predict the fire-hazard problems posed by organic materials.

This contribution would effectually lead to an improvement of material design and composition.

Revisions of material consistency and design certainly have to be based on research, technology, and economic considerations.

Primarily, because of this relative cheapness, the current reliance on conventional polymers rendered fire-resistant by which the use of additives probably will continue, but the added smoke and toxic-vapor hazards they pose must be relieved.

A subjective aspect of fire safety that thus far has not been mentioned is the need for unambiguous legislation and mandatory enforcement of regulations or codes that govern the use of all types of organic materials in civilian as well as military items.

This aspect is obvious, but nonetheless may be the most difficult to obtain.

I would like to have that in the record.

Mr. HECHLER. Yes.

Mr. CRONIN. What are you quoting from?

Commander JOHNSON. This is any Army technology report concerning fire-safety aspects of polymeric materials.

Mr. CRONIN. What is the date?

Commander JOHNSON. The date of publication is April 1, 1974, and the information cutoff date, sir, was October 31, 1973.

Mr. CRONIN. I would suggest whoever wrote that should do a couple of things:

The first thing they should do is see the British Fire Fighting College, which is built on a former Air Force base, and the second thing they should do is read the testimony that came before this committee in setting up a firefighting college in the United States of America.

A lot of this information is being handled. In fact, much better by Great Britain than by the United States at this stage of the game.

But I couldn't agree more with the conclusions of the necessity to do more in these areas.

Over and above the question of just this matter of just fire, could you just share with us some thoughts for a minute on how you would see some of these things that you have been able to do in the military which are passed over to the civilian?

I saw the slide at the end there, but I mean over and above the example of, say, the Huey fuel cell which is I think an excellent example of the type of thing that should be put into the system development of an aircraft from beginning to end. More than just the question of transferring it over to the civilian transportation aspect is the transfer into the general aviation aircraft as well.

Could you just give us some ideas of the types of things that you think could be transferred over the next, say, 10 years to improve the safety of both the airliner and the general-aviation type aircraft?

Commander JOHNSON. Sir, in regard to material types of things?

Mr. CRONIN. Any of them.

Commander JOHNSON. I am concerned on any crash of a civilian airline.

We generally consider the pilot, copilot, and engineer are going to be expended. Consequently, the stewardesses are back in the rear of the airplane in charge. They are given the worst seats possible, except for one, and that is the back seat up forward. The restraining straps are not the best. The Army developed a 16–G seat for their helicopters for impact. I think there is a tremendous opportunity for exchange of technology there.

I was involved in the rescue of 23 people out in the Caribbean that crashed in the ocean. It was amazing. Not one liferaft came out. They were all hanging on the ground escape chute.

Fortunately, the engineer kept a cool head and was able to keep control of the people.

I was able to recover one of the cushions used for flotation gear.

You can imagine those people trying to get out the escape door with a cushion.

I found out a man of my size floats 6 feet under water using the cushion as flotation gear.

Generally, people in the water are injured or stunned. You need something better than a seat cushion.

The toxic fumes are very possible in our present-day aircraft, we have done much work on toxicity. The toilets, I think, in the aircraft are very susceptible to fire.

We are constantly questioned about extinguishing fire. I think this is historical thinking. I would like to say, "Let's prevent the fire." Then if we are going to have a fire let's get the best firefighting agent in to do the job and advise the pilot of the situation so he may take some remedial action.

One of the things I would like to mention, I think these types of joint efforts and cross polarization creates, not stymies creatively. It gives incentive to the engineers.

I have seen this happen, where somebody with an idea didn't have the facilities at his particular lab, but somebody else did.

I saw a cooperative effort go into creativity this way: I think it stimulates it.

I have established a data bank on all aircraft survivability, work that has been done in the past, all that is being done presently, and all of it that we have projected to do in the future.

All of this is also collated with combat data. We can't live in the isolation of empirical testing. We relate it to real world situations.

The data put in there is put in by experts in the communities. They are now able to punch a button, dial it on the phone. If you want design information for the designer, then it comes back in his language, and he is not overcome with a ream of paper.

If it is an engineer, his code goes in and back to him.

This is presently in operation. I anticipate we will complete this setup by fiscal year 1977. Does that answer your question, sir?

Mr. CRONIN. Very well.

No further questions.

Mr. HECHLER. Mr. Parris?

Mr. PARRIS. One question, very briefly.

This is my day for apologies. I have three subcommittees going on at the same time. I have been playing musical chairs this morning.

On the first page of your statement, Commander, you talk about focal point for R. & D.

On page 5, you refer to a number of individuals that come from over 20 different laboratories representing all military services, NASA, industry, et cetera.

Do I understand from your observation on the first page that this R. & D. is not exclusively military utilization?

This is more or less an application of the question Mr. Cronin asked.

Commander JOHNSON. Yes.

Mr. PARRIS. Is this R. & D. across the board or is this substantially, if not exclusively, military?

Commander JOHNSON. It is primarily for the military. We are chartered by JLC/S. The best polymer chemist is Dr. Parker with NASA.

Dr. Parker is chairman of one of the subject groups. He works strongly with the people there.

There are the informal communications.

Mr. PARRIS. Hopefully, the efforts that have been made by NASA, and FAA, in fire retardation and prevention are coordinated into and shared with your group; is that correct, sir?

Commander JOHNSON. Yes, sir.

Mr. PARRIS. Thank you.

Commander JOHNSON. One thing I would like to respond to that: you can have all the R. & D. and technology in the world, but until you get that into a viable specification that you can validate and that you can see it in the contract, I am sorry, you probably miss an awful lot of application in engineering.

Mr. PARRIS. But you call here application engineering.

Commander JOHNSON. Yes, sir; that is what I call it.

I believe, Mr. Chairman, that a few of these comments might have been misleading. There is no formalized method as a general point for technology transfer to civil organizations, other than NASA.

I would like to make a few comments, if I may, that I have read recently in the publications from the committee, and heard in regard to the safety problem and joint efforts.

It is a very vast problem, involving pilot error, materials, ground control, et cetera.

The joint program is not a panacea, and people shouldn't try to make it do everything.

We established the joint group. I selected a few key people to identify the various problems, and to establish the priorities based upon what we can do and not what we should do.

This helped us establish our short-range, high-payoff efforts. This made our credibilities, while we set up mid-range objectives and our long-range goals.

As an example, the pilot response problem in emergency is different than our materials fire problem, but they must interface, if it requires the pilot to initiate an action.

First, I wanted to reduce the potential emergencies for the pilot. Then we will increase the emphasis on the pilot response problem as the program progresses.

We sought solutions to these problems and we felt we could answer, as we learned how to do business.

I have stopped several projects that didn't prove out. I considered them successful because we would not go down that road again unless there is a major technology breakthrough.

I am concerned about putting the fire out, but what actually I am concerned about is preventing it.

This type of approach has allowed us to try to get ahead of the game, rather than being responsive, or the catch-up type of effort.

Unfortunately, I have felt in the past that our safety and survivability efforts have been primarily responsive to some catastrophic incident or public outrage. I am very heartened and very encouraged by this committee's recognition of the problem, foresight and effort in seeking the resolution.

God bless you, gentleman, and I pray for your success.

Mr. HECHLER. General Yeager?

General YEAGER. Moose, I would like to ask you, the title and the mission of your organization is aircraft survivability. I would like to

ask what percentage of your effort are you devoting to fire damage from combat and actual systems design of safety engineering?

Commander JOHNSON. Considerable, General.

The major cause of our losses in Southeast Asia was by fires. We found our aircraft held together structurally. We were able to get out.

A fire was initiated from some source. It was well over some 60 percent which is in keeping with the National Transportation Safety Board statistics on civil aircraft losses. This is the way we relate to the civilian losses, it doesn't matter what causes the fire once you have the fire.

Captain Rivers, a POW with 7½ years in Hanoi-Hilton, was hit by AAA gunfire and the airplane held together structurally. He had the beach in sight. The resuce was there and the tail burned off.

General YEAGER. The initial solution is not to get in a war, to start with, isn't it?

Commander JOHNSON. Yes, sir; but that is political. We are talking R. & D.

General YEAGER. That is political.

Mr. HECHLER. Mr. Milford?

Mr. MILFORD. Just one question, concerning your remarks on common technology.

Have you developed a glossary?

Commandor JOHNSON. Yes, sir.

Mr. MILFORD. You wouldn't give an old flying buddy a copy; would you?

Commander JOHNSON. Yes, sir.

Mr. HECHLER. Any further questions by members of the committee?

[No response.]

Mr. HECHLER. I would assume—I am going to use your Petronius illustration—I would assume it could be freely translated also to apply to the necessity of keeping incumbent Congressmen.

I will use it for that purpose. Thank you.

Mr. PARRIS. I thought it applied to the Bolling Report.

Mr. HECHLER. Thank you, Commander Johnson.

Our next witness is the Honorable Isabel A. Burgess, Acting Chairman of the National Transportation Safety Board.

We are very pleased to welcome you to the committee, Ms. Burgess.

Ms. BURGESS. I am very glad to be here.

Mr. HECHLER. Do you have any associates that you care to identify?

Ms. BURGESS. Yes. I have three associates with me, as you can see, Mr. Hechler.

I have Mr. Roscoe, who is our acting head of the Bureau of Aviation Safety at this point; Mr. Puls, who is our legal counsel; and Mr. Carroll, who is also with the Bureau of Aviation Safety, and who has participated in many of these joint programs.

Mr. HECHLER. Welcome all, and you may proceed, Ms. Burgess.

Ms. BURGESS. I have a statement which I wish to present first.

Mr. HECHLER. Do you care to summarize it?

Ms. BURGESS. It is not very long.

Mr. HECHLER. You may proceed as you care to.

Ms. BURGESS. I think it brings up some points that may be pertinent here.

STATEMENT OF HON. ISABEL A. BURGESS ACTING CHAIRMAN, NATIONAL TRANSPORTATION SAFETY BOARD

Ms. BURGESS. The National Transportation Safety Board appreciates the opportunity to participate in the subcommittee's continuation of the series of hearings on the general subject of aeronautical research and development and specifically on the problems of aviation safety research and development which you are considering today.

I am Isabel A. Burgess, Acting Chairman of the Safety Board.

With me are Marion F. Roscoe, Acting Director of the Bureau of Aviation Safety; John J. Carroll, Assistant to the Director of the Bureau; and Fritz L. Puls, General Counsel to the Safety Board.

The Safety Board was created by the Congress when it passed the Department of Transportation Act of 1966 which simultaneously established the Department of Transportation. The Board is an autonomous agency within the Department and is composed of five members appointed by the President and confirmed by the Senate. The Board has been in operation since April 1967.

The Safety Board occupies a unique position in the field of aviation safety, being responsible for the determination of the probable cause of all U.S. civil aviation accidents. Our investigative work involves the Safety Board in every facet of a complex field including design, manufacture, operations, performance, and maintenance.

The Safety Board's activities also include special studies into critical general aviation and air carrier safety problem areas—midair collisions, crash safety, approach and landing accidents, and many more. Most important, however, are the findings and corrective recommendations of the Board which are directed to preventing recurrences.

Our impact, therefore, on the industry, the academic world, and the various agencies involved in safety R. & D. is widespread. Our recommendations, while not mandatory, continuously identify to the research community those subjects and hazards which demand remedial treatment.

However, it should be noted that the Safety Board does not conduct any R. & D. We do not have the facilities, the personnel or the resources to undertake any such activity and, in fact, have been specifically reminded in public hearings before the House Appropriations Subcommittee on Transportation that the congressional mandate to the Safety Board does not include undertaking research projects or research-related activities.

Therefore, in fulfilling the statutory responsibility to investigate accidents, to determine probable cause, and to make recommendations to prevent recurrence of such accidents, the Safety Board depends for support upon agencies with R. & D. responsibilities and capabilities.

In addition to receiving support from agencies in our accident investigation responsibilities, we participate in an advisory capacity in the National Aeronautics and Space Administration and Federal Aviation Administration Coordinating Committee, the Joint Services Aviation Conference, the National Aviation System Planning Review Conference, and several other technical committees of the Society of Automotive Engineers and NASA.

The Safety Board's work has significant impact on industry and private aviation safety R. & D. efforts. All safety problems identified through our accident investigation are reported and may become the subject of extensive treatment in many sectors.

Except for those safety recommendations calling for definitive studies by a specific agency, programs are initiated as the need and criticality become known. Our role is considered by many to be basic and vital to air safety research.

Speaking specifically to the Safety Board's contributions which have led to R. & D. undertakings, a number of aviation accident investigations resulted in recommendations to the FAA which require substantial research and research facilities for completion, for example: the development of standards for collision avoidance systems; the resolution of vortex turbulence problems in airport traffic areas; the impact of critical meteorological conditions; the detection of en route clear air turbulence; standardization of traffic flow procedures at uncontrolled airports; and airport terminal control.

Extensive crash and safety R. & D. was undertaken by FAA, the Department of Defense, NASA, and the aircraft industry as a result of the Safety Board recommendations resulting from our investigation of "survivable" accidents. Interagency and industry liaison, support, and cooperation at a high level in research of approach and landing accident prevention has been the result of the Safety Board's findings and recommendations developed from our investigation of many catastrophic accidents.

Statistics developed by the Safety Board from its computerized records of accidents also serve as an important source of information for Federal agencies, aviation manufacturers and others engaged in civil aviation R. & D. It is recognized that the Board's general aviation accident data bank and its investigative reports and files offer those involved in R. & D. programs a solid basis for identifying problems and for determining the scope and direction of R. & D activities.

In your subcommittee review with the appropriate agencies and nongovernment organizations, you may wish to address your attention to another aspect to research which involves its completion and also consider if there is a serious problem concerning when a research program should be terminated; and I add, is finally implemented.

The Safety Board is well aware that much remains to be accomplished in the improvement of the interchange of information in the aviation safety R. & D. field. With respect to this, we have reviewed our testimony presented to your subcommittee on January 20, 1972, and the Safety Board wishes to reiterate three points we believe are signally important to aviation safety R. & D.

1. Civil aviation R. & D. require Federal support when there is a significant public interest, such as safety, and when it is clear that private industry cannot or will not act independently.

2. Most of the research funds allocated to the area of safety should be oriented toward applied safety R. & D. since safety problems do not result from lack of knowledge but do result primarily from a lack of application of this knowledge.

3. Through the joint ventures of government and industry, significant results can be achieved in the application of safety R. & D.

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to safety problems. Such cooperation in the exchange of resources and knowledge can be most effective.

It is our hope that the subcommittee will, in its deliberations, give emphasis to these concepts as being vital to the progress and success of the R. & D. effort in aviation safety.

I would like to conclude with another basic point, in addition to those appearing in my prepared statement.

There is a continuing need for coordination of research among the agencies charged with Aviation Safety R. & D. in the Government. Also it must be recognized that there are substantially differing end products of such organizations.

FAA R. & D. programs are oriented essentially to their regulatory functions—establishment of minimum standards—and, in the case of their air traffic control function, system requirements.

NASA's more basic research relates more closely to technological advancement. The military R. & D. function is more directly related to applied "user requirements."

Because of this diversity arising from each agency performing in accordance with its own statutory responsibilities, and notwithstanding existing interagency coordination efforts, there still may exist a need for a central coordinating and information gathering mechanism within the Government.

We would recommend that the subcommittee, through this hearing, continue to give careful consideration to whether the existing coordination is adequate; if not, what alternatives should be pursued, including the designation of a focal point to coordinate and provide visibility of aviation safety R. & D. in the United States.

Effective coordination and communication are essential to assure the broadest possible application of new developments and findings—lending priority and emphasis to the effective solution of the most serious safety problems with which we are faced.

I hope these views will provide the subcommittee with a better understanding of the Safety Board's relationship to the Government's aviation safety research programs and the way in which we support, influence, and benefit from these activities.

This concludes my statement, Mr. Chairman. I thank you and the members of the subcommittee for inviting the Safety Board to participate in this important hearing today.

Mr. HECHLER. Thank you, Ms. Burgess. Mr. Milford?

Mr. MILFORD. Thank you, Mr. Chairman.

Ms. Burgess, I would like to get into an area of aviation safety that you are intimately familiar with, and that you work with daily.

That is accidents investigation. For purposes of this discussion, I would like to confine our attention to investigation of accidents in the jumbo jet category, the Boeing 747 or DC–10, for example.

Preliminary to the questions that I am going to ask, I would like to briefly go to a bit of background that will brief some of our members as to the procedures followed by the NTSB in investigating a major accident, similar to what I went through with General Yeager.

For the record, and for the benefit of the few who might not be familiar with your procedures, please make the horrible assumption that a jumbo jet suffers an accident involving fatalities.

If you would, please, describe briefly the actions NTSB would take from the time of accident, up to public hearing, including the various organizations that might get involved in it.

Ms. BURGESS. Mr. Milford, in answer, in response to your question, I will start by making the horrible assumption, as you say, and give you a basic rundown of what our operation would be.

However, because I have some very talented gentlemen with me who are also thoroughly familiar with it, if I overlook something, I will ask them to break in and add to it, so that you may have a complete record.

Mr. MILFORD. Yes.

Ms. BURGESS. When we first receive notification, in this case we receive notification of an accident of a 747, perhaps in the mountains of Colorado, in a remote area.

At that time, of course, the closest person in the field office would go out to secure the area, secure the wreckage.

In this case, he would be from the Denver field office. Then our investigation "Go team" of specialists—whose members rotate each week—proceed from Washington to the accident site. This team is composed of investigators and has been alerted by a duty officer who is the investigator-in-charge for the whole aircraft accident investigation. The NTSB is in charge of the total investigation.

Accompanying the investigator-in-charge will be specialists in structures, in systems, in powerplants, operations, air traffic control, weather, human factors, a person to get witness' statements, and another to get maintenance records. If there are particular needs other than that, we will send other specialists.

Mr. MILFORD. These are all NTSB employees?

Ms. BURGESS. Yes, all of them are.

A Board member always goes, for organizational purposes, to see that people have what they need and to be sure that everything is properly in hand.

Our investigator-in-charge will hold an organizational meeting soon after our group arrives. We also provide for participation of representatives from the company that manufactures the plane, from the company which owns and operates the plane, and from the union representing the pilot of the plane.

The FBI will be there if there are fatalities, not only to investigate possibilities of explosion or sabotage, but also to identify fatalities.

The representative of the airport, if there is an airport involved, would be there.

The engine manufacturer, if they think that it might involve an engine problem will be there, and a number of others, but there is no one there, according to our rules and regulations, who does not have a specific responsibility and a reason for being there.

Mr. MILFORD. Would you agree that the modern-day commercial airliner has become a massive and complex machine, with many complicated mechanical and electrical systems contained within it?

Ms. BURGESS. I think there is no question about that.

Mr. MILFORD. Would you also agree that the operation of a commercial airliner involves many detached operations and functions that are totally outside the confines of the aircraft, but that directly affect operation and safety of the aircraft and its passengers?

For example, air traffic control, navigation and landing aids, dispatching, fuel servicing, company- and Government-mandated operating procedures; all of these would affect it?

Ms. BURGESS. I think we would agree with that.

Mr. MILFORD. What I am trying to establish is the fact that an aircraft accident can result from any one of many factors, and that the factors are not necessarily confined to either the pilot or the immediate aircraft.

I am also trying to establish the fact that modern a jetliner is not in the same category as a family automobile.

Many of us are accustomed to think of an automobile, but, train, as being made by a manufacturer. We automatically look to that manufacturer to correct any defects or to be responsible for any loss that might be suffered as a result of the defects.

Now, if you could discuss a bit further the modern jumbo jet airliner, in the composite effort or would you agree it is the composite effort of numerous aerospace manufacturers, even though it might carry the name of Boeing, Douglas, or Lockheed, for example, the engines from Pratt and Whitney, hydraulic gears may be from Bendix Avionix, Collins, et cetera, but literally hundreds of separate items and systems are found on the aircraft.

While Boeing may be the original airframe designer for the 747, that company may actually manufacture actually less than 5 percent of the component parts and systems that are contained within the aircraft.

Am I generally correct?

Ms. BURGESS. I am not sure about the 5 percent, but I would agree with you otherwise.

Mr. MILFORD. I am not trying to be specific.

Ms. BURGESS. I think we would all agree with you.

Mr. MILFORD. Ms. Burgess, so that the record can be clear on a few specific points, I would like to submit some particular questions to elicit your opinion and comments on them.

For example, would you agree that the accident investigation personnel under the employment and control of NTSB do not really have the expertise, means or abilities to investigate a major accident alone?

I am talking about using your hired people alone. Instead, NTSB must depend on personnel, expertise, and cooperation of various aircraft and aircraft component manufacturers?

Ms. BURGESS. Mr. Milford, I would take exception to your statement that we do not have the expertise.

Obviously, we do have tremendous expertise, but because of the scope and size of many of these accidents, we are dependent upon outside help. We receive help not only from aircraft manufacturers and aircraft component manufacturers, but we also get help from NASA, from the Bureau of Standards, from NOA, from FBI, and many other Government agencies.

In fact, on occasion, we have had a great deal of help from the military.

Mr. MILFORD. I did not in any way wish to downgrade the abilities of NTSB. I have a high respect and could only be complimentary of that agency and the great work it has done.

The point I make, that I think is a very important one, is that the complexity of the problem and the complexity of the aircraft that it would cost the U.S. Government a fortune to maintain on staff all of the expertise needed to investigate?

Ms. BURGESS. I don't think it would be possible.

Mr. MILFORD. Would you agree, these various industrial teams that assist you and that you are in some degree dependent upon for determining causes of accidents have a very real conflict of interest during these investigations, or at least have a strong possibility of having their own conflict of interest?

You may direct that to your legal counsel, if you would like.

Ms. BURGESS. I will turn it over to legal counsel.

We discussed it earlier. He has participated in any number of accidents in which I have not held a hearing.

Mr. Puls, would you like to comment?

Mr. PULS. I would like to start off by making one point: I want to distinguish between investigations, per se, and the analytical process that goes on when we get the facts together.

Nobody participates in an analysis; only the Board's people do that.

There is no participation, although I know industry and ALPA have objected in the past for lack of participation.

I think there is a possibility of a conflict of interest, and how serious it is, is a little hard to tell at any point in time.

It is getting worse. I think we all sense this. Litigation has become a major problem; size of recoveries are astronomical.

This is big business. We would be naive to think if an airline is involved, or a manufacturer is involved, looking down the road at what lies ahead, conflicts may not occur.

But I think the people that work in the field on these things are still struck by the fact that people who represent these companies, understand they are there as individuals with expertise to help us. They are not there as spokesmen for their companies.

Now, just where we are at present is hard to tell. The potential is there, but I am always struck by the fact that they are very cooperative.

The ALPA, of course, participate to a great degree; they are not potential defendants. I think their participation is extremely helpful.

At the same time, we do see a growing tendency, for example, to have employees of a carrier or of FAA to submit statements to us, after being seen by counsel. If you put yourself in their position, it is not unusual.

I may be anticipating, but a major problem, when we look at impact of litigation on our activity, is the inhibition on the free flow of information involved. Whether it be getting the facts at the accident site; getting the facts after accidents; or getting carriers to communicate with one another on vital safety information, I think your question invites a very broad answer.

I mean it is a serious problem.

Mr. MILFORD. You were present in the committee room when General Yeager was testifying, and I asked him about the procedures followed by the military accident investigation boards.

Do you see any particular advantage to military system of holding all of these reports, work products, notes, everything, in confidentiality?

Mr. PULS. Yes, is a quick answer, though I don't know how long they are going to be able to preserve this system.

It is under attack in the courts constantly. The military, as I understand it, have gone so far as to have, in effect, two hearings, making part of it available to the public and the other part restricted.

The attorneys want both. It is a real problem with us. We have certain advantages the military don't have. We have a statute which provides that the reports of our Board may not be used nor are they admissible as evidence in litigation arising out of the accident.

Starting back in the early thirties, that was fairly broad.

Under that, we made public our reports but objected to their being used.

That is being whittled away by the courts. We are at the point in time where probably only the final report of the Board itself and that portion which goes to probable cause is protected.

Nothing else is. When you get to information we develop, this, again, I am afraid, invites a long answer.

Starting in the early 1950's, the CAB in performing this function, took the position they wouldn't provide any information coming out of an investigation. It was a pious hope. It didn't work.

The courts decided, since that agency and then the NTSB, moves in, takes over the investigation, keeps everybody else out, plaintiffs' attorneys, insurance adjusters, et cetera, that we had as an obligation to make known all facts we develop.

We do. Every fact that comes out of our investigation is a public document available to lawyers of this country.

As a matter of fact, they want the facts before the aircraft wreckage is cool. That is a problem. They don't want to wait.

We do make that available. We don't make available our analysis. We are going to be in court shortly on that issue, I am sure, because we are claiming it is an intra-agency communication.

Lawyers claim that it is not. What people seem to forget, we investigate accidents to determine cause for accidents prevention. We do not investigate accidents for attorneys.

As an attorney, I hate to say that. There seems to be an impression, since we are doing this with public funds, they are entitled to everything.

I think Mr. Roscoe can say better than I, if you want information, you are sometimes going to grant some kind of confidentiality.

We are practically at the position now where it is almost impossible to do this. There is a statute that provides that the Board or FAA, if in the public interest, needs something confidential, it may do so, but the Court of Appeals in the District of Columbia has just held it can no longer be used to protect FAA swap team reports, confidential reports of carriers for safety purposes.

How does that affect us?

In every carrier aircraft there is a cockpit voice recorder. It is one of the most valuable tools we have. Pilots don't particularly like it because everything they say on the flight deck is being recorded.

After the first accident that occurred in which we recovered these tapes we made a decision at the Board and by regulation that states we will only make available those pertinent portions. Anything pertinent to the accident we make available to the public. Anything else we don't. We have done this under the assumption that the statutes say we can do this.

Now, the court tells us the statute may no longer be usable. How long can we protect them?

This is where we are, Congressman. It is a problem that is not unique here. It is all over the world.

If you can spare me a couple of more minutes and let me explain: at a recent meeting in Montreal, with about 38 countries involved in accident investigation, the question was asked, for example: How many countries, in order to get the facts from a surviving captain and take his statement can keep it confidential in an effort to get all the information they need from him? Eight countries raised their hands. Canada and Russia were the two I remember.

We could not. We have no way of keeping it confidential, but put yourself on the other side, plaintiff's attorney, insurance attorney; you want all the information you can get.

General Yeager said this is the way they try their case.

Mr. MILFORD. To be sure I understand and what you are saying in my lay fashion, you are in effect saying we are asking manufacturers participating in these accidents to admit their liability when that admission may cost untold millions of dollars in liabilities to their companies, not even counting their company's reputation.

Mr. PULS. We certainly hope they will give us the facts, and if they are faced with the problem of giving us the facts, if that is going to expose them to vast liability in the future, the question answers itself.

Mr. MILFORD. Do you feel that litigation is needed or even possible in this field to try to make accident investigations totally confidential and as they were in the old CAB days, or as they are now in the military?

Mr. HECHLER. You mean legislation?

Mr. MILFORD. Legislation.

Mr. PULS. I will speak for myself on this: We discussed it at the Board, and I think are approaching the point where something is going to be required, but I question whether it should be so inclusive as to make everything produced at an investigation confidential.

I can imagine the country's trial lawyers reaction to that. It seems to me there may be certain critical items.

Mr. MILFORD. I am not as interested in the welfare of the lawyer as I am in the safety of the people who ride the airplanes.

Mr. PULS. To do the job better, we will require protection for some of the material we develop.

And either that, or there is always the possibility of "no fault" legislation. It takes the accident investigation of aircraft out of the litigation field and you go to a domestic Warsaw approach, something of that type. That is one possibility, I suppose.

Mr. MILFORD. If we projected this onto its ultimate conclusion, it would appear that if a jumbo jet should leave Dulles tomorrow and crash in the mountains of Colorado, as we mentioned, that there is a distinct possibility or even a reasonable probability that neither the

American public or the aviation industry would ever really know the reason why.

Ms. BURGESS. I couldn't agree or disagree with that, because I would tend to disagree with you, because it seems to me with our modern-day expertise, in accident investigation the sophisticated equipment we have to work with, that we will find the source of the accident or the cause of the accident.

Now, perhaps Mr. Roscoe would like to speak to this.

Mr. ROSCOE. I would be reasonably confident that we would find the cause of the accident, or at least, if we did not, that we would narrow the scope of the causal area sufficiently to identify those events in the causal sequence that should be safeguarded to forestall the recurrence of that type of accident.

Now, I can't say with 100 percent certainty that the real cause would be found.

There are certain things in the realm of flight operations involving the individual that are very difficult to account for, but I think from the standpoint of investigative techniques, the tools that we have today for investigation, such as the flight data and cockpit voice recorders, have enabled us to determine what was happening to that aircraft at the time of the accident. We have been able to locate and recover these recorders under some very adverse circumstances. The information obtained has been very beneficial.

I would be reasonably certain we could find at least from the accident prevention standpoint sufficient information to satisfy the public to the extent that a similar accident need not recur.

Mr. MILFORD. Mr. Chairman, due to the nature of the questions I have been asking, I would appreciate the privilege of making a short statement to the effect that I do not in any way want to infer that there is any type of danger in flying a modern day jet, or any jet we have in the air.

One of the reasons why flying is the safest means of travel is the type of interchange you have seen here.

This industry has always gone to extremes, to be safety oriented, and to this day I don't care whether you are flying a Cessna 150 or a jumbo jet, the most dangerous part about flying is still driving to the airport.

Mr. HECHLER. Thank you, Mr. Milford. Mr. Pickle?

Mr. PICKLE. Mr. Chairman, I would like to ask the panel some general questions relative to policy.

Do you look into matters of safety or accident only when an accident has occurred, when it has occurred?

Ms. BURGESS. No, Mr. Pickle. We do not.

We obviously do look into the matter at that time, but we also find through our accident investigations sometimes a recurring type of accident, for example, short takeoff and landings, for which we have had special seminars and conducted special studies to obtain additional information.

Mr. PICKLE. Are you requested by various agencies, FAA in particular, to comment on not only a crash but accidents of a various nature which you have reference to?

Ms. BURGESS. We do.

Mr. Carroll has been more involved in this.

Mr. CARROLL. Yes, sir.

Mr. PICKLE. Do you want—until you are generally requested for comment by CAB or FAA, or some agency, or do you make your own investigation and forward your observation to them?

Mr. CARROLL. No, sir. We have an ongoing program to evaluate the most critical safety problem areas as they are identified to us.

Mr. PICKLE. When they are identified, you express yourself from a safety standpoint to the agency concerned?

Mr. CARROLL. Yes sir, and also to the industry and the aviation community.

Ms. BURGESS. Mr. Pickle, you are speaking of the recommendations?

Mr. PICKLE. Findings and recommendations.

Ms. BURGESS. A formal recommendation, to whomever?

Mr. PICKLE. I would assume if your organization reads or hears or is notified that some element of, some question of safety exists with a particular aircraft, for instance, that you wouldn't wait until that aircraft crashed, but you would express yourself to the agency concerned. You have a group working on that.

Ms. BURGESS. Immediately.

Mr. PICKLE. Let me ask more specifically with reference to the DC–10; did you express yourself on the cargo door problem?

Mr. CARROLL. Yes, sir.

Mr. PICKLE. To whom?

Mr. CARROLL. In the issuance of our accident report, on the American Airlines accident that preceded this, that it was later characterized as virtually a carbon copy in the case of the Turkish DC–10 in Paris, we had issued our findings relating to the failure that occurred on the American accident, and issued recommendations: one of which was to preclude the possibility of this cargo door becoming unlatched in the future and the other being to call for modifications to the aircraft cabin floor that would provide for pressure relief in the event of an explosive decompression.

Mr. PICKLE. Did you make that recommendation for modification to FAA?

Mr. CARROLL. Yes.

Mr. PICKLE. Did the FAA act on it?

Mr. CARROLL. This was the subject of very extensive hearings, sir, in both the House and the Senate, and it is a very complex situation.

Yes, to a certain extent, they did. There is a question as to whether the form in which the matter was treated was adequate.

Mr. PICKLE. You and I know that several months were involved in both investigations, together with recommendation and follow-through on action.

I don't know that it had definitely been resolved yet or what steps have been taken, but after you made your recommendation, was any action made on it?

Was any action taken on it?

Ms. BURGESS. Mr. Pickle, you are talking about followup after we made our recommendations.

Actually, you may be interested to know that I did go to the scene of the American accident in Detroit. I must say I was shocked at the damage which was done to the floor, by the flow control cables of that big plane simply through the loss of the door.

The Board made recommendations to the FAA, to require that they have a fix to prevent such a catastrophe from happening again. Actually our people talked to the FAA to find out what had been done, and found that two or three service bulletins had been issued. We had assumed from the fact that these had been issued that the situation had been corrected.

Mr. PICKLE. I think we would admit that there were some bulletins issued, but not an airworthiness certificate.

Ms. BURGESS. That's right.

Mr. PICKLE. I am trying to find out, when a problem raises itself, who takes action to see that it is corrected, or that it is resolved regardless of who may be right or wrong?

In your case, you made a finding or you made a report.

Now, that was the end of it as far as you were concerned; is that correct?

Ms. BURGESS. It really was not the end of it. We did not follow it up to the extent that I feel we should have.

Mr. PICKLE. My question is, then: What I am trying to get at: Should we have legislation that tries to bring to a head questions which have been raised that perhaps are not settled and somebody ought to try to say, well, this must be done or not done.

Should we leave that to FAA in this case; should we leave it to the oversight committee, to the Congress, to whom?

Mr. PULS. We have been asked this question: should our recommendations be given the force of regulation practically for seven years and we have always said "no."

I think it is still a good answer, simply because what we recommend has to be done.

Now, we are not in the regulatory business, certification business.

I think our primary strength is one step removed as of this moment, the responsibility to take the action rests with the Administator of the FAA.

Mr. PICKLE. Do you think in all these cases, the FAA has properly been vigilant in the areas of safety?

Mr. PULS. That is a hard question to answer, because I think too many things go into the decisions.

We make a recommendation based on safety, almost purely.

We are not going to make a recommendation that is not feasible. FAA has to make a judgment based on other considerations.

There are things we suggested which he hasn't done. We disagreed, and went back. He has in effect told us, this can't be done for this reason, and perhaps he is right.

But the vast number are inbetween. I don't think the percentages are important, but he does take action.

Mr. PICKLE. You people representing your panel, are you satisfied that proper vigilance is being carried out on all these matters that have been raised such as the cargo door?

Ms. BURGESS. I think we have a human factor here. It is a very difficult question to answer.

Obviously, the cargo door is a very good example of where vigilance was not carried out to the extent to which it should have been.

In other areas, it is; it varies.

How can you really determine totally whether it is all black or all white? You can't.

Mr. HECHLER. If the gentleman will yield, maybe we ought to add another category.

We talked about pilot error. Maybe we ought to talk about administrative error.

Mr. PICKLE. The Chairman makes a good point. I can see the point.

I can understand why you are an investigatory agency rather than regulatory agency.

Yet, when serious questions are raised, I think we have to concern ourselves now, are they being resolved and has some action been taken on them.

Have you been asked to make a report or have you made a report on the DC–10 engine?

Ms. BURGESS. On the engine, yes.

Mr. PICKLE. To whom have you made that?

Ms. BURGESS. It goes to the manufacturer of the airplane; also goes to the manufacturer of the engines.

We all participated on that. That is the National Airline plane.

Mr. PICKLE. Yes, I don't want to be specific.

I am talking now about the problems raised with reference to icing or ingestion.

Have you made a specific recommendation to the FAA in this respect?

Ms. BURGESS. We are making one; are we not?

Mr. ROSCOE. This is on the recent occurrence, on the flight out of Miami.

Mr. PICKLE. I don't have reference to that. That would be a good example.

Have you been asked to make a report on that Miami flight?

Mr. ROSCOE. We have made a report on that.

We have made a recommendation.

Mr. PICKLE. Had you made a report prior to that time of other incidents involved with respect to the engine?

Ms. BURGESS. Yes, the one over Albuquerque. The final report does not have to be issued until after we have made our critical recommendations.

I believe there was a recommendation that went out immediately on that.

Mr. PICKLE. When you make these recommendations, and I recognize these are hard to clearly say: could or couldn't have happened; should or shouldn't have happened.

When you make that recommendation, and give it to the FAA, do you also give that same report to this committee, to any congressional committee?

Ms. BURGESS. If these are requests, or if the committee is on the mailing list, you get it automatically.

Otherwise, unless you really want it, we don't send it to you.

I should think you would get it automatically. There is tremendous dissemination of all reports.

Mr. PICKLE. Under the administrative setup we have, you make your report, or your recommendation, and then whether anything is done is left to the FAA?

Ms. BURGESS. That's correct. Copy goes to the Secretary of Transportation as well as to FAA.

We have taken a very sharp and critical look at the manner in which we handle the recommendations that we have made, and to their response.

And we are now establishing a totally independent division within our Bureau of Aviation Safety, which will handle and follow up only recommendations which we have made.

We also are establishing a similar organization in our general manager's office, as an overview, because we will also get into the Bureau of Surface Transportation Safety.

I would like to call to your attention: here is a copy of our last annual report to Congress.

Now, for the first time, we have listed in here all of our recommendations, the source of the recommendations and the response by the people who have received the recommendations.

You may find this very interesting.

Mr. PICKLE. Mr. Chairman, I would observe that we ought to seek better ways to make a determination of the questions which have been raised.

I sense that serious questions about safety may have been reported by this agency and others and if there is disagreement in the administrative setup, that it may become swallowed up.

I don't want to pass judgment. I make this reference because it is under investigation, but I am wondering if our own staff, or if we should set up in any way to see if these questions, once raised, have been resolved, or that some court has not been reached on them.

Otherwise, a bad situation could exist.

You may have made a report. That doesn't stop what has been taking place, if indeed it has been taking place erroneously.

I don't want to pass judgment if it has or hadn't.

I do say there is a question mark in some of these areas, and we can make our reports and we can exchange views, but when a plane goes down, that doesn't help anyone.

Mr. HECHLER. I appreciate the gentleman's comments.

Mr. MILFORD. Will the gentleman yield?

Mr. HECHLER. Yes.

Mr. MILFORD. The record may perhaps unfairly reflect on FAA and some of our other agencies .

I have had many years of work with the FAA, and I know for a fact any NSTB report which goes to FAA is closely considered, and that every effort is made to evaluate it completely and implement it and I also would point out in all fairness, that when you are dealing with a vehicle such as the DC–10 or any of our modern aircraft, that you are dealing with an extremely complex machine, wherein, later on, looking back and saying, hell, it was a simple door, a simple this, a simple that; it appears simple in retrospect, but in the development and in followup action, it is very complex.

Mr. PICKLE. Did the Chairman want me to yield to him?

Mr. HECHLER. Yes. I would like to make this observation, that Congress has to set its own house in order, too, because the primary responsibility for the type of questions that you are now raising, obviously, lies in the Committee on Interstate and Foreign Commerce.

Maybe, after the reorganization of Congress, as proposed by the Bolling Committee, and others, and this committee gets full jurisdiction, we may be able to grasp the nettle here.

I appreciate the fact you have raised these questions.

I think it is very, very important these questions be raised.

I think it is important also that we appreciate and realize the jurisdiction which the Science and Astronautics Committee has which does not extend into the type of jurisdiction over civil aviation, R. & D., and oversight, which Interstate and Foreign Commerce has. My colleague, the Honorable Harley O. Staggers, the Dean of the West Virginia delegation, chairs that committee.

Mr. PICKLE. Mr. Chairman, the Interstate and Foreign Commerce Committee is making an investigation of this particular plane, and in more than one category, and there are some members who are less than satisfied as to the findings and to the reports and the action taken.

But we still have it under investigation. It has not been settled. It is probably being pursued.

I raise the question. I am trying to find out where do you fit into this picture?

How can we bring these questions in the open?

I don't want to be as condescending as my friend from Texas about airworthiness of all of these planes.

Of course, they are complicated, but that is why we have you as a Board.

Ms. BURGESS. The very basic point is we investigate; we determine the probable cause, if we can, which we generally do.

We have made specific recommendations for the correction of that particular cargo door.

We hope these corrections will be made so it will never happen again.

I think you had a point; did you not?

Mr. PULS. I wanted to add one fact: All these recommendations are made public, and Mr. Pickle, that is of great assistance, believe me, it is.

And if we are responsible and do a good job, and I think we have been, I think our record is very good, there are exceptions where there are differences of opinions, but that is the fact.

Mr. PICKLE. Thank you, Mr. Chairman.

Mr. HECHLER. Thank you, Mr. Pickle.

Mr. CRONIN. I have two quick questions, Mr. Chairman.

First of all, Mrs. Burgess, I am a great admirer of your Board. I have read some of your reports, seen some of the accidents you have covered, and quite frankly, I think it is incredible the work that you have been able to do.

In one of our previous hearings, in 1972, the NTSB recommended increased R. & D. crash safety, NAV aids and human factors and now in your testimony, you stated that safety problems do not result from lack of knowledge, but do result from a lack of application of this knowledge, and I wonder if you could perhaps expand.

It somewhat ties into some of the other things that have been said; that more directly in the R. & D. aspect, how you run into roadblocks on the problems of applications, and to take a positive approach, how can we help you resolve some of those problems?

Ms. BURGESS. Well, this is of course an all-encompassing question, and it has many facets to it.

However, inasmuch as the question is primarily technical, I thought that I would ask both Mr. Roscoe and Mr. Carroll, in the light of their personal experience and knowledge.

Mine is general, overall. I can answer questions, but not as specifically as they can.

Mr. ROSCOE. The recommendations for research and development that I believe you are referring to were submitted to this committee to point out that there were a number of safety problem areas in each of these topical subjects that perhaps could be overcome by further R. & D.

As a matter of fact, the Board in its recommendation process has not issued any recommendations that specifically called for R. & D. in these areas.

However, the Board has issued recommendations in each of these areas, that have required perhaps or have stimulated further reserach and development in order to effect the recommendation.

Mr. CRONIN. By other government agencies, or private section, stimulated R. & D?

Mr. ROSCOE. Both, and I think that is about as much as I can comment on that particular question.

With regard to the issue of knowledge existing that perhaps has not had its full application to accident prevention, Mr. Carroll may have further comment.

Mr. CRONIN. In other words, you are providing stimulation to do it?

Mr. ROSCOE. Yes.

Mr. CRONIN. But not doing the actual work.

Mr. ROSCOE. That is correct.

Mr. CARROLL. Yes, Mr. Cronin.

You mentioned several of the areas in which we thought further R. & D. should be followed out.

Fortunately, we have a magnificent working arrangement with the staff of NASA. They look very carefully at the accident investigation reports and studies, special studies that we do; they look at the conclusions, findings and recommendations.

They look at our accident statistics. They come, visit with us and get a briefing, after almost every accident that we send a team out on.

When they come back, the people with whom we deal at staff level at NASA come over or we go over and discuss these things.

We meet with them regularly at the NASA-FAA coordinating Committee Meeting; and on occasion, they call upon the NTSB to give our views in certain safety problem areas.

As a result, NASA has picked up not only those areas in which we make specific recommendations, but they have come along and picked up the other areas of critical concern to us and have launched an aviation safety technology program covering each one of the safety areas that we have identified to them as being critical.

Of course, they have gone beyond that, into the areas that are beyond our purview: space, et cetera.

But I suppose as an example of where things might fall through the cracks, after a long series of approach and landing accidents that occurred in the recent time frame of the late winter of 1968 and the

early winter of 1969, there were many approach and landing accidents of major proportions that occurred in a very short period of time. That alarmed us considerably.

And among the recomendations that we made around the middle of January 1969, was one that concerned the asking for FAA and NASA, and the entire aviation community, including industry, to work on the development of an altitude alerting system, a ground proximity warning device, terrain avoidance system—whatever you want to call it.

Well, there is a recommendation that was made; it has been repeated with the conclusions and findings and recommendations of numerous additional investigative reports of major catastrophic accidents that have occurred since that time, and yet there is still no requirement for the system.

The system has been developed by a major manufacturer who recognized on the basis of our accident investigation findings, that such a device was needed.

They went out, put their money into the development of the system themselves; did develop it and sold it to some foreign carriers.

It was certificated by the FAA for use by the KSSU group of carriers in Europe.

This system was the result of demand on the part of those who felt it was necessary to give the pilot one more added backup—the terrain avoidance system.

And in previous testimony, we have cited a number of accidents that we felt would have been prevented, had this system been operating on the aircraft.

Mr. CRONIN. What is preventing it from being utilized in the United States now?

Mr. CARROLL. Only altitude awareness and the full use of existing altitude systems on the aircraft by the flight crews.

But you might put it, on the other hand: What has failed and allowed these accidents to happen, in spite of all of the existing operational procedures and equipment?

Mr. CRONIN. I am trying to find out why are we not utilizing this today, in the United States. You mentioned that it has been certificated for foreign use as being utilized abroad, but not being utilized here.

Mr. CARROLL. We have recommended that FAA develop a system and set standards for it and make it mandatory. FAA has reported back to us that they feel present systems and procedures are adequate.

Mr. CRONIN. I see.

Mr. CARROLL. Pan American Airlines recently started on a program to retrofit all of their aircraft with this system, and this, of course, came in the aftermath of a number of very serious accidents that they have had.

Mr. CRONIN. Is this equipment made in the United States?

Mr. CARROLL. Yes, sir.

Mr. PARRIS. Would the gentleman yield?

Are you talking about the King radio altimeter system?

Mr. CARROLL. Not specifically, sir. This is one along that line. The one that is being installed is the Sunstrand system.

Mr. MILFORD. Perhaps in answer to the question we are asking, there is a vast difference in the landing aids present and in the normal and vitally available use in this country as opposed to foreign countries;

and hence, a greater need for the foreign carrier to adopt this equipment than we would have in this country.

Mr. CRONIN. That is an excellent point.

Another point: I am aware of a good deal of work currently being done jointly with the military and the FAA, at Lincoln labs, and the Cambridge research lab for integrated systems. It seems the American approach has always been that total integrated system as opposed to a few pieces.

Mr. CARROLL. Yes, sir.

A year ago, May, in light of the continuing disagreement, you might call it, between the FAA and NTSB, as to whether this is a viable and valuable system, the FAA did issue, in 1973, a notice of proposed rulemaking, an advance notice that called upon the aviation community to report back to them what they felt to be the advantages or disadvantages, and if it is to be what features should it have.

And they have followed that up to now by examining the various ground proximity warning systems, and among the Lincoln lab and other facilities. The NAFEC facilities, where the evaluations are being accomplished.

I think this is probably an example of the lack of application of the knowledge.

The system has not only been developed; it has not only been bought, installed and certificated by FAA, but now we are conducting research on it.

Mr. CRONIN. If you had your "druthers," if you had your magic wand, what would you do to try to eliminate this problem, this gap? What would you do? What would you suggest to us to help close that gap?

Mr. CARROLL. Speaking for myself, having participated in General Yeager's joint safety conference, I find this an outstanding vehicle with which to bring forth the individual safety problems as seen by the various military services, and the FAA, and ourselves, and NASA who also participated, and also having a working knowledge of what the other fellows' problems are and what are the priorities with which they are being treated, and where are the ones that are falling through the cracks.

So that, hopefully, someone, somewhere could pick up and assure that the best applications can be made.

Mr. CRONIN. What you are really saying is, the basic problem is not one of reluctance; it is being made aware of the options with full discussion by the decisionmakers of what the parameters are that they have to work with to make something happen.

Mr. CARROLL. Yes, sir. In all fairness to the situations in which parties have different views and opinions on whether a system should be researched, developed, or thrown away, from their own points of view; they are operating within the constraints of what their statutory responsibilities are as far as an agency, or the commercial interests in the case of industry.

Mr. CRONIN. Before we run out of time: One quickie on general aviation. I know that this is a good example of where you interface with NASA and some of the things that NASA is doing with R. & D.

They are testing a general aviation aircraft with spoilers on it. I understand what they are doing with stall, spin problems, et cetera,

crashworthiness is something that is almost never discussed in general aviation.

It is one of your concerns with the airlines.

Are you satisfied with what is going on in the general aviation R. & D. field, and would you have some suggestions on how that might be beefed up?

Ms. BURGESS. I would like to make a comment on that, first, if I may. Not long ago, I did go down to Langley Air Force Base, where NASA is doing studies and doing research in crashworthiness of general aviation planes. I believe this is the first time this has actually been done in depth by an organization such as that.

It is one of the things that we have requested at the board level for a very long time, crashworthiness being considered for R. & D. and built into many of these small general aviation planes, because we have seen, time and time again, where the pilot or the passengers would survive, had the cabin been designed with that in mind.

Now it may be that Mr. Roscoe or you would like to add to that in the other areas.

I want to give GAMA credit, also, because they are beginning to get into this field. They took recognition of the problem.

Mr. CARROLL. I suppose that I view the situation as one of great frustration, having worked in the field of crash safety investigation at Cornell University, and the Flight Safety Foundation. Looking back to findings of 30 years ago, the enormous funds that were spent by the old NACA in crash test work, the funds that were spent by Flight Safety Foundation and AVICR in crash testing the DC–7 and the Constellation, the enormous work done by the NACA Lewis Flight Propulsion Laboratories in crash testing many, many light planes and small transport and jet aircraft, and looking at the findings over the years. I wonder when in the world are we ever going to really get down to applying what we knew 30 years ago.

Mr. CRONIN. Within that framework, I would like to see if I can get you to make a recommendation.

We saw for example, we went out and flew the little Beechcraft with the spoilers on it, a pretty simple system, practically fool-proof operation, relatively minor cost, possibly even lower cost than existing flaps.

But recognizing the gamble that a general aviation manufacturer has to make to put that on any aircraft, it was mentioned the problem of suits with the airlines, and certainly these suits are in many ways more disastrous from a financial point of view to general aviation manufacturers than they are to the majors.

Given that problem in slowing down the improvement of general aviation aircraft: Do you foresee some way that Government can help to resolve those problems so that the knowledge in essence that we have had for 30 years, that is not being applied—can start to be applied and start saving lives?

Mr. CARROLL. I am very pleased with the developments over the last 3 years, and the fact that the word "crash" will be discussed today, where it wouldn't have been 3 or 4 years ago; that GAMA is taking an active interest in leadership among the general aviation manufacturers to bring about research on the part of each of the companies manufacturing light aircraft, and that it has become a subject that

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everyone speaks of out loud, "crashworthiness," crash safety, crash fire prevention.

It was a bad thing to talk about in our "liberated" environment 3 or 4 years ago.

Mr. CRONIN. But if your Beech or Cessna or Piper—if you are one of those—if you have done the research and know how to solve the problem, what gets you into the problem?

Mr. PARRIS. Money.

Mr. CRONIN. More than money.

Mr. CARROLL. Public interest, aircraft buyer interest.

Mr. CRONIN. It is more than that. What I am trying to get at is some sort of Government guarantee; that is the basic problem. There has to be.

Let us use the spoiler example; spoilers are cheaper than the flaps. They have got a fool-proof system. They are tested, tried, developed by NASA, put on the plane. They work.

It is a great step forward for most general aviation pilots. The problem in this case isn't the money. The problem is not demand, because certainly if they were tried, they would be quickly accepted.

The problem is basically the courage of a manufacturer to go out and sell that product and overcome the fear that if there are accidents in that plane caused by something completely different, pilot error, an engine failure, or whatever, that this whole market is not going to be destroyed because of that—some new-fangled thing on that plane.

Keep away from it. I think the American Yankee is a good example—the nose wheel. What they went through for several years. It took them years to come out of it.

Is there some way your Board, FAA, some agency of Government can help us bridge that gap, so that we can start applying this knowledge that is already here?

Mr. PULS. Well, if it is a development that is obviously a safety step forward, and is so important, one way you get it on the airplane is to have the FAA require it by regulation.

They issue type certificates, et cetera. That doesn't solve the problem of the manufacturers, because under that system he is told to put that in.

There may be some developments that are that important.

Mr. CRONIN. I think that is a key point to improving the built-in safety of general aviation aircraft.

I would appreciate it if you and the other people in the room would give that some thought and perhaps give us the benefit of your thoughts, either on or off the record on how to bridge that gap. I, as one member, would greatly appreciate it.

Mr. CARROLL. The one circumstance, I think that is necessary to recognize is that in the regulatory process, the FAA is called upon to establish minimum standards, and perhaps the dynamic steps forward that are taken are beyond the minimum standards that can reasonably be expected.

Mr. CRONIN. Thank you very much.

Mr. HECHLER. Mr. Parris?

Mr. PARRIS. Mr. Chairman, I just have one question: A part of the charge of this subcommittee in these hearings is to determine the nature of the organizational arrangements for bringing the results of the safety R. & D. into the air transportation system.

Ms. Burgess, as part of your statement, you say, we would recommend to the subcommittee that it give careful consideration as to whether the existing coordination is adequate and if not, what alternatives should be pursued.

It seems to me that we have asked the same question. Would you venture an opinion as to the answer?

Ms. BURGESS. Would I mention what?

Mr. PARRIS. Would you venture an opinion in answer to that question: Is the existing coordination adequate?

Ms. BURGESS. Well, there is no existing organization which actually overlooks all R. & D. which is in existence today, and I am not sure that you can have such a board. What you need is the informational list of R. & D. that is now in progress.

Mr. Carroll spoke to this yesterday, and he said there used to be a list—this is something that you requested, General, a few minutes ago and said it would be useful—that there was a list by the Guggenheim Foundation, that was funded up until 1969.

And then at that time, the funding was withdrawn and the list was no longer kept current.

So as a result there is no longer such information available.

Now, this is something that perhaps should be reinstituted.

I know that the Board several times has requested of OMB, which was turned down either by OMB or Congress, the funding of a joint committee on aircraft accident prevention.

Another is civil aviation safety information center. This would be establishment of these.

And the third is an accident prevention research information library, which would relate to yours. These have been sought by NTSB.

These responsibilities—and I believe at that time is when we were discouraged from establishing this sort of thing, either because we did not have the capability, the personnel or perhaps for other reasons.

You have been involved with that more than I have.

Mr. PARRIS. Could I interrupt?

I don't mean to in any way shorten your comments, but I have the feeling that the bell is going to ring here in 1 minute, and is it fair to interpret your comments that the existing coordination is not adequate?

That is my interpretation of your comment, and we have the caveat, that it would never be perfect.

Do you prefer that it can be substantially improved upon in the light of some of the comments of General Yeager and others along there, along the lines of their suggestions?

Ms. BURGESS. I think that Commander Johnson, General Yeager, and the people sitting here would all agree that it could be improved upon.

Mr. PARRIS. The question is: How?

Ms. BURGESS. How and the best approach.

Mr. HECHLER. We will continue until the second bell, about 5 minutes from now.

General Yeager.

General YEAGER. First, I would like to agree on the privilege status problem.

We in the Air Force have met with the different branches of the service and we agree that it is not necessary to classify the whole accident report in that status; only that portion that could be used in the liability suit. I think that these honored gentlemen could answer the question.

I think we could get legislation passed as long as we have people like those who are sitting here.

Second, we all are in the safety business. We are now achieving an analysis capability in incident reporting.

We in the Air Force get an average of 80 incident reports a day. The only reason these incidents aren't accidents is because the pilot, or someone, took action to stop the trend. Today, we are finally getting the capability through computers to minimize these incident trends so we can prevent future accidents.

Actually, an accident is an incident that progressed.

I think the NTSB is in the same situation as we are.

Mr. PULS. General, let me make a comment on your last comment on incidents.

Maybe you know the figure, but in Montreal, in talking to the Australians, who have a fine accident investigation set up and computer setup, we asked them: Why did it pay off; you only have 200 accidents a year.

They report 7,000 incidents. If they have got 7,000 accidents, I keep asking: How many do we have which are not reported?

Mr. HECHLER. Any other comments by members of the committee?

Mr. Wells?

Mr. WELLS. I will defer questions for the record, Mr. Chairman.

Mr. HECHLER. We may have some additional questions for the record.

I think we have covered a lot of ground this morning, even though we haven't gotten to all the witnesses we planned to.

We certainly want to thank you, Ms. Burgess and your associates, and in order to complete the hearing we will reassemble at 2 p.m., if that is agreeable, at which time we will hear from Mr. David Israel, of FAA, Mr. J. Floyd Jones of NASA.

If there are no further comments——

Mr. Wells?

Mr. WELLS. One point, Mr. Chairman.

Would it be possible for one of your associates to remain for this afternoon's session, Ms. Burgess?

Ms. BURGESS. Yes, Mr. Carroll will remain.

Mr. HECHLER. If there is no further business before the committee, the committee will recess until 2 p.m. this afternoon.

[Whereupon, at 12:15 p.m., the subcommittee recessed to reconvene at 2 p.m.]

AFTERNOON SESSION

Mr. HECHLER. The committee will be in order. We are very pleased this afternoon to welcome in the continuation of these aviation safety hearings David R. Israel, who is the Acting Deputy Associate Administrator for Engineering and Development of the Federal Aviation Administration.

Mr. Israel, You have a couple of associates with you.

Mr. ISRAEL. Yes, sir. On the left I have Larry Greene from the Office of the Assistant Secretary for Systems Development and Technology of the Department, and on my right, Colin Simpson of the Aircraft Safety and Noise Abatement Division, Systems Research and Development Service, Federal Aviation Administration.

Mr. HECHLER. Welcome, gentlemen.

STATEMENT OF DAVID R. ISRAEL, ACTING DEPUTY ASSOCIATE ADMINISTRATOR FOR ENGINEERING AND DEVELOPMENT, FAA; ACCOMPANIED BY LAWRENCE GREENE AND COLIN SIMPSON

Mr. ISRAEL. Mr. Chairman, I am pleased to have the opportunity to address this committee today on the subject of aviation safety research and development.

In this short presentation of the FAA's research and development activities on aircraft safety, I will only address the safety aspects of the design, certification, and operation of U.S. civil aircraft, including general aviation and air carriers. The FAA has no related responsibilities with respect to military aircraft, although we coordinate with the Department of Defense on matters of mutual interest. I will not discuss today the safety aspects of the air traffic control environment—for example, midair collisions—the training and certification of pilots, passenger screening and, other antihijacking measures, or the carriage of hazardous materials. In short, I will focus on only aircraft safety rather than the larger, field of aviation safety.

FAA's concern for aircraft safety is, nevertheless, a broad one. The scheduled and nonscheduled air carrier portion of U.S. civil aviation is comprised of over 2,500 aircraft, engaged in approximately 13,000 operations per day and utilizing about 658 airports in the 50 States. For general aviation, there exists approximately 150,000 aircraft, ranging from the small single-engine pleasure craft to multiengine aircraft equivalent to certificated air carrier equipment, operating into and out of approximately 12,000 airports. There are some 70 major models of certificated air carrier aircraft in U.S. operation. The general aviation fleet, even excluding experimental aircraft, has hundreds of aircraft models.

The Federal Aviation Act of 1958, section 312(b), empowers the Secretary of Transportation to "undertake or supervise such development work and service testing as tends to the creation of improved

aircraft, aircraft engines, propellers, and appliances." Under section 601(a) the Secretary is empowered:

> And it shall be his duty to promote safety of flight of civil aircraft in air commerce by prescribing and revising from time to time:
> (1) Such minimum standards governing the design, materials, workmanship, construction, and performance of aircraft, aircraft engines, and propellers as may be required in the interest of safety;
> (2) Such minimum standards governing appliances as may be required in the interest of safety.

In support of this charter, the FAA's efforts in aircraft safety R. & D. are directed almost exclusively to rulemaking, certification matters, and flight advisory functions. The FAA's program is designed to gather the necessary operational, technical, and economic data base to support and meet these regulatory and advisory objectives. Our program, then, includes:

(*a*) Establishing the quantitative basis for rulemaking, new operating procedures, or new advisory publications;

(*b*) Working on recognized aircraft safety problems that exist or are forecast to arise; and

(*c*) Working to provide a knowledge and data base to establish standards, and means to comply with them, for new aircraft designs that will be presented for certification.

This R. & D. program is organized into four areas:

Fire safety.

Transport safety.

General aviation safety.

Quiet short-haul transport safety.

The fire safety portion of this program provides information on which to base improved regulatory requirements covering crash fire prevention, engine fire prevention, and cabin fire control, and increased cabin survivability during crash fires. Activities to accomplish this include:

Development and testing of modified fuels that reduce postcrash fire hazards.

Development of onboard methods of generating nitrogen for inerting fuel tanks to prevent fuel tank explosions.

Development of test methods and criteria to control smoke and toxic gas emission from burning cabin materials and to prevent cabin fire propagation and flash fire spread.

The transport safety portion of the program provides data for improved regulations and operational criteria to continue the high level of safety in current transport aircraft and during the certification and subsequent operation of the next generation of advanced technology transports. Activities include:

Flight and landing tests to provide data in support of new regulations for determining transport aircraft landing distances.

Development of criteria for use in simulations to complement flight test criteria for aircraft certification and flight operations research.

Development of methods for predicting turbine engine failure.

Recording of transport operational data both in flight and on the airport surface to establish operational performance, requirements, and ground loads for certification and to support and verify current operational procedures requirements.

The general aviation safety portion of the program comprises crash survivability, pilot training and proficiency, and devising solutions to multiple-cause aircraft accidents (including engine and propeller failure). Activities include:

Development of methods of analysis for the dynamic crash response of the seat-man combination and the entire airframe to enable higher levels of crashworthiness regulation to be promulgated.

Development of data on which to base standards for ground trainers to be used in pilot training.

Determination of aircraft design characteristics necessary to reduce stall-spin accidents.

Development of test methods and the provision of data to upgrade propeller vibration and stress certification standards.

The quiet short-haul transport safety portion of the program provides the analytical and test data suitable for the formulation of airworthiness certification and operational standards for this type of aircraft. Activities include:

Determination of the approach and landing characteristics for steep angle approaches.

Determination of the requirements for system failures such as loss of one engine and loss of stability augmentation.

Assessment of the requirements to accommodate environmental factors such as icing and crosswinds.

Determination of minimally acceptable flight characteristics.

In each of these program areas, we look to NASA, DOD, as well as to industry, for experience and assistance. FAA and NASA both have requirements to work in aircraft safety areas such as fire safety, crashworthiness, and aircraft stability and control. These requirements, however, are different in nature. The NASA responsibility involves the conduct of research to advance the aeronautical state-of-the-art by means of new methods of aircraft design and analyses, the development of advanced aircraft and engine design approaches, and the development of new materials to be used in aircraft. These products are then used by the aircraft industry to design and produce new aircraft. As noted, the FAA responsibility involves application of the current state-of-the-art in aeronautical engineering and materials to provide the data base for updating the regulatory standards for the certification of new aircraft and for their safe operation in the airspace. This current state-of-the-art includes the new NASA developments once they have matured to the point of being usable directly by the industry.

Because of the close relationship of the FAA and NASA responsibilities, we have several joint activities with NASA. Among the key ones are:

1. A joint effort in actual crash tests of general aviation aircraft.
2. Derivation and testing of new analytical techniques in predicting structural deformation and breakup in crash tests.
3. Design and testing of modified fuels for fire safety.
4. Joint operating experiments related to short takeoff and landing aircraft—STOL. (In this activity, the FAA concerns are related to the way new designs are able to operate within precise air traffic control procedures. We provide experiments and tests to be accomplished in the NASA flight and simulator program.)
5. Preliminary examination of the operational problems through the use of simulation. (With NASA we have jointly pursued the use

of this tool as a very important adjunct to our safety and certification program. The FAA has established an office at NASA-Ames Research Center in California to utilize these unique NASA simulators.)

We establish and monitor the progress of joint R. & D. programs and prevent any duplication of effort between the two agencies by a NASO/FAA coordinating committee of long standing. The membership of this group includes the top officials of both organizations, and is jointly chaired by the Deputy Associate Administrator (Aeronautics) for NASA and the Associate Administrator for Engineering and Development for FAA. This committee meets quarterly, or more often if either cochairman desires. The 7 meetings of this group over the past 2 years have each involved aviation safety items.

The FAA coordinates with other Government agencies and there are about a dozen interagency agreements with the Air Force, Atomic Energy Commission, National Bureau of Standards, the Army and the Navy covering many aspects of aircraft safety research and development. The FAA also participates in working areas of the military Joint Technical Coordination Group on Aircraft Survivability. Also existing are informal working agreements with the British and French on quiet short-haul aircraft, as well as conventional aircraft safety matters.

Coordination of aircraft safety R. & D. efforts with industry is accomplished in several ways. The first involves frequent contact by FAA personnel with the major airframe manufacturers, such as the Lockheed Aircraft Corp., the McDonnell Douglas Corp., and the Boeing Airplane Co.; with associations such as the Aerospace Industries Association, the Air Transport Association and the Aircraft Owners & Pilots Association; and with the smaller aircraft companies, such as the Cessna Airplane Co., the Beech Aircraft Co., and the Piper Aircraft Corp. The second method involves participation by our personnel in a variety of industry committees such as the American Institute of Aeronautics and Astronautics, the Society of Automotive Engineers, and the National Research Council. The third method involves the interchange of technical information that occurs during the conduct of contractual efforts by industry such as the cabin fire smoke tests done for the FAA by the Lockheed Aircraft Corp., the study of the feasibility of generating nitrogen on board aircraft for fuel tank inerting by the AiResearch Manufacturing Co., and a joint FAA/NASA contract with the Grumman Corp. on transport crash structural response.

The objectives, plans, status, and progress of the aircraft safety R. & D. program within the FAA is reviewed formally twice each year by the Associate Administrator for Engineering and Development. During the year, new problems, programs or work areas may arise from recent accidents, National Transportation Safety Board reports, et cetera. The Flight Standards Service, as the operating service in aircraft safety, submits requests for engineering and development assistance as a result of these accidents and incidents, together with their recommendations on priority with respect to the existing R. & D. efforts being performed for them. The Associate Administrator for Engineering and Development weighs these requests relative to the total R. & D. workload, the available manpower, and contractual funds to determine those on-going efforts that should be cancelled or postponed if the new tasks were to be undertaken. Consultation between the

operating and the R. & D. elements of the FAA resolves the inclusion of the new work and the elimination of existing or planned work to the satisfaction of both parties. When it is decided that new work should be undertaken by FAA, we then face the additional decision as to where it should be done. The choice ranges between accomplishing it with our own manpower and facilities, the use of other Government agencies and facilities, or the use of industry or universities. Much of the work requires large specialized facilities, such as wind tunnels, sled tracks, et cetera, and hence a large part of this work is done at Government facilities. In the other extreme, some of the very basic research work—of which we do very little—would go to universities. The work which falls between these would generally go to industry.

The aircraft safety R. & D. efforts in the FAA are conducted by the Systems Research and Development Service, here in Washington, and the National Aviation Facilities Experimental Center at Atlantic City, N.J. At this Center there are a variety of facilities necessary for aircraft safety research: wind tunnels, sled tracks and catapults, jet engine stands, and impact testing facility, a power plant fire test facility, aircraft simulators, and the like.

Of our total yearly effort on aircraft safety R. & D., approximately one-half is conducted in-house and the remainder evenly divided between other Government agencies and industry, including universities. The fiscal 1975 program will be approximately $4.1 million.

As examples of the products of this program, I will mention four items:

1. As a result of bird impact testing at NAFEC, requirements written into FAR–25 certification requirement for transport category airplanes included a rule for transport tail surfaces to withstand an impact of an 8-pound bird at cruise speed.

2. As a result of test and experimentation to determine the flammability of transport cabin interior materials, requirements have been included in FAR–25 reflecting these findings. Further, a notice of proposed rulemaking on smoke and an advanced notice of proposed rulemaking on toxic gas emission are in process.

3. As a result of efforts involving flight testing study and experimentation in the area of general aviation flying and handling qualities, the methodology of evaluating stability, that is, dutch roll, spiral stability, et cetera, has been clarified; a requirement for certification, part 23. In addition, a quantification of these handling qualities under FAR–23 enabling better type procedures has been achieved as a result of such R. & D.

4. As a result of R. & D. engine fire test programs, special conditions were applied to certification of recent wide-body aircraft to provide protection against explosive hot surface ignitions.

Gentlemen, that concludes my presentation. Thank you.

We also have much more detail, what we call a program plan covering all of our work in aircraft safety, our products and our plans. That would be made available to you if you wish.

Mr. HECHLER. How long is that?

Mr. ISRAEL. About 40 pages.

Mr. HECHLER. Without objection that will also be included in the record, along with your complete statement, Mr. Israel. We appreciate your bringing these things to the committee's attention.

[The program plan referred to above is as follows:]

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ENGINEERING AND DEVELOPMENT PROGRAM PLAN- AIRCRAFT SAFETY

APRIL 1973

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15. Supplementary Notes

16. Abstract

The Aircraft Safety Program Engineering and Development Plan describes the objectives, the scope of work, and the funding requirements to meet the Federal Aviation Administration's research needs in aircraft safety for the 1973-1982 period. The plan covers work in Fire Safety, General Aviation Aircraft Safety, Transport Safety, Quiet Short Haul Air Transport (QSAT), and Aviation Security.

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1. EXECUTIVE SUMMARY

1.1 Introduction

Program 18 - Aircraft Safety. The objective of the Aircraft Safety Program is to provide the technical and economic data base to assist in determining feasibility of new rules, acceptability of the techniques for showing compliance, and to develop in-service monitoring for aircraft and engine airworthiness, crashworthiness, flight performance, operations and for pilot performance and aviation security. Included under this broad objective are all civil aircraft ranging from small general aviation fixed and rotary wing aircraft to aircraft used for business and commercial activities, and the small, medium, and large transport aircraft. The multiple activities, operations, and environments that are engaged in or encountered by these aircraft, the airmen that operate them and the passengers and cargo that are carried result in a wide variety of hazards that must be attacked by an equally wide variety of safety improvement efforts. These are exemplified by the following specific goals:

a. Develop airframe, engine, flight characteristics and equipment criteria for conventional and quiet shorthaul aircraft.

b. Develop operational techniques and criteria, taking into account aircraft performance and man-machine considerations.

c. Obtain in-service data for assessment of currency and adequacy of engineering and operational standards.

d. Develop impact and fire protection crash survivability criteria.

e. Determine extent to which flight simulators can be used for flight operations research and aircraft certification.

f. Develop pilot qualification, recurrency, and training certification criteria.

g. Develop technical, economic and operational feasibility of techniques, devices and systems to prevent hijacking and sabotage.

Program 18 is uniquely aimed at maintaining and improving safety and so differs from NASA and manufacturers research efforts which are aimed at the design improvement process. Joint programs with NASA and the military permit complementary use of aircraft and facilities to provide an appropriate range of research efforts to serve respective agency needs.

1.2 Projection of Demand

Research and development is conducted in response to specific requests from the operating offices and in anticipation of the need for certification or operating criteria in critical safety problem areas.

- The short-term requests from operating services for E&D work have averaged ten per year with an average cost of $375,000 each over a two year period, or somewhat less than $4 million per year.

- Long-term development efforts are required to steadily attack existing and forecast safety problems resulting from industry's use of new technology. These must be undertaken early enough in the industry's aircraft development cycle to permit FAA to provide minimum safety level airworthiness considerations. This requires an additional 2-3 million per year.

- The initial release of the Program Plan contains, or is based on, a desired level of expenditure and schedules which may not reflect actual budget limitations and priorities. For this reason, the individual levels of expenditure for the program and the sum of all of the program funding requirements will not necessarily correlate with the actual FAA Engineering and Development budget, for any given fiscal period. Subsequent adjustments to this Program Plan will attempt to minimize these differences.

1.3 Development Approach and Products

The program is divided into the following elements. Major current and planned efforts are listed.

Fire Safety

Inflight fire and crash fire protection requirements

- Modified Fuel
- Fuel Tank Inerting
- Cabin Fire Extinguishment, Smoke, Toxcity Limits
- Cargo Compartment Fire Prevention, Detection, Extinguishment
- Propulsion Fire Prevention, Detection, Extinguishment

Transport Safety

Airworthiness, flight performance and operation requirements

- Rational Landing Distance Rule
- Flight Simulation Complementary to Transport Certification
- Methods of Compliance - Flight Loads
- Methods of Compliance - Maintenance
- Minimum Flight Characteristics
- Propulsion Engine Icing Requirements
- Propulsion Engine Electronic Control Requirements

Quiet Short Haul Air Transportation Safety

Airworthiness, flight performance and operation requirements

- STOL performance safety margins
- STOL performance certification test techniques
- STOL operations requirements
- STOL crosswind and icing requirements

General Aviation Aircraft Safety

- Occupant restraint and crash energy absorption requirements
- Aircraft structure crash energy design requirements
- Method of compliance - flight loads
- Ground trainer flight training acceptance criteria
- Method of compliance - propeller vibration and stress levels
- Stall avoidance and deterrent requirements

Aviation Security

- Weapon detection systems
- Bomb detection systems
- Airport security concepts

Portions of the program are conducted at NAFEC. A portion is accomplished through outside contracts including interagency agreements which allow FAA the expedious access to and use of other agency's in-house and contractual capabilities. The NASA/DOT/FAA interagency agreement providing for joint use of the NASA/Ames simulators is especially useful in the flight characteristics, performance, and operations programs involving future generations of aircraft.

1.4 Resource Requirements

To be responsive to requests from operating services in a timely manner funding level of the following order is required. Specific projects and costs are in the body of this plan.

	1973	1974	1975	1976	1977	1978-82
Fire Safety	701	1212	1500	1250	900	6000
Transport Safety	410	810	2060	2900	2400	7000
QSAT Safety	248	1160	835	850	850	4000 *
Light Aircraft Safety	441	1065	1525	1825	2150	6200
Aircraft Security	347	454	550	500	300	3000
TOTAL	2147	4701	6470	7325	6600	26200

* For FY 1975 and subsequent years, $600K of these funds are provided by Program 22 QSAT.

2. INTRODUCTION

Program 18, Aircraft Safety, has as its general objective the maintenance and improvement of safety for passengers, airmen, and aircraft, both on the ground and inflight. Included under this broad requirement are all civil aircraft ranging from small general aviation fixed and rotary wing aircraft, to aircraft used for business and commercial activities and culminating in the small, medium, and large transport aircraft used by the certificated air carriers. The multiple activities, operations, and environments that are engaged in or encountered by these aircraft, the airmen that operate them and the passengers that are carried exposes the aircraft to a wide variety of hazards that must be attacked by an equally wide variety of safety improvement efforts. Program 18, Aircraft Safety, is the agency's Engineering and Development Program for accomplishing these safety efforts. This program plan describes these efforts, the requirements for them, their outputs and how these are utilized and the funding requirements for the next ten-year period.

Aircraft Safety work takes a variety of forms. There are major development programs such as the General Aviation Safety Demonstration and the Modified Fuel efforts that are multi-year with definite end goals to be reached. Also, there are shorter range projects that can be grouped into classes, such as, Conventional Takeoff and Landing Aircraft (CTOL) Flight Characteristics, where attaining the project goal is one step in attacking the safety problems in that class of work. An example would be the completion of flight tests and analyses of flying and handling qualities of light general aviation aircraft to permit improvement of the certification requirements in FAR 23. This would be just one phase of the overall CTOL Flight Characteristics work. Finally, there are a few types of effort that are continuous in nature with a steady stream of safety outputs. An example is the fire testing of new cabin interior materials at NAFEC in the search for materials with improved fire resistance and reduced toxic fumes and smoke output to permit periodic upgrading of regulations.

The variety of technologies and types of work that are required in the Aircraft Safety Program are exemplified by the specific goals which were listed on page 5.

The Aircraft Safety Program is structured to match these goals. Program details are presented in the following sections of this plan.

3. BACKGROUND/REQUIREMENT/NEED/PROBLEM

The Federal Aviation Act of 1958 empowers the Secretary of Transportation to "undertake or supervise such developmental work and service testing as tends to the creation of improved aircraft, aircraft engines, propellers and appliances," (Section 312). He is also empowered "and it shall be his duty to promote safety of flight of civil aircraft in air commerce by prescribing and revising from time to time:

a. Such minimum standards governing the design, materials, workmanship, construction and performance of aircraft, aircraft engines and propellers as may be required in the interest of safety;

b. Such minimum standards governing appliances as may be required in the interest of safety."

These basic legal requirements are acted upon by the agency E&D effort in terms of:

a. Response to specific short term requests from the operating offices and services of the agency to provide the basis for new rulemaking, new operating procedures or new advisory publications.

b. E&D on recognized safety problems that exist or are forecast to arise pertinent to the aircraft and its components, airmen, passengers and passenger security at airports.

c. E&D to provide a knowledge and data base to establish standards (special conditions, etc.) and means to comply with them for new aircraft designs that will be presented to the agency for certification.

The majority of the efforts in the Aircraft Safety Program fall into the first and third categories listed; response to immediate and specific requests from the operating services and preparing the way to meet the future certification needs of these services. Some E&D efforts are a combination of all these categories.

As of April 15 1973, twenty -four requests for E&D work on Aircraft Safety were active. Table 1 lists these showing the diverse nature of the work requested. As can be seen, the primary source for these requests is the Flight Standards Service, with the Airports Service, and the Office of Air Transportation Security providing the remainder.

Although not listed as a specific request for E&D, a portion of the Aircraft Safety Program budget is provided by the Quiet Short-Haul Air Transportation Systems Office for both engineering and operational support of its program.

TABLE 3-1

ACTIVE REQUESTS FOR AIRCRAFT SAFETY R&D

Number	Title
FS-100-65-73	Evaluate Factors Influencing In-Service Propeller Fatigue Failures
FS-400-68-28	Capabilities, Specifications and Effectiveness of Pilot Ground Trainers
FS-400-68-28A	Development and Proving of an Objective Private Pilot Flight Test
FS-100-69-98	Select and Install a Turbulence Measuring Device or System
FS-100-69-103	Evaluation of the State-of-the-art for Materials Smoke Generation Criteria
FS-100-70-104	Turbine Engine Combustor Failures
FS-100-70-107	Investigation of Oxygen Concentrations and Measurement Techniques for Inerted Fuel Tanks
FS-100-70-108	Nonmetallic Fuel Tanks, Lightning Protection
FS-100-71-114	Tentative Airworthiness Standards for Powered Jet Transport Category Aircraft
FS-100-71-115	Jet Aircraft Handling Qualities Data
FS-100-71-116	Stability Criteria for Large Transport Aircraft
FS-300-72-1	Ionization Probe to Detect Failures in Jet Engines
FS-100-72-117	Development of Nitrogen Separation Techniques for Fuel Tank Inerting
FS-100-72-118	Funds to Support Phase II of the Joint FAA-USAF-NASA Runway Research Program

Number	Title
FS-100-72-119	Program for Fuel Conductivity and Charging Tendency Survey
FS-100-72-121	Analysis of VG and VGH Data
FS-100-72-122	Development of Dynamic Crash Loads Criteria
FS-100-72-123	Turbine Rotor Burst Protection
FS-100-72-124	Development Dynamic Crash Loads Criteria
AS-580-72-1	Develop Optimum Runway Groove Configuration
SE-330-3-71	Aircraft Sabotage Explosion Tests
SE-330-5-71	Emergency Jettison of Bomb/Sabotage Device
AFS-100-73-129	Feasibility Test of Proposed New Far 25 Landing Rule
AFS-100-73-131	Small Rigid Airplane Gust Analysis

5. PROGRAM STRUCTURE, SUBPROGRAMS, PROJECTS AND/OR TASKS REQUIRED

The Aircraft Safety Program consists of five major elements, three dealing primarily with transport aircraft, one dealing with light aircraft and the final one dealing with aircraft security and anti-hijacking.

5.1 Fire Safety

5.1.1 Problem

Although every effort is being made to improve the already superb level of safety in transport aircraft, crashes do occur occasionally and occupants perish from crash impact and fire. A sufficient number of crashes have occurred that would have been survivable if the subsequent fuel fire had not caused fatalities to warrant a comprehensive E&D effort to both reduce the possibility of ignition and severity of the fuel fire and to protect the cabin occupants until their safe egress. Historic cabin fire fatalities warrant continued improvement in the length of time that the cabin remains habitable before the hazardous effects of cabin material fire, toxic gasses, smoke and flash fire occur.

In addition to the severity of engine fires caused by flammable fluids igniting in the engine compartment, current aircraft turbine engines have pressure ratios such that engine burner can failures produce high temperature supersonic flames that can severely damage adjacent structures.

5.1.2 Program

The program tasks below provide the technical and economic basis for new or revised standards.

5.1.2.1 Modified Fuel

The objective of this effort is the development, testing and eventual service use of a modified jet fuel which will reduce the likelihood and severity of a post crash fire and thereby increase the time available for safe passenger evacuation.

Early work resulted in fuels that were gels with superb crash fire prevention characteristics but with severe pumping and engine operating problems.

More recent work resulted in reducing the viscosity of these gels to improve their operating qualities while maintaining their crash fire reducing potential. While

progress was being made on gels, a new series of anti-misting fuel additives was developed by several chemical companies, that appeared so promising that the program was reoriented to concentrate on these types of modified fuels. Their anti-misting properties should reduce or eliminate the fuel spray from crash ruptured tanks and the resulting fire ball. Also, the amount of additive required is around 0.3% of fuel weight which makes them economically attractive and much more amenable to use in current jet aircraft.

Elements of this effort to be carried out in the next several fiscal years involve:

- Full-scale crash tests of suplus RB-66 jet bombers and UH-1 helicopters to verify the crash fire reduction.

- Engine and fuel system operational tests culminating in agency certification of an engine using a modified fuel.

- Analysis of the logistics pertinent to air carrier fleet use of modified fuel together with analysis of the costs and benefits involved.

- Development of a specification for modified fuel.

5.1.2.2 Fuel Tank Inerting in Jet Aircraft

The large fuel tanks in heavy jet aircraft develop large volumes of fuel vapor mixed with air as fuel is consumed. These can constitute a serious explosion hazard. A method of inerting this volume has been developed wherein an inert gas, nitrogen, is injected into the tank ullage volume to prevent combustion. Current and future work will determine the practicality of extracting nitrogen from engine bleed air rather than carrying liquid nitrogen in bottles on board and to eliminate the attendant logistics problems of storing and servicing aircraft with liquid nitrogen at airports.

5.1.2.3 Minimize Airframe Crash Fires

This effort involves continued improvement of cabin materials in terms of their flammability, smoke and toxic properties. It also covers increasing the fire resistance of the fuselage structure to external fuel fires and the controlling and isolating cabin fire spread by means of curtains, partitions and extinguishing agents.

This effort is a continuing one to provide data to update progressively the crash fire survivability of aircraft cabins. Not only should the dangers from flame, smoke, toxic gases and flash fire be scaled so that one is not more lethal than the other but also, the danger from each should be reduced to provide increasingly longer time for passenger and crew evacuation. In recent years the flammability of cabin materials has been reduced significantly by regulation. Work on the smoke limits for burning materials is nearing completion, work on toxic gas limits is underway and will be followed by work on flash fires. While these efforts are being pursued, analyses and tests will be carried out on the synergistic effects of each hazard on the other. All work will culminate in the data needed to support regulatory action including definition of acceptable means of compliance in performing laboratory tests of the products of burning materials. These standards will have been correlated with full scale cabin effects and human medical tolerance limits.

5.1.2.4 Minimize Hazard of Inflight Cargo Compartment Fires

This work is to develop cargo compartment design and fire detection and extinguishing criteria to reduce the hazard of inflight cargo compartment fires. Covered under this work are the fire safety integrity of airborne cargo containers, the fire characteristics and detection and extinguishing criteria for large bulk load cargo compartments, including those transporting gasoline powered vehicles.

5.1.2.5 Fuel Conductivity and Charging Characteristics

This work will determine, through a survey of airport fueling facilities, the electrical charge levels of fuel being delivered into transport aircraft. Maximum acceptable limits of fuel charge will result to prevent explosions during refueling.

5.1.2.6 Systems for Suppression of External Fires

The feasibility of suppressing an external fuel fire, after spilled fuel in a crash has been ignited, will be investigated. The requirements will be determined for the suppression of external crash fuel fires and systems designed for this purpose. The most feasible of these systems will be fabricated and tested to determine if such a requirement should be made mandatory.

5.1.2.7 Propulsion Fire Safety

(1) Burner Can Burn Through - In airline service and laboratory testing flames emitted from engines with pressure ratios of 12 can destroy several feet of surrounding structure. Future engines having pressure ratios over 30 could produce a catastrophic flame. The properties of such flames are being determined together with the characteristics of materials to contain them and methods for early detection are being devised so that new airworthiness regulations can be developed.

(2) Hi-Pressure Ratio Installation - New high pressure ratio turbofans have engine compressor case temperatures well over 1000°F thereby almost guaranteeing a fire if any fuel, oil, or hydraulic fluid leakage occurs. High pressure bleed ducts from these engines also pose critical problems. An analysis of these problems will be followed by appropriate engine tests to develop improved criteria.

(3) Advanced Fire Extinguishment - Extinguishments that are effective in the 1000° temperature environment of new engines will be evaluated.

(4) Fire Detection Systems - Acoustic sensing, infra red sensing and other fire detection concepts will be tested and evaluated.

(5) New Standard Burner for Fire Test Certification - Would provide a device more representative of fire conditions in new engines. The burner and test conditions used today for certification produce an environment less severe than actual engine fires.

(6) Powerplant Installation Fire and Explosion - Identification of the hazards associated with inadvertent explosive ignition of combustible fluids or vapors in various powerplant installation designs will be conducted with the emphasis being on overpressure relief.

Incipient Fire Detection - would develop a means to sense fuel vapor before a fire started and permit prevention of the actual fire.

Safety Standards for Fuels Other Than Kerosene - would be determined for advanced engines.

5.1.3 Products

5.1.3.1 Recent Products

Turbine Fuel Flammability Limits Developed	1967
Low Cost Carbon Monoxide Indicators Developed	1967
Established Effects of Lightning Ignition of A/C Fuel Tank Vent Efflux.	1968
Evaluated General Aviation Exhaust Gas Heat Exchanger Systems.	1968
Study of Flame Propagation Through Aircraft Vent Systems Completed.	1969
Crash Fire Hazard Rating System for Controlled Flammability Fuels Developed.	1969
Completed Full-Scale Inflight Fire Protection Investigation on Turbofan Powerplant Installations.	1969
Investigation of Two Methods Improving the Crashworthiness of Integral Fuel Tanks.	1970
Issued Criteria for A/C Fire Extinguishing Agent Concentration Analyzer Utilization.	1970
Characteristics of Fire in Large Cargo Aircraft.	1970
Developed Nitrogen Fire Protection System for Inflight Fire Control.	1971
Released Criteria for Resistance to Burner Can Burn Through Flames in Low Pressure Ratio Engines.	1972
Completed Full-Scale Crash Test Demonstrations of Crash Fire Reduction with Modified Fuel.	1973
Established Feasibility of On-Board Nitrogen Generating System for Fuel Tank Inerting.	1973
Developed Correlation of Cabin Material Laboratory Smoke Test Results with Large-Scale Conditions.	1973
Established Feasibility of Detecting Incipient Burner can Burn-Through Flames.	1973

5.1.3.2 Future Products

	Schedule
Modified Fuel Specification	9/75
Design Criteria for On-Board Nitrogen Generation	12/75
Transport Cabin Fire Control Criteria	12/77
Cargo Compartment Fire Control Criteria	12/77
Airworthiness criteria for prevention of critical areas in event of burner can burn through.	1/74
High pressure ratio installation airworthiness criteria.	7/75
Qualification of advanced fire extinguishments.	7/75
Qualification of advanced fire detection systems.	7/74
Powerplant installation airworthiness criteria for inadvertent explosive ignition of vapors.	1/75
Airworthiness criteria for new engine cycle fuel and other powerplant systems aspects.	1980-85

5.1.4 Fire Safety Resources	1973	1974	1975	1976	1977	1978-82
Modified Fuel	304	624	500	300		
Nitrogen Inerting	100	126	200			
Cabin Fire Protection	147	202	150	200	200	2500
Cargo Compartment Fire			100	200	150	500
Propulsion Fire:						2000
Burner Can Burn Through	120	70				
High Pressure Ratio Engine Fire		90	100	100	100	
Advanced Fire Extinguishant			50	50		
Fire Detection Systems	30					
New Standard Burner		100				
Powerplant Fire & Explosion			50	50		
Incipient Fire Detection			100	100	100	
Electrostatic Charge Density			50	50	50	
Safety Standards-New Fuels					100	
9550 Requests			200	200	200	1000
TOTAL	701	1212	1500	1250	900	6000

5.2 Transport Safety

5.2.1 Problem

New technology is emerging that has high probability of being used in the next generation of jet transport aircraft. Examples are composite structures, active control systems and supercritical wing aerodynamics. While these advances will permit more efficient transport aircraft permitting a high rate of return on investment by means of high productivity and low operating costs, they pose safety and certification problems that have not yet been encountered by the FAA.

Composite structures are stronger and lighter than conventional aluminum structures but their lack of yeilding deformation before failure makes their behavior under crash loads uncertain. Environmental effects on these materials have yet to be explored. Active control systems permit much smaller tail sections and an inherently unstable aircraft. They also provide for gust alleviation and flutter prevention. This agency has not yet certificated an aircraft where failure of an electronic control system results in an uncontrollable aircraft subject to flutter destruction. Yet the high productivity of these aircraft can be attained only by use of all these technical advances.

Sufficient R&D must be done pertinent to the certification implications of these advances to assure that the body of rules and their means of compliance result in safe transport aircraft that maintain the level of safety in public air transportation that now exists.

5.2.2 Program

The program tasks listed below provide the technical and economic basis for new or revised standards and accepted means of showing compliance for transport airframe, propulsion, flight characteristics, performance, operations.

5.2.2.1 Airframe Airworthiness Criteria

Airframe airworthiness standards and means of compliance must change to provide for:

New aircraft configuration, construction, and materials, such as:

- o Wing and tail surfaces activated to suppress flutter and gusts.
- o Supercritical wing.
- o Composite filament type structures.

Improved analytical capability to accurately perform:

- o Flight and ground loads analysis.
- o Flutter analysis and procedures.

(1) Flight Loads Design Criteria

Using the current more realistic definition of atmospheric turbulence and the expanded operational envelopes of current and projected transports, the requirements for defining the flight loads to be used in design shall be updated. Data on the flight profiles and certain aspects of the operational envelope will be collected by the Flight Data Acquisition System discussed under 5.2.2.3, Flight Operations. The effect on flight loads design criteria when gust alleviation, and/or flutter suppression techniques are used will be defined.

(2) Ground Loads Design Criteria

Current transport regulations for landing, braking, turning, pivoting loads do not adequately cover the new multiwheel, multistrut gear configurations. In order to update the regulations to cover current and projected designs, data on new in-service aircraft is needed. The Flight Data Acquisition system discussed under 5.2.2.3 Flight Operations provides a few elements of data, but sensors for several other parameters must be acquired and several such systems installed in representative aircraft.

A taxi load design procedural means of compliance to the regulation was developed in prior years using the meager aircraft response data then available from the manufacturers and NASA. At that time insufficient runway data was available to properly consider the phasing and asymmetry of the runway profile (longwave) and roughness. This information is now available and the procedure will be evaluated with regard to any necessary modification.

(3) Non-Destructive Inspection Equipment

One of the keys to safety is the assurance that the aircraft as manufactured is without material flaws and that in service, if flaws occur, they are detected before they become serious.

New and promising techniques to inspect new materials and construction techniques, as well as, improved methods for current materials and construction will be evaluated for aircraft maintenance standards.

(4) Structural Design Criteria for Bomb Loads

To ensure safety if a bomb is captured inflight the aircraft operations manual should contain information on the area of aircraft best designed to absorb explosive loads without creating hazard to the overall integrity of the aircraft and vital systems. Safe means to jettison the bomb, on-board explosion tubes to vent the blast forces over-board are a few of the design concepts that may evolve.

(5) Airframe and System Safety/Reliability Management

The modernization of maintenance concepts has progressed logically from the "one visit" overhaul through progressive maintenance to "on condition" maintenance. The current trend is to measure the safe condition of the aircraft in terms of reliability indices. Implementation of this type of maintenance requires consideration in the initial design and must be carried through strength validation, manufacture, operation, and maintenance. Data collection systems, computer data analysis programs, strength validation procedures, design and maintenance reliability indices, maintenance data displays and comparison and feedback programs to design and strength validation will be developed and serve as the basis for new certification criteria.

(6) Composite Materials

The DOD and NASA have sponsored and stimulated the development of new materials such as the boron and graphite filament reenforced composites. The DOD has several primary components being designed or in service. Military requirements are not always compatible with civil needs. Additional standards will be needed in areas such as environmental and endurance aspects, lightning protection, long life joining techniques, quality control and inspection; etc.

(7) Active Control Systems

The certification requirements and means of compliance must be established for active control systems used for gust alleviation, flutter suppression and to provide aerodynamic stability to an unstable configuration.

5.2.2.2 Flight Characteristics

(1) To provide a data base and criteria for the development of revised and new regulations or special conditions applicable to a new aircraft design at the time the manufacturer applies to FAA for a type certificate requires appropriate advance investigation by FAA of the flight envelope for those areas unique to the design class; i.e., Jets, SST. FAA decisions on requirements to achieve a minimum acceptable level of safety are critical to the manufacturers since all wish to start from a comparable base and need the requirements as early as possible for design and production purposes.

Because of the greatly expanded speed, altitude, and maneuvering capabilities of recent and proposed aircraft, there are correspondingly large changes in the flight characteristics. The regulations do not adequately cover these or may even be restrictive. For instance, the SSTs and next generation subsonic aircraft are statically unstable in the longitudinal axis. Although the existing regulations prohibit such a design concept, the agency simulated such flight conditions in E&D programs involving both ground and aircraft flight simulations so as to permit the FAA to establish for industry the level of static longitudinal instability which will be accepted.

The dynamic response characteristics, rather than the old, more familiar static stability and control parameters determine the flying qualities; that is, the safety of flight inherent in the aircraft as well as the ease and comfort. For some aircraft configurations and for certain flight regimes stability augmentation is required to achieve minimum acceptable flight characteristics. Powered flight controls, plus automatic stabilization systems, are being used to correct and compensate for inherent airframe design instabilities. All of these require new regulations and/or new acceptable means of showing compliance with a general regulation.

The program covers the range of existing and probable future civil aircraft configurations such as rotary-wing, executive jet and advanced transport. The overall program is open-ended and paced by the advancing state-of-aeronautical technologies, concentrating on controllability and maneuverability levels for critical flight regimes. Most of the E&D effort is

experimental rather than analytical and subject to the availability of suitable research facilities, especially ground-based and inflight simulators such as variable-stability aircraft. Because of the close relationship of civil and military handling qualities criteria and the efficiency of adding FAA test requirements to on-going performance development programs of military services and NASA, some of this work is under-taken jointly with these organizations.

5.2.2.3 Flight Operations

(1) Validation of Adequacy of Certification and Operation Standards

In order to develop corrective actions and new or revised certification and operating standards, operational data on such parameters as accelerations, control surface, engine and landing gear usage in various flight conditions must be collected on new transports. This will require the installation of airborne data acquisition systems to obtain statistically significant samples of normal operational data.

(2) Aircraft Certification Development

The unique performance and operational regimes of STOL, SST, and other advanced transport concepts will be investigated in ground and flight simulations to provide the data base for new certification, and operational standards. This effort examines the pilot-aircraft interactions that are critical to flight safety and are determined directly from the aircraft dynamic response characteristics, the pilot capability and the mission segment undertaken. The Flight Simulation of Advanced Aircraft (FSAA) and other simulation facilities at Ames are operated under the FAA-NASA Interagency Agreement and flown by FAA personnel in the examination, for example, of: (1) SST (Concorde) flight dynamics - approach operations performance; (2) Powered-lift STOL configurations minimum speed criteria, acceptable techniques of lift thrust control, etc., (3) conventional transports (next generation) stall determination criteria and margins; (4) use of simulation as tool to complement flight test for transport certification. These simulations allow the evaluation of proposed airworthiness change and certification flight test techniques to be explored beyond that which could be safely accomplished in flight test programs. In addition,

potentially hazardous areas that might be unforeseen with the introduction of new technology in the forthcoming conventional subsonic aircraft can be examined. Atmospheric considerations such as cross-winds, shears, and turbulence are becoming more critical in design and operation and can be part of the simulations, as needed, without awaiting the vagaries of the real world.

(3) Operational Use of CAT Systems

The feasibility of using an airborne turbulence intensity measuring system to provide a universal value to reduce the hazard posed by unexpected encounters with clear air turbulence is being evaluated. The means of integrating the turbulence intensity levels into the airway/weather system in real time for use by all aircraft in the hazard area will be covered. The progress of advanced concepts to detect and quantify turbulence in advance of an encounter will be monitored and the most promising system evaluated.

(4) Rational Landing Distance Rule

A proposed "rational landing distance" rule will be evaluated by means of testing a variety of transport aircraft on both dry and wet runways to measure actual stopping distance under a variety of approach speeds, glide slope angles, number of engines operating and braking methods. It is expected that this new certification method will be extended to include rational take-off accelerate-stop distance criteria.

5.2.2.4 Propulsion Certification Criteria

(1) Engine Failure Detection

A technique of relating ionized particles in the exhaust stream of failing engine as a method of forecasting engine failure will be investigated.

(2) Icing Protection

Means will be developed to update the regulatory requirements applicable to large turbofan engines to include ice detection and removal on the fan and front compressor stages blades, in addition to the ice protection now required on the inlet cowling and center bullet fairing.

(3) Stall Margin Sensors for compressors and fans of large turbines will be assessed, since compressor stall is becoming a critical safety item in high compression ratio engines.

(4) Improved Airborne Engine Vibration Instrumentation will be developed that differentiates flight loads from engine vibration.

(5) Jet Flameout Analysis and Prevention will be a joint FAA/NASA effort to understand this complex phenomenon, and thus preclude occurrence.

(6) Advanced Electronic Engine Controls Criteria will be evaluated in order to prepare a data base for development of regulatory requirements to certificate this new control method.

5.2.3 Products

5.2.3.1 Recent Products

Measurement of Lightning Strikes to Aircraft	1968
Investigation of Turboprop Engine Characteristics During Bird Injection	1968
The Development of Dynamic Taxi Design Procedures	1968
Dynamic Simulation of Sweptwing Transport Aircraft in Severe Turbulence	1968
Fracture Toughness and Crack Propagation of 300M high strength steel	1968
Friction Effects of Runway Grooves, Runway 18-36, Washington National Airport	1968
Model Fuselage Crash Impact Study	1969
Friction Effects of Runway Grooves, Runway 4R-22L, John F. Kennedy Airport	1969
Dynamic Test Criteria for Aircraft Seats	1969
Inflight Investigation of Lateral Directional Dynamic for Cruising Flight	1969

Altimetry, A Literature Review and Bibliography	1970
Simulator Analysis of the Longitudinal and Lateral Stability and Control Power Requirements	1971
Airline Operational Data From Unusual Events Recording Systems in Boeing 707, 727 and 737 Aircraft	1971
Flight Tests of the Longitudinal Stability and Control Power Requirements During Approach	1972
ILS, Flight and Ground Data From Unusual Events Recording System in a Commercial B-737 Aircraft	1972

5.2.3.2 Future Products

	Schedule
Experimental data to be used as the basis for revising FAR 25 pertinent to aircraft landing and take-off distances.	1973-1975
Criteria for use of simulation to complement flight test in transport certification.	1975
Supersonic Aircraft Standards	1974
Transport Flight Loads Design Criteria	12/1974
Transport Landing, Pivoting, Taxi, In-Service Loads Data Collection and Airworthiness Criteria	6/1975
Airframe and System Safety/Reliability Airworthiness Criteria	6/1975
Structural Airworthiness Criteria for Bomb Loads	6/1975
Non-Destructive Inspection Techniques	6/1976
Composite Materials Regulatory Compliance Means	6/1980
Advanced Technology Transport Standards	1977-80
Active Control Systems - Structural Requirements	1978
Active Control Systems - Aerodynamic Requirements	1978

	Transport Flying Qualities					1977	
	Revised or new regulatory requirements or corrective action for new aircraft based on the actual flight spectrum data obtained from similar operational aircraft.					1976	
	Powered Lift STOL Aircraft Performance and Operational Standards					1975	
5.2.4	Transport Safety Resources	1973	1974	1975	1976	1977	1978-82
	Airframe Airworthiness						2600
	Transport Flight Loads				200	100	
	Transport Ground Loads				300	100	
	Non-Destructive Inspection Techniques			140	100	100	
	Bomb Disposal Design	45					
	Airframe System Safety and Reliability Management	44		150	200	200	
	Composite Materials Criteria		27	140	200	200	
	Active Control Systems Criteria			330	200	100	
	Flight Characteristics						1500
	Advanced Transport Flying Qualities	50		250	100	300	
	Flight Operations						2100
	Performance/Operational Standards	128	316	350	350	350	
	Transport Certification Flight Test Simulation			250			
	Clear Air Turbulence System	50			250	250	
	Rational Landing Distance Criteria	27	400				

	1973	1974	1975	1976	1977	1978-82
Propulsion Certification Criteria						800
Engine Failure Detection	66			100	100	
Engine Icing Protection			300	400		
Stall Margin Sensors				100	200	
Improved Engine Vibration Measurements				100	200	
Jet Flameout Analysis and Prevention				100	100	
Electronic Engine Controls		67	150	200	100	
TOTAL	410	810	2060	2900	2400	7000

5.3 QSAT Safety

5.3.1 Problem

To meet the goals of the agency's Quiet Short Haul Air Transportation System Program, effort is required to provide analytical and test data suitable for the formulation of airworthiness certification and operational standards for QSAT type aircraft. The flight characteristics and operational flight profiles of these aircraft are enough different from current transport and rotary wing aircraft that a completely new body of safety rules will be required in the areas of flight characteristics and terminal operations. This work will provide data for a new Part XX Federal Air Regulation to provide airworthiness standards.

5.3.2 Program

The program in the near future involves exploration of QSAT type aircraft flying and handling qualities by means of the U. S. Navy's X-22 research V/STOL aircraft under a joint FAA-military flight test program. The unique X-22 permits variation of the aircraft longitudinal and lateral flight characteristics to permit exploring and determining minimum acceptable flying and handling qualities during typical QSAT operations.

The operational aspects of QSAT flight will be concentrated in the terminal area where these aircraft perform quite differently from conventional CTOL transports. The NASA Ames flight simulator, programmed to represent QSAT aircraft dynamics, is utilized for this work under a joint FAA-NASA Interagency Agreement.

The experiments being conducted at Ames have drawn the interest of both the British and French Civil Air Authorities. Both countries have sent some of their leading STOL pilots and engineers to participate in the test planning and flight evaluation. The French government made a Brequet 941 aircraft available to the FAA to conduct the necessary flights and data acquisition prior to programming its characteristics on the NASA simulator. The information derived from this program could lead to a mutual set of standards for all three countries.

Work also is underway to evaluate the environmental effects of icing and crosswinds on QSAT aircraft.

As the QSAT systems overall program proceeds and it becomes possible to determine more precisely the size, and configuration and powered lift form of those aircraft that will be developed to provide actual QSAT passenger transportation, these E&D

efforts in airworthiness and operations can be more finely tuned to provide the proper level of safety for this new air transportation means.

The following specific work items constitute the current and planned QSAT Safety Program.

5.2.2.1 Approach and Landing Characteristics

The approach angles of a steep gradient aircraft, approach speeds, rates of sink, allowable angles of attack, configuration changes, the beam width and height of electronic guidance systems, and landing distances are all unique areas requiring investigation and revised or new safety standards.

5.2.2.2 Performance and Operations

The unique portions of the Short Haul Aircraft flight envelope will require close evaluation of certification standards with: system failures such as one engine inoperative take-offs and go-arounds during approaches; loss of stability augmentation and the resulting flight characteristics; obstacle clearance planes; noise abatement procedures; and pilot qualifications.

5.2.2.3 Environmental Considerations

The Short Haul System will require that the aircraft have a dependable high completion rate regardless of weather. The two immediate problem areas are crosswinds and icing. It is envisioned that most STOLports will only have a single runway, thereby, increasing the percentage of time and magnitude of the crosswind that a STOLcraft will see. The initial effort is to develop a means of reducing, redirecting and tailoring the wind profile with an airport crosswind control system and evaluating its feasibility to reduce the hazard. The high lift devices associated with a STOLcraft flying at low speeds and altitude may make ice, and/or freezing rain or drizzle, a hazard that we have not seen since the days of the DC-3 & 4. The unique characteristics of the STOLcraft are being identified with respect to the relative protection needed and a determination made as to the necessity to revise the current icing airworthiness requirements. The development of modified icing standards and new freezing rain/drizzle standards, if required, will take considerable time and effort.

5.2.2.4 Flight Characteristics

Dynamic analyses and experimental flight tests will be conducted to determine the minimum acceptable flight characteristics for

QSAT type aircraft. The slow flight regime and steep approach requirements for these aircraft coupled with the variety of powered lift concepts that might be utilized, make the determination of minimum acceptable longitudinal and lateral dynamic flight characteristics a complex task. Research aircraft such as the X-22 and others will be used to obtain test data from which suitable certification standards can be developed for all future designs of this type that would be offered to the agency for certification.

5.3.3 Products

5.3.3.1 Recent Products

A Flight Simulator Study of STOL Transport Lateral Control Characteristics	1970
Simulator Tests to Determine Lateral Directional and Longitudinal Stability and Flight Control Requirements	1971-72
Technical Feasibility of a Floating Interim Manhattan STOLport	1972
Interim Report on Ground Level STOLport - Aircraft (DHC-6) Evaluation	1973
X-22 Flight Tests to Verify Longitudinal Stability and Flight Control Requirements	1973

5.3.3.2 Future Products

	Schedule
STOL Performance Airworthiness Criteria	
First generation (i.e. turboprop)	12/73
Second generation (i.e. AMST)	4/75
Finalized Powered Lift Standards	12/75
STOL Operational Criteria	4/74
STOL Certification Test Techniques	2/74
VTOL Performance Airworthiness Criteria	12/76
Steep Gradient Flight Path Criteria	6/74
Crosswind Control Device Recommendation	6/74

Icing and Freezing Rain Criteria	6/74
Performance Criteria With System Failures	
First generation STOL	6/74
Second generation STOL	9/75
VTOL	9/77

5.3.4 QSAT Safety Resources

	1973	1974	1975	1976	1977	1978-82
Performance and Operations	96	486	380	300	300	2000
Environmental Considerations	0	220	250	200	200	600
Flight Characteristics	152	454	205	350	350	1400
TOTAL	248	1160	835*	850*	850*	4000*

5.4 General Aviation Aircraft Safety

5.4.1 Problem

Light aircraft flown for personal and business uses have one of the poorest safety records of all forms of transportation. Each year some 1400 fatalities occur out of approximately 5000 accidents involving the destruction of over 1000 aircraft.

Pilot error is listed by the National Transportation Safety Board as the principal cause in over 80% of the fatal accidents. These errors range, in order of frequency of occurance, from failure to maintain flying speed (stall/spin), continued flight into adverse weather including spatial disorientation, improper pre-flight procedures, the exercise of poor judgment and flying while physically impaired to a large variety of miscellaneous reasons for crashes. The aircraft/pilot combination is the main contributor to light aircraft crashes. Physical failure of the aircraft itself, without the pilot aiding it, is relatively rare, with engine malfunction being the largest factor. Structural failure of the aircraft is an extremely rare phenomenon.

* For FY 1975 and subsequent years, $600K per year of these funds are provided by Program 22, QSAT.

5.4.2 Program

The E&D program presented here attacks the problem of crash survivability, the problem of devising solutions to the multiple causes of aircraft accidents, and the problems of pilot training and proficiency. All accidents culminate in the aircraft impacting the earth and it is this impact that causes most of the fatalities, although fire occurs in many cases. The large number of fatalities that occur with relatively little aircraft structural damage warrant a major effort to provide the analytical and experimental test base for upgrading the crash loads requirements of FAR 23 to include dynamic crash load protection and to provide a means for compliance. Improved crash survivability appears to be the most effective way to improve light aircraft safety since it would apply to all accidents without regard to their cause.

5.4.2.1 General Aviation Safety

The efforts in this area are assembled into three destinct areas, Impact Survivability, Flight Safety and Pilot Competence. These emphasize the need for improved crash survivability protection in light aircraft; the need for those flight safety improvements to prevent crashes that could be made within the state-of-the-art that also would maintain the performance and marketability of the aircraft, and the need for a reduction of pilot related accident cause/factors.

These efforts would establish a validated basis for safety standards leading to safer aircraft. These standards would be developed with the cooperation of the aviation community including the airframe manufacturers, user organizations and other government agencies.

5.4.2.2 Impact Survivability Criteria

The effort to improve crash survivability protection in light aircraft is divided into three chronological phases.

Phase I - Development of Analytical Techniques (FY-72 FY-74) During this phase, analytical techniques for crash survivability design will be developed. The development will emphasize:

- occupant packaging including energy absorption devices and restraint systems
- cabin design to insure maximum protection of the occupants through controlled crush characteristics.

- fuel-system crashworthiness
- application of existing technology in structural dynamic analysis

The emphasis on development of analytical techniques recognizes that full-scale crash test verification of each new model or improvement would place an economic burden on an industry characterized by low volume production runs.

Phase II - Verification of Analytical Techniques (FY-74 FY-75

During this phase, full-scale crash tests would be conducted to verify the full range of the analytical techniques developed during Phase I. Manuals clearly describing the analytical techniques would be prepared and widely distributed to assure the understanding and availability of the new techniques to the industry.

Phase III - Parametric Design Analysis (FY-75)

During this phase, trade-off studies would evaluate crash safety improvements versus economic and other costs, such as weight, performance, marketability, etc. The study would review many possible combinations of crash safety concepts to find a practical combination yielding optimum expected crash safety improvements. A proposed dynamic crash design criteria would be finalized based on the analysis of various practical aircraft configurations and a statistical analysis of aircraft accident data.

5.4.2.3 General Aviation Flight Safety

There are several areas of emphasis to develop practical airworthiness improvements that apply aerospace state-of-the-art to general aviation within the economic bounds of the industry.

(1) Flight Loads Design Criteria

- Power Spectrual Density Analysis

In prior years the agency developed and validated a design procedure for analyzing large airplane response to continuous turbulence. This will be extended to provide for more simplified procedures for small rigid type aircraft.

. VG VGH Analysis

For the past ten years NASA has been acquiring and reducing VG/VGH data on a number of general aviation aircraft. An analysis will be made regarding its impact on FAR 23.

(2) Engine and Propeller Certification Criteria

. Propeller Failure

Investigation of factors influencing propeller blade failures involves devising and testing a vastly improved apparatus for flight test measurement of propeller blade vibrations and stresses. This unit will be used for aircraft type certification demonstrations and will permit updating the applicable regulations.

. Rotary Combustion Engine Safety Criteria would evaluate these new engines and determine regulatory changes and procedures required.

(3) Flight Characteristics Criteria

The minimum acceptable flight characteristics criteria for light aircraft will be developed on the basis of both analytical and experimental flight tests. These will cover flight control near stall, manuevering criteria, longitudinal stability and crosswind landing criteria. The main area of emphasis is the avoidance of stall/spin accidents through a program to develop and evaluate criteria and/or hardware for use in airplane design to avoid stalls in operational service.

5.4.2.4 Pilot Competence

This effort responds to the need for improving the training and performance of the general aviation pilot. Primary areas of emphasis are described below.

(1) Airmen Performance Criteria and Skill Degradation

Determine skill degradation rates of all pilot categories-private, commercial, instrument, and multi-engine as a function of total and recent flying experience.

. Instrument flying "motor skills:" - (ability to perform specific maneuvers) of non-instrument rated private and commercial pilots have been measured and a statistical curve developed for use in estimating the amount of instruction time required to return these pilots to certification flight performance level.

- Pilot knowledge of the use, function and integration of flight instruments has been measured.

- Degradation of ability to perform flight maneuvers required for private and commercial certification is being measured under current contract effort.

- Remaining categories of pilots will be measured similarly. Continue development of criteria for the characteristics of ground trainers and for their use in lieu of aircraft for pilot training.

(2) Field Flight Evaluation of Objective Flight Test

- Abbreviated field evaluation of an objective private pilot flight test developed under prior year contract is presently underway as part of effort indicated above.

- Development and full-field evaluations of objective flight tests for all pilot categories are programmed.

5.4.3 Products

5.4.3.1 Recent Products

Development of an Engine Powered, Liquid Dispense System for Agricultural Aircraft	1968
Reciprocating Engine and Exhaust Vibration and Temperature Levels in General Aviation Aircraft	1968
Metallurgical Evaluation of Aircraft Exhaust System Components Failed During Ground Test Program	1968
Study to Determine the Flight Profile and Mission of the Certificated Private Pilot	1968
General Aviation Cockpit Display and Control Simulation	1968
Evaluation of Angle of Attack Instrumentation in Training of Student Pilots to Private Pilot Certification	1968
Evaluation of Low-Cost Collision Avoidance Ground Training Equipment	1968
Evaluation of Experimental Flight Data Recorders in an Aircraft Crash Environment	1968
Model Fuselage Crash Impact Study	1969

An Engineering Investigation and Analysis of Crash-Fire Resistant Fuel Tanks	1970
Flying Qualities of Small General Aviation Airplanes Part I	1969
Dynamic Test Criteria for Aircraft Seats	1969
Experimentation and Evaluation of Improved Stall Warning Equipment	1969
Accelerated Testing of General Aviation Engine Exhaust Systems	1970
Study of Pre-Flight Procedures of General Aviation	1970
A Study of the Effect of Time on the Instrument Skill of the Private and Commercial Pilot	1970
Flight Evaluation of a Pilot Assist Stability Augmentation System for Light Aircraft	1970
Develop an Objective Flight Test for the Certification of the Private Pilot	1970
Study to Determine the Operational Profile and Mission of the Certificated Instrument Rated Private and Commercial Pilot	1970
Investigation of Two Methods for Improving the Crash-worthiness of Integral Fuel Tanks	1970
Flying Qualities of Small General Aviation Airplanes Part 2	1970
Flying Qualities of Small General Aviation Airplanes Part 3	1971
Crash Resistant Fuel Systems Demonstration and Evaluation	1971
Flying Qualities of Small General Aviation Airplanes Part 4	1971
Inflatable Restraint Concepts for General Aviation Aircraft	1972
Seat/Restraint System Analytical Procedures Developed	1973

	Purchase Test Aircraft to Support Crash Program	1973
	Initiate Aircraft Crashworthiness Analysis	1973
	Established FAA-GAMA Working Group on Stall/Spin Avoidance	1973

5.4.3.2	Future Products	Schedule
	Aircraft crash analysis methods developed; crash tests initiated.	12/74
	Parametric design analysis completed.	5/75
	Flight loads design criteria completed.	12/75
	Provide data to support more stringent currency requirements for all categories of pilots.	1974-80
	Provide data to support flight and ground training technology and syllabi more responsive to the requirements of the future.	1974-80
	Acceptable flight test measurement means of propeller vibration and stresses for aircraft certification developed.	1/74

	1973	1974	1975	1976	1977	1978-82
Design Criteria - New Engines				100	100	
9550 Requests			100	100	100	500
TOTAL	441	1065	1525	1825	2150	6200

5.5 Aircraft Security

5.5.1 Problem

In the last ten years there were 127 hijacking of U.S. commercial airlines. Of these, all but ten have occurred since 1968. Fortunately, the loss of life from hijackings has been limited to three people, but the indirect operational and passenger reaction cost in lost business has been significant. Explosive sabotage has been limited to three aircraft explosions in the last ten years, only one of which occurred during flight and causing passenger fatalities. However, bomb threats have dramatically increased in the last few years and now approach 1000 per year.

5.5.2 Program

The objectives of the R&D program is to develop systems and devices which are effective and economically viable in operational use to prevent and deter either hijackings or sabotage for whatever reason in the civil air transportation system. The effort involves assessment of the various technologies available such as electronic explosive vapor detection, neutron explosive detection, imaging X-Rays, dogs for explosive detection, trace element seeding of explosives to permit detection and telephone call tracing. These are potential techniques to detect explosives on passengers and in baggage and in aircraft. Techniques for weapon detection involve magnetometers, X-Rays, non-imaging methods, holography and sonics. The agency recently has been requested by the Department of Transportation to evaluate the requirements and potential devices for the security of all functional aspects of the entire airport complex.

The outputs from the projects described below will be used in establishing regulatory requirements for commercial airlines or for guidance in purchasing airport equipment for use by law enforcement agencies.

5.5.2.1 Explosive Vapor Detection

The September 1973 effort is the first effort to quantify the requirement of an electronic vapor detection to replace the use of dogs. This effort defines the disfusion of explosive vapors between their source and potential detection locations for several applications in the air transportation environment. The results indicate the detector sensitivities required may well be achievable with further development.

The 1972 effort will complete the requirement definition by identifying dynamite vapor emission rates and molecules, and determining the modified emission rates of the explosive where contained in typical passenger luggage. It will also identify possible normal atmosphere substances that could be interference to the detector function.

Assuming the sensitivity requirements indicated from the above study are compatible with potential projected detectors, a program will be initiated to achieve the required hardware capability. The cost and schedule and such hardware program are difficult to definitize at this time.

5.5.2.2 Dogs

Dogs are currently the best solution to search task for explosives in the airport environment. The 1972 effort was to train four animals and handlers for this specific purpose and demonstrate both their usefulness and limitations at Washington, D. C. Metropolitan Airports.

A recent decision has been made to use available LEAA funds for procurring 40 animals and handlers for use in emergency explosive search at 20 region airports.

5.5.2.3 Neutrons

The prior and initial application efforts for this concept indicated a discrimination problem between the nitrogen and explosives and personal baggage items containing copper. The program with AEC Livermore is a laboratory effort to resolve this discrimination problem and identify the best neutron sources. Optimum instrumentation and operational safety aspects of the equipment will also be covered.

At the completion of this effort, a decision will be made concerning the development of an operational unit. This decision will also be influenced by the development of other techniques for this purpose.

5.5.2.4 Seeding of Explosives

The lack of a practical explosion detector dictates this program be reconsidered. Seeding with Colbalt 60 has been proven technically feasible but was discarded for safety reasons. Other non-radioactive seeding elements are possible. The seeding of products for identification has not been accepted for reasons of economics, logistics, manufacturing, and legal aspects and this study will consider these aspects.

The decision on any follow-on program resulting from this study will be dependent on the findings and other development in explosive detection.

5.5.2.5 Electro-Magnetic Weapon Detector for Baggage

This type of detector has been successfully developed for people and will be a most practical device if the required performance can be achieved with carry-on baggage. The only current alternative is physical search. The 1972 work determined the characteristics of the magnetic field, if any, that will permit weapon detection with reasonable false alarms in normal baggage handling systems.

If this technique can be demonstrated a combined weapon detector for people and hand carried baggage is justified by operational needs.

5.5.2.6 Non-Imaging Weapon and/or Explosive Detector for Baggage

This effort is directed as an alternative to the electro-magnetic approach and in addition to weapons will be used for explosive detection. The output of this program will be an operationally evaluated piece of hardware assuming successful completion of the prior prerequisite phases of the planned contract.

5.5.3 Products

5.5.3.1 Recent Products

Development of Electro-Magnetic Weapon Detector	1972
Completion of Field Evaluation of Off-The-Shelf Metal Detectors	1972

Development of Electro-Magnetic Weapon Detector	1972
Report on Evaluation of X-Rays in Operational Use	1972
Report on Training and Use of Dogs in Detecting Explosives	1973
Report on Evaluation of Fast Neutrons for Detecting Explosives in Checked Baggage	1972
Report on Operational Anti-Hijacking System 10A - 6/1/72	
Report on Technical Concepts to Prevent Hijacking and Sabotage	1972

5.5.3.2 Future Products

	Schedule
Explosive Vapor Detection Equipment	6/74
Operational Use of Dogs at 20 Airports	6/74
Neutron Activation Equipment	12/74
Demonstrate Explosive Seeding	3/74
Airport Security Concepts - Requirements	6/73
Electro Magnetic Hand Carried Baggage Detector	4/74
Non-Imaging Explosive Detector	1/74

5.5.4 Aircraft Security Resources

	1973	1974	1975	1976	1977	1978-82
Weapon/Baggage Detection	215	100	200	200		1000
Explosive/Sabotage Detection	132	140	150	100	100	1000
Aviation Security Systems		214	200	200	200	1000
TOTAL	347	454	550	500	300	3000

6. Resource Requirements

	1973	1974	1975	1976	1977	1978-82
Fire Safety	701	1212	1500	1250	900	6000
Transport Safety	410	810	2060	2900	2400	7000
QSAT Safety	248	1160	835	850	850	4000 *
Light Aircraft Safety	441	1065	1525	1825	2150	6200
Aircraft Security	347	454	550	500	300	3000
TOTAL	2147	4701	6470	7325	6600	26200
						5240/yr

7. Interface and Coordination With Other Programs

The variety of efforts in the Aircraft Safety Program require a large number of coordinated efforts with other government agencies but primarily with the military services. The Department of Defense agencies not only have superb testing facilities for aircraft, engines and operational tests but also have some safety problems with military aircraft that are similar to those of civil aircraft. This commonality of interests leads to the conduct of joint safety programs whose results are mutually beneficial to both the DOD and the FAA. Examples of other agencies with whom joint efforts are carried out are in the National Aeronautics and Space Administration, the Atomic Energy Commission and the National Bureau of Standards.

* For FY 1975 and subsequent years, $600K of these funds are provided by Program 22, QSAT.

A list of current Interagency Agreements is provided below.

USA-FAA DOT-FA72WA-272
Optimum Runway Groove Shape

USAF-FAA-NASA DOT-FA72WAI-278
Landing Performance Computer Correlation Program

U. S. Army - FAA DOT-FAWAI-275
Fuel Electrostatics

National Bureau of Standards - FAA DOT-FA67-NF-AP-21
Study of Cabin Flash Fires

Atomic Energy Commission - FAA DOT-FA71WAI-211
Neutron Activation of Explosives for Detection

Fairfax County, Va. - FAA DOT-FA72WAI-251
Dogs for Explosive Detection

U. S. Navy - FAA DOT-FA72WAI-246
X-22 Variable Stability V/STOL Program

U. S. Air Force - FAA DOT-FA72WAI-243
Total In-Flight Simulator (TIFS) Variable Stability Transport Program

NASA-FAA DOT-FA-72-WAI-285
Simulation Facilities of Ames Research Center

NASA-FAA DOT-FA-72-WAI-308
Flight Path Control Spoiler Evaluation

U. S. Navy - FAA DOT-FA-71-WAI-231
Review of FAA V/STOL Standards (Part XX)

British and French Civil Air Authorities - FAA Informal Working Agreements on STOL Aircraft Standards

U. S. Navy - FAA DOT-FA-71-NA-AP-98
Engine Combustor Tests with Modified Fuel

U. S. Navy - FAA DOT-FA-72-NA-AP-17
Modified Fuel Crash Tests

Mr. HECHLER. I notice you have several specific interagency agreements, you mentioned about a dozen. You also mentioned some of the joint work you are doing with NASA and some of the specific divisions of responsibility with NASA.

Do you have a written interagency agreement with NASA so far as deciding how you divide certain aspects of research in the aviation field?

Mr. ISRAEL. I would have to double check. I don't think so. I don't think we have a written document.

Mr. HECHLER. What is the principle on which you proceed that you establish the line of demarcation?

Mr. ISRAEL. The principal vehicle for resolving such issues would be discussion at the meetings of the NASA–FAA Coordinating Committee.

Mr. HECHLER. How do you decide what you are going to do in Atlantic City or what NASA will do, and with what kind of general guidelines?

Mr. ISRAEL. As noted, I am not aware of any formal written guidelines or agreement. As a new problem arises, or as new ideas and new possibilities arise, we sit down and ask ourselves such questions as: Where is the expertise in this problem? Where are there existing efforts going on? What facilities are available? Generally speaking, because it is a fairly small, well-knit community that is working on aircraft safety, I think the answers are generally well known. I don't think this is a large void. The participants in the field know reasonably well where the other areas of expertise are. On the basis of where the people are, where the facilities are, et cetera—the decision gets made rather simply. There are certain areas, relating to facilities, for example, that we—FAA—decided we would not get further into. For example, advanced simulators. We decided several years ago we would leave that entire area up to NASA. We in fact have a group of people at NASA–AIES to use their advanced simulators. For wind tunnels, we would go to NASA first.

Mr. HECHLER. How do you make that decision?

Mr. ISRAEL. The decision is made basically by working-level managers and will be reviewed at the NASA–FAA Coordinating Committee meeting, if necessary, to confirm it.

Mr. HECHLER. I know what your mechanism is. I am trying to see if I can figure out what the principle is that you use in making the decision, and you say expertise or facilities. That seems to be kind of a casual way of making a decision like that. It may be the most important factor.

Mr. ISRAEL. For a given type of test, a key question is who has the necessary facility? If the problem is fire extinguishing in an aircraft, in an airframe, we know that we have such airframes at NAFEC. They have been instrumented and used before. If the problem is the simulation of dynamic response of a new or old aircraft, or some wind tunnel work, our first thought would be to go to NASA. Another example is the problem of eliminating or avoiding trailing wake vortices behind aircraft. We are not aerodynamicists; thus the work on an aerodynamic solution to wake vortices is pursued by NASA. Not much of a decision was involved there; it was obvious that NASA should be involved. The derivation of a system of ground sensors to sense and

avoid wake vortices was something in which we had experience because we had been looking at measuring upper altitude winds. In general, we look to NASA for advancement of the state-of-the-art, aircraft design, and techniques of operating aircraft. For the more prosaic engineering aspects of burning materials, putting out fires and that sort of thing, we have had the experience and facilities and we generally do that at NAFEC.

Mr. HECHLER. Mr. Israel, you probably heard some of the discussion this morning. I wondered if you would care to make any comments or general observations to add to what was discussed this morning, particularly with relation to FAA or any other general application of what we ought to be doing in the aviation safety field that you would care to add.

Mr. ISRAEL. Yes, sir.

To my mind, the people working on safety, as I said earlier, are a relatively small, well-knit community. I don't think the problem is lack of information. I don't think the problem is duplication. I think there is a good exchange of information through the professional societies, the industrial committees and the meetings which you heard of this morning. I don't think it is a problem of cataloging or sending around information. I think those who are working in the field at the detailed level have a pretty good idea of what is going on.

I similarly don't feel that it is really a problem of coordination. As I look to the interface we have with NASA, we have the NASA–FAA Coordinating Committee. Only infrequently do we find something that seems to fall across our joint responsibilities. Generally, when a subject comes up for solution, it becomes clear as to whose area of expertise and responsibility it should be.

For example, as regards a collision avoidance system. Several years ago NASA had some interest in the problem. While the effort started on a coordinated basis, very shortly it became clear that we had the primary lead, interest, and knowledge. Subsequently they terminated their work and we are doing it all.

Also, I don't believe that the organizational arrangements or approaches used by the Joint Technical Coordination Group on Aircraft Survivability are directly pertinent. You form such a group, in my mind, when you want to eliminate duplication among the services, or when you wish to provide a leading edge to get something new started. I don't, again, believe that either is the case in the aircraft safety problem.

I don't think you need a new organization to coordinate what is going on. I think the basic question in aircraft safety is whether we are doing enough. That is a very hard question: Are you doing enough? On a number of occasions, I have looked at our own program and wondered, for example, whether $3½ million was enough. This is very different from some of the other FAA R. & D. programs where the results of these other programs are new pieces of equipment, a new computer, new traffic control display or collision avoidance device. The result of our work in FAA in aircraft safety is information that we use for rules and regulations, and it is very hard to assess the value of it. The basic questions that must be faced are: Are we doing enough aircraft safety? How do you decide if we need to be doing more? How much more?

I hope that is responsive.

Mr. HECHLER. Mr. Milford.

Mr. MILFORD. Thank you, Mr. Chairman.

To follow up the question that you asked, and I am not sure we really came to an answer, if I understand your interchange with the chairman about the related roles between you and NASA, would I be summarizing it properly to say that a problem arises and is identified and whoever has the best expertise, the law of assumption kind of takes over, would that be a fair summary?

Mr. ISRAEL. That coupled to the fact we look to them if it is largely a matter of aerodynamics or design of a complete operating aircraft. The advanced R. & D., generally speaking, I feel is with NASA. For some of the closer in day-to-day engineering and development to support the regulatory work, we would think that we would start with our own facilities.

Mr. MILFORD. You were present this morning, I believe?

Mr. ISRAEL. Yes.

Mr. MILFORD. As you know, I have been asking a series of questions in relation to liability litigation and the effects on accident investigation and air safety in general.

I would like to pursue that a bit in relation to FAA's role.

Mr. ISRAEL. Sir, I must confess I am not the right witness for that subject. Unless it has an R. & D. flavor, I could not help you. I am really not involved in the legal or the aircraft accident investigation aspects.

Mr. MILFORD. No further questions.

Mr. HECHLER. Since you brought that up, do you have any idea how much is spent on aviation safety R. & D. Government wide? You used the figure $3½ million, I believe.

Mr. ISRAEL. Mr. Chairman, I was using the word "aircraft safety." I want to make that distinction. For FAA, in terms of what I described as aircraft safety, $3½ million. I think NASA's budget in the same area, but their definition may not be exactly the same, is $8 to $10 million.

If you talk about aviation safety and wish to include collision avoidance or terrain warning which we heard discussed this morning, medical aspects, human factors, and instrument landing systems—that is, the whole host of other things that pertain to aviation safety—then in the FAA is several tens of millions.

In terms of aircraft safety, no, sir, I don't know how much, for example, the Department of Defense budget is.

Mr. HECHLER. You see no need for any kind of a national safety information system or central repository?

Mr. ISRAEL. Frankly, no. Do either of you?

Mr. GREENE. No.

Mr. HECHLER. How does everybody find out what is going on?

Mr. GREENE. I believe we get quite a bit of safety information now. It is almost a problem to keep up with it, it comes from a variety of sources, whether NASA, DOD reports, or British reports, plus the personal contacts that occur. I think our people do have a good feel for what is published and what is going on.

Mr. ISRAEL. It is surprising how many meetings are going on, professional society meetings et cetera. I am conscious of this because I sign the travel requests.

Mr. HECHLER. That does not always result in communication and coordination. Sometimes it results in obfuscation.

Mr. ISRAEL. That is true, but really I think there are multiple opportunities, including publications, reports, the industry committees, the professional society meetings, very many opportunities for our staff to know what is going on, and we are, of course, meeting frequently with the NASA staff. So I find it hard to believe that we are not making progress because we don't know what is going on.

I am not sure it would hurt if you wanted to have a central repository, but I am not sure it would help either.

Mr. GREENE. Mr. Chairman, may I add something, sir?

Mr. HECHLER. Certainly.

Mr. GREENE. One of the best mechanisms for the application and the transfer of this technology is through the various people who put the technology into practice. That is, the aircraft industry. Both NASA and the FAA/DOT work very closely with those elements. Just as General Yeager spoke this morning of the activities he has done in crash investigation working with the industry representatives. I have been an industry representative working with Air Force crash investigations. Those men work on civil as well as military programs within those companies, and I can assure you, sir, there is not a single developer who consciously builds, or affects an unsafe configuration. He learns of safety in military experience, civil experience, he learns how to solve it in design and he applies it. That is probably the most direct way in which the technology is brought to bear.

Mr. HECHLER. I was interested in hearing what General Yeager said this morning that there is no central authority that makes or requires routine exchange of flight safety research data. I must know what to ask for and I must know who has it, before I can get any of these data; and to use an extreme example, I remember I had an assignment once in Europe at the end of World War II to collect some material for a combat history of operations, as combat was going on. So I went to the G–3 and I said I would like to look at some of your operational documents and he said, well, specifically which document do you want and which data do you want.

Mr. GREENE. Yes, sir. That is a trap.

Mr. HECHLER. This makes it a little bit difficult if you are seeking things to simply say. Oh well, it is all available, it is published. You can get it if you can define what the specific number of that document is.

Mr. GREENE. I agree, sir. I was talking with General Yeager. I have known him for a good many years. I was talking with him prior to his testimony today, and one of the things he is particularly anxious to be able to do is have, at least in the military structure, an almost instant readout of a problem diagnosis.

Mr. HECHLER. What is wrong with that?

Mr. GREENE. There is nothing wrong with it, sir, if we have enough money to build it or buy it. It is a question of data retrieval. You must build a system, a computer logic and all the rest of the processes, and

it is a tremendous computational job. Otherwise you get the question that you raised: What document do you want? Unless you know the contents of all the documents it is hard to find.

Mr. ISRAEL. There is a lot of experience in trying to build these information retrieval systems that are going to be general purpose. However, after the expenditure of many millions of dollars, someone asks a specific question, and it usually turns out to be the one question you were not prepared to answer. There is no question that putting some of this information together could be helpful. I don't believe that there is a lack of opportunity, a lack of publications. I don't think that the progress is being inpeded to any noticeable extent. It may be that a new investigator in the field, in his apprenticeship, may not know where to go immediately to find something out. It seems to me reasonably clear that anyone who has worked in the field does know where to look for information. For example, one source would be the professional societies and their subcommittees. There are some 12 or 10 committees in which we participate. The Society of Automotive Engineers has panels on aircraft instruments, aerospace landing gears systems, aircraft exterior lighting, noise measurements, et cetera.

I don't want to belabor the point. I just don't see information as a major impediment to progress.

Mr. HECHLER. We are all inundated by papers, in the effort to try to get quickly what is already available in the aviation safety area.

Mr. Milford, any further questions?

Mr. MILFORD. No.

Mr. HECHLER. Mr. Wells?

Mr. WELLS. Mr. Israel, following this line of inquiry on the specific recommendation that General Yeager had, your comments were directed mostly to your contacts with NASA, and in your testimony you did make a brief reference to your working with Commander Johnson's office from the testimony this morning.

On the national information system, as distinct from some management superstructure, I think we are trying to separate the two different aspects.

Mr. ISRAEL. Yes, sir.

Mr. WELLS. Do you feel confident in your judgment that you do not have a problem as far as information access to the military or civil, whatever the area might be at this time?

Mr. ISRAEL. Yes, sir. I do not have a problem.

Mr. HECHLER. We don't want to create one for you if you don't have one.

Mr. WELLS. And we will be hearing some testimony from NASA on the safety Aerospace Research Data Institute, which they have at the Lewis Research Center, which is probably understaffed. We are going to get some testimony that this could well be expanded, which puzzles me a little bit about your response that you do not see a problem as far as the adequacy, availability, proper cataloging so that anyone, anywhere in the industrial or government system can plug in fairly quickly to get what they are looking for.

Mr. ISRAEL. Perhaps I did not say it correctly. I meant to say that the existing facilities handle the problem and I included that as one. I don't see where some entirely new overall encompassing military-civil-national safety information system is needed.

Mr. WELLS. But could our existing system be improved?

Mr. ISRAEL. I think so.

Mr. GREENE. More funds would certainly help that program at Lewis. We are very familiar with it and working closely with it. Certainly if the funds were available, we could accomplish more through that process. But that is a matter of balancing the priorities. We do not now supply funds and we don't have funds to supply, but we work with them and if it is crucial, we can scrape funds up to help.

Mr. WELLS. Your testimony seems to characterize a system which is fairly informal and depends on people knowing each other and having contacts within this closely knit community. This is in contrast to a catalog system that General Yeager referred to in his system, which would be accessible to the entire industrial community as well as government. I think this is kind of the issue as we see it.

Mr. ISRAEL. In my judgment I don't see the need for it.

Mr. HECHLER. If there are no further questions, the committee will stand in recess for 10 minutes, after which we will hear from J. Lloyd Jones of NASA.

Thank you, Mr. Israel, and your associates for appearing before the committee.

The committee will reconvene in 10 minutes.

[Whereupon, at 2:40 p.m., the committee recessed, to reconvene at 2:55 p.m.]

Mr. HECHLER. The committee will be in order.

Resuming our hearings on aviation safety, the committee welcomes J. Lloyd Jones, Deputy Associate Administrator Aeronautics, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration.

It is a pleasure to have you with us, Mr. Jones.

Do you have a prepared statement?

Mr. JONES. Yes, Mr. Chairman, I have. With your permission, and in the interest of saving time, I would present an abbreviated version of that statement and submit the full statement for the record.

Mr. HECHLER. The entire statement will be incorporated into the record.

AVIATION SAFETY TECHNOLOGY

Statement of

J. Lloyd Jones

Deputy Associate Administrator for Aeronautics
Office of Aeronautics and Space Technology
National Aeronautics & Space Administration

before the

Subcommittee on Aeronautics & Space Technology
Committee on Science and Astronautics
House of Representatives

Mr. Chairman and members of the Subcommittee, the continuing exploration of aeronautical research and development in these hearings is an important, useful process, and we are pleased to have this opportunity to discuss our views on aviation safety research and development.

That NASA regards aviation safety as important is attested to by a doubling of our aviation safety research budget from $4.2M in FY 1972 to $8.4M in FY 1975. The improvement in aviation safety is one of several major goals established by NASA which contribute to the objective of improving our nation's aviation system.

The transfer of ideas, techniques, and technology, including safety-related technology, between civil and

military systems is taking place effectively. Historically, this process was explored in both the Joint DOT-NASA Civil Aviation R&D Policy Study (CARD), and the Joint DOD-NASA-DOT Study of Research and Development Contributions to Aviation Progress (RADCAP).

These studies verify the fact that in the past, military aviation requirements generally demanded a more advanced technology which later found applications to civil systems. In recent years, however, diverging requirements of civil and military aviation systems have somewhat lessened the applicability of military systems technology, with the resulting incentive for more civil aviation-oriented research.

An important channel for the transfer of safety-related technology has always been the U.S. aircraft industry. Serving both civil and military customers in a competitive business environment, the industry provides for many channels of safety technology and information transfer between civil and military users.

Another effective channel for the transfer of aviation safety knowledge was the NACA, and now NASA. The NACA Subcommittee on Aircraft Safety drew upon both military and civil organizations for its membership, and concerned itself with identifying problems, advising on appropriate research

to solve the problems, and reporting on research results. NASA continues to conduct basic aviation safety research and technology development upon which both civil and military aviation draw.

To aid in the transfer of safety information and research findings, NASA established the Aerospace Safety Research and Data Institute (ASRDI) at Lewis Research Center in 1968. Within the Institute, there is an Aerospace Safety Data Bank, whose function is the gathering, analysis, evaluation, retrieval, and dissemination of safety-related technical information. The services of this Data Bank are made available not only to NASA, but also to its contractors, other government agencies, and the technical community at large. Briefings describing its capabilities are being provided to interested organizations at the present time. Recent special publications of ASRDI include directories of technical specialists in the fields of fire technology and structural failure. NASA technical publications, technical papers presented at technical meetings, and press releases on technical achievements also help to transfer knowledge of safety research results to both civil and military users. In addition, point-to-point contact between individual technologists cannot be overlooked as an effective mode of transfer.

Yet another channel for assuring the transfer of safety knowledge between civil and military aviation is the assignment of military technical liaison personnel to NASA Centers, and more recently, the assignment of NASA technical specialists to military aviation laboratories. The co-location of military researchers in NASA laboratories, working with NASA engineers and sharing NASA facilities also encourages the prompt transfer of ideas, techniques and technology between civil and military aviation.

The FAA and military services also exchange personnel in various program areas, and NASA participates in several joint safety research programs with FAA and the military services. The National Transportation Safety Board's Bureau of Aviation Safety fosters the exchange of safety information between civil and military aviation in the interests of accident prevention.

Independent groups such as the Flight Safety Foundation, and universities such as USC's Institute of Safety and Systems Management and University of Michigan's Safety Institute are also effective in fostering the sharing of safety knowledge and experience between both military and civil aviation.

My point should be clear: there are many active channels of communication in our country which are effectively transferring safety knowledge freely and creatively between civil and military aviation.

NASA's aviation safety research programs respond to needs identified by civil operators, the military services, manufacturers, regulatory agencies, investigatory bodies, and the public. Our response is to perform research to provide technical information that will help these various groups improve the execution of their responsibilities for aviation safety. With the help of these groups, we try to identify system weaknesses and move to provide technology which eliminates these weaknesses.

NASA's approach to aviation safety research is two-fold: To provide technology advances by which accidents can be avoided; and to provide technology advances that will enhance the chances for survival should an accident occur. Thus our program is at once preventive and remedial.

Illustrative of "preventative" safety programs is the Terminal Configured Vehicle (TCV) program at Langley Research Center. This program is directed towards providing advanced technology for improving the safety of operations

in the terminal area. Since the majority of fatal accidents occur in the terminal area, the expected improvements in aircraft and system capabilities will yield an improvement in approach and landing safety by reducing the chances that accidents occur. It is difficult to evaluate the safety benefits of a "preventive" program such as this, except on a long term after-the-fact statistical basis.

Should an aircraft accident occur in spite of preventative measures, the primary concern becomes one of assuring occupant survival, with a secondary concern for determining how future reoccurrences of the accident can be prevented. Our program in aircraft fire technology is an example of "remedial" research to provide the materials, structures, and fuels technologies which can be incorporated into future aircraft that will reduce the likelihood of a lethal fire, should the aircraft crash.

In both of these approaches to increased aviation safety, NASA involves the FAA and industry as appropriate to insure that our research is responsive to the need, to assure early transfer of knowledge of research results so that the implementation of improvements can be speeded, and to provide FAA with a technological basis for upgrading safety standards in a rational manner. The individual military

services and the DOD Joint Technical Coordinating Group are involved where they can contribute and benefit.

To obtain the most effective use of the resources provided us, it is important that the Federal agencies and departments coordinate their safety research programs in a complementary and synergistic manner wherever possible. It is our opinion that there does exist a coordinated aviation safety research and development program within the Federal government. There does not exist, however, a centrally-managed program. This is not necessarily an objectionable situation, for due to the ad hoc, dynamic nature of aviation safety needs, such a centrally-managed program might be more unwieldy than beneficial. Due to the differing responsibilities of various Departments and Agencies, ranging from R&D to regulatory, civil to military, it is not clear that incorporating such a program oversight responsibility within a single Agency or Department would lead to more effective coordination than now occurs. Instead of speculating on how a new organizational arrangement might or might not work, I would like to describe how NASA presently coordinates its aviation safety research.

As reported during the March testimony before this Subcommittee, we have provided a focal point within NASA for aviation safety research by establishing the Aviation

Safety Technology Branch in OAST. This is directed by Mr. John H. Enders, who is with me today and who has a considerable background in aviation safety research.

Working closely with other OAST Divisions, this Branch is our Agency's Headquarters single point of contact for aviation safety research matters and is responsible for formal and informal coordination of the NASA Aviation Safety Research program with other agencies, the military, and industry. Though we have established a single NASA point of contact for aviation safety research matters, we face multiple points of contact in other agencies. This should not be construed to be a criticism, since their organizations are generally broader in scope and responsibility than is NASA's OAST. Coordination of some safety research programs which affect several departments or divisions in other agencies thus can be a complex task, but this has presented no serious difficulty to NASA.

The aviation fire research and technology program is a complex effort being performed by many groups, and using it as a specific example may help to show how safety R&D coordination is accomplished. In-flight and post crash fires have claimed victims who otherwise might have survived. The variety and complexity of aircraft fire situations argues against the likelihood of a single, simple solution. Rather,

the approach must incorporate a variety of technologies, applied to the propulsion system, fuel system, aircraft structure and cabin interior. The problem fundamentally is one of safely carrying a large number of passengers at high speeds and altitudes in a lightweight aerodynamic structure that also contains thousands of pounds of fuel and potential sources of accidental ignition. As aircraft have grown in size, the passenger support systems have become more complex, and there are large unoccupied areas where a fire, if started, could establish itself before it is detected. New plastic materials which provide a designer with more options in maintenance, texture, wear, cleanability, form and contour than has ever before been possible, are organic in nature as are the materials they replaced. They thus contain the same constituents necessary to burn and to produce smoke and toxic gas. Efforts to inhibit the flammability of these materials have been fairly successful to date, but in situations where an external fuel source or ignition source is present (e.g., post crash fire, or on-board electrical short), the flame inhibitors themselves produce toxic gases and smoke when subjected to intense heat loads.

There are substantial efforts underway in the fire research area by NASA, FAA, USAF, USN, USA, and to some extent by the NBS. In addition, the RAE in England and the DFVLR in Germany have programs in aviation fire safety.

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COORDINATIVE GROUPS (Representative Sample)

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Coordinating Research Council (Fuels)	X	X	X	X				X
Research and Technology Advisory Committees	X	X	X	X	X	X		X

etc.

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Tire, Brake, Runway, Antiskid System Research	X	X		X		X		
Lightning Effects Research	X	X	X	X		X		X
Stall/Spin Research	X	X		X				X
Fire Suppression and Control for Aircraft	X	X	X	X	X	X	X	X
Terminal Area Research	X					X		X

etc.

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Both domestic and overseas aircraft manufacturers perform in-house research also. Since this research embraces cabin materials and insulation, fuel systems, engines, structures, and procedures, a wide variety of disciplines and talents are involved in government and industry laboratories throughout the U.S. and abroad. NASA has formed an Inter-center Ad Hoc Steering Group to help in coordinating fire safety research efforts. Members of this group interface with FAA, the JTCG/AS, the Air Force, Navy, and Army, and the NBS. In addition, the National Academy of Sciences' National Materials Advisory Board (NMAB), which has membership from NASA, FAA, the military services, and private organizations and universities, is providing valuable inputs to the fire research program. NASA has met with these organizations and we are presently jointly determining specific research needs, planning and conducting a program to satisfy these needs, drawing upon the various expertise and facilities within the individual organizations.

More broadly, the figure shows a listing of representative formal coordinating groups, ad hoc committees and panels, and joint programs through which our overall aviation safety research is coordinated with other groups, conducted, and reported.

In addition to these formal coordination mechanisms, the Aviation Safety Program is coordinated extensively at the more informal, working level through mechanisms such as briefings, tours, exchange of data, and guest invitations to major NASA experiments. For example, the NASA Aviation Safety Technology Branch receives briefings from NTSB accident investigators as soon after aircraft accidents as facts are available, to determine if technical assistance can be provided to speed their investigation. Under this Branch's direction, screening of NTSB accident/incident reports and safety recommendations is conducted in order to determine safety R&D needs. This Branch emphasizes the role of coordinator and stresses information transfer. For example, briefings have been provided in recent weeks to the FAA Associate Administrator for Safety on the overall NASA aviation safety program to FAA and USAF fire experts on the NASA fire technology program, to DOD representatives on NASA research applicable to VTOL and conventional landing safety, and to FAA on NASA human error research. The NASA Intercenter Steering Group for Aircraft Fire Technology, recently visited the facilities of the three major airframe manufacturers and the fire test facilities at FAA's NAFEC in Atlantic City to review progress in fire research, and to explore the possibilities of future joint programs. During major tests, such as the

general aviation crash test program at Langley Research Center and the fuselage burn tests (which, incidentally are scheduled today) at the Johnson Space Center, invitations are extended to FAA, DOD, and industry personnel to witness the test, with backup briefings provided to cover test technique, test conditions, etc., and preliminary test results. These are but a few coordinative elemtns which assure that the NASA aviation safety program is responsive to the real needs of the aviation community for advanced technology to help in solving safety problems.

The difficulty encountered in coordinating safety in general is apparent; a meaningful interchange of data and information for research in the fire technology area, for example, must be accomplished through fairly large numbers of specialists having interest in and understanding of fire technology; they are unlikely to be equally interested or well-grounded in other safety problem areas, such as clear air turbulence, control of aircraft on the runway, turbine engine disintegration protection, or general aviation stall/spin prevention.

This complex picture of coordination may appear to be somewhat random; however, given motivated people and the resources needed to communicate effectively with one

another, coordination is accomplished. The system is working, but improvements in coordination can always be beneficial, and NASA is continually striving to improve the process wherever it can. Since safety research must be conducted in a creative environment, sometimes using non-conventional ideas and approaches, it is essential that any new coordinative mechanism not suppress creativity. At the same time, limited resources argue for prioritizing the research effort, in order to obtain the most safety improvement from our investment.

We plan to establish an ad hoc panel to the RTAC panel on Aeronautical Operating Systems within the next few months, to provide for more effective coordination of NASA Aviation Safety Research. This panel will be composed of industry, government, and university experts having broad experience in military and civil aviation safety research.

The AACB and NASA-FAA Coordinating Committee, both of which are more broadly constituted than for aviation safety R&D, perform usefully as a point of coordination on interagency safety research matters. The NASA RTAC system likewise serves to draw upon and to inform industry in matters broader than, but including, safety research.

There is no single Executive Branch organization which has a comprehensive oversight of aviation safety R&D, but Mr. Chairman, this Subcommittee has provided much of the impetus and encouragement to NASA and others to establish a more coordinated civil aviation safety program. This Subcommittee has also provided guidance to NASA on prioritizing aviation safety research, to which we have reacted in what we feel has been a responsible manner.

To summarize, we in NASA believe that there are extensive channels and mechanisms for the transfer of safety ideas, techniques, and technology between civil and military aviation, and that applicable knowledge is flowing effectively. We perceive no single, comprehensive coordination mechanism for aviation safety R&D within the Federal government, but given the complex nature of the safety problem area, we believe that coordination is taking place effectively. It is not clear to us just how a nationally-managed program would simplify the process in a functional way. And finally, NASA has already moved to provide an organizational arrangement which will simplify our coordination interface with non-NASA organizations on aviation safety matters.

Mr. Chairman and members of the Subcommittee. I thank you for the opportunity to discuss NASA's views on this highly important topic.

NASA COORDINATION AND COOPERATION WITH OTHER ORGANIZATIONS

COORDINATIVE GROUPS (Representative Sample)

	DOT/ FAA	USAF	USA	USN	NSF	NTSB	NBS	INDUSTRY
NASA Aerospace Safety Research and Data Institute	X	X	X	X		X	X	X
National Materials Advisory Board — Comm. on Fire Safety	X	X	X	X	X		X	X
Coordinating Research Council (Fuels)	X	X	X	X				X
Research and Technology Advisory Committees	X	X	X	X	X	X		X
etc.								

COORDINATED OR JOINT PROGRAMS (Representative Sample)

	DOT/ FAA	USAF	USA	USN	NSF	NTSB	NBS	INDUSTRY
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Tire, Brake, Runway, Antiskid System Research	X	X		X		X		
Lightning Effects Research	X	X		X		X		
Stall/Spin Research	X	X	X	X		X		X
Fire Suppression and Control for Aircraft		X	X	X				
Terminal Area Research	X					X		
etc.								

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STATEMENT OF J. LLOYD JONES, DEPUTY ASSOCIATE ADMINISTRATOR FOR AERONAUTICS, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NASA

Mr. JONES. Mr. Chairman and members of the subcommittee, the continuing exploration of aeronautical research and development in these hearings is an important, useful process, and we are pleased to have this opportunity to discuss our views on aviation safety research and development.

That NASA regards aviation safety as important as attested to by a doubling of our aviation safety research budget from $4.2 million in fiscal year 1972 to $8.4 million in fiscal year 1975. The improvement in aviation safety is one of several major goals established by NASA which contribute to the objective of improving our nation's aviation system.

The transfer of ideas, techniques, and technology, including safety-related technology, between civil and military systems is taking place effectively. Historically, this process was explored in both the joint DOD–NASA civil aviation R. & D. policy study (CARD), and the joint DOD–NASA–DOT study of research and development contributions to aviation progress (RADCAP).

These studies verify the fact that in the past, military aviation requirements generally demanded a more advanced technology which later found applications to civil systems.

In recent years, however, diverging requirements of civil and military aviation systems have somewhat lessened the applicability of military systems technology, with the resulting incentive for more civil aviation-oriented research.

An important channel for the transfer of safety-related technology has always been the U.S. aircraft industry. Serving both civil and military customers in a competitive business environment, the industry provides for many channels of safety technology and information transfer between civil and military users.

Another effective channel for the transfer of aviation safety knowledge was the NACA, and now NASA. The NACA Subcommittee on Aircraft Safety drew upon both military and civil organizations for its membership, and concerned itself with identifying problems, advising on appropriate research to solve the problems, and reporting on research results. NASA continues to conduct basic aviation safety research and technology development upon which both civil and military aviation draw.

To aid in the transfer of safety information and research findings, NASA established the Aerospace Safety Research and Data Institute (ASRDI) at Lewis Research Center in 1968. Within the Institute there is an aerospace safety data bank, whose function is the gathering, analysis, evaluation, retrieval, and dissemination of safety-related technical information.

The services of this data bank are made available not only to NASA, but also to its contractors, other Government agencies, and the technical community at large. Briefings describing its capabilities are being provided to interested organizations at the present time. Recent special publications of ASRDI include directories of technical specialists in the fields of fire technology and structural failure.

NASA technical publications, technical papers presented at technical meetings, and press releases on technical achievements also help to transfer knowledge of safety research results to both civil and military users. In addition, point-to-point contact between individual technologists cannot be overlooked as an effective mode of transfer.

Yet another channel for assuring the transfer of safety knowledge between civil and military aviation is the assignment of military technical liaison personnel to NASA centers, and more recently, the assignment of NASA technical specialists to military aviation laboratories. The co-location of military researchers in NASA laboratories, working with NASA engineers and sharing NASA facilities also encourages the prompt transfer of ideas, techniques and technology between civil and military aviation.

The Federal Aviation Administration and military services also exchange personnel in various program areas, and NASA participates in several joint safety research programs with FAA and the military services. The National Transportation Safety Board's Bureau of Aviation Safety fosters the exchange of safety information between civil and military aviation in the interests of accident prevention.

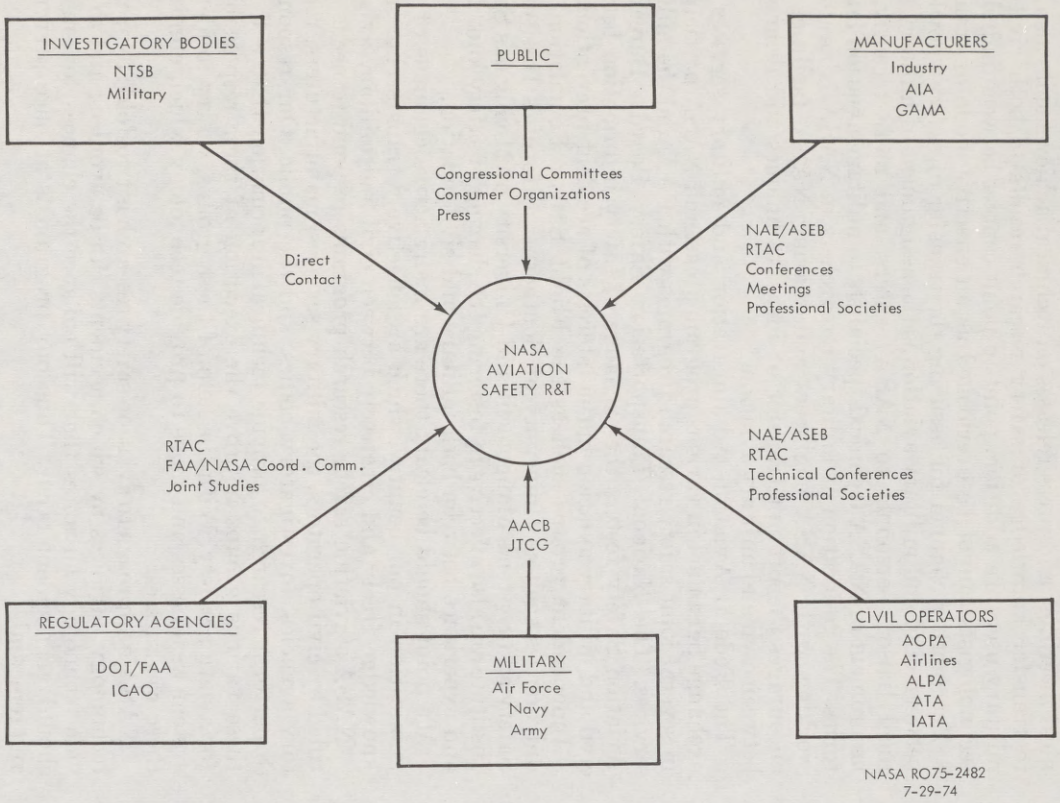
Independent groups such as the Flight Safety Foundation, and universities such as University of Southern California's Institute of Safety and Systems Mangement and University of Michigan's Safety Institute are also effective in fostering the sharing of safety knowledge and experience between both military and civil aviation.

My point should be clear: there are many active channels of communication in our country which are effectively transferring safety knowledge freely and creatively between civil and military aviation.

NASA's aviation safety research programs respond to needs identified by civil operators, the military services, manufacturers, regulatory agencies, investigatory bodies, and the public. Our response is to perform research to provide technical information that will help these various groups improve the execution of their responsibilites for aviation safety. With the help of these groups, we try to identify system weaknesses and move to provide technology which eliminates these weaknesses.

NASA's approach to aviation safety research is two-fold: to provide technology advances by which accidents can be avoided; and to provide technology advances that will enhance the chances for survival should an accident occur. Thus our program is at once preventive and remedial.

NASA AVIATION SAFETY R&T RESPONSIVENESS



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Illustrative of "preventative" safety programs is the terminal configured vehicle (TCV) program at Langley Research Center. This program is directed toward providing advanced technology for improving the safety of operations in the terminal area. Since the majority of fatal accidents occur in the terminal area, the expected improvements in aircraft and system capabilities will yield an improvement in approach and landing safety by reducing the chances that accidents occur. It is difficult to evaluate the safety benefits of a "preventive" program such as this, except on a long-term after-the-fact statistical basis.

Should an aircraft accident occur in spite of preventative measures, the primary concern becomes one of assuring occupant survival, with a secondary concern for determining how future reoccurrences of the accident can be prevented.

Our program in aircraft fire technology is an example of "remedial" research to provide the materials, structures, and fuels technologies which can be incorporated into future aircraft that will reduce the likelihood of a lethal fire, should the aircraft crash.

In both of these approaches to increased aviation safety, NASA involves the FAA and industry as appropriate to insure that our research is responsive to the need, to assure early transfer of knowledge of research results so that the implementation of improvements can be speeded, and to provide the FAA with a technological basis for upgrading safety standards in a rational manner. The individual military services and the DOD joint technical coordinating group are involved where they can contribute and benefit.

To obtain the most effective use of the resources provided us, it is important that the Federal agencies and departments coordinate their safety research programs in a complementary and synergistic manner wherever possible.

It is our opinion that there does exist a coordinated aviation safety research and development program within the Federal Government. There does not exist, however, a centrally-managed program. This is not necessarily an objectionable situation, for due to the ad hoc, dynamic nature of aviation safety needs, such a centrally managed program might be more unwieldy than beneficial. Due to the differing responsibilities of various departments and agencies, ranging from R. & D. to regulatory, civil to military, it is not clear that incorporating such a program oversight responsibility within a single agency or department would lead to more effective coordination than now occurs. Instead of speculating on how a new organizational arrangement might or might not work, I would like to describe how NASA presently coordinates its aviation safety research.

As reported during the March testimony before this subcommittee, we have provided a focal point within NASA for aviation safety research by establishing the aviation safety technology branch in OAST. This is directed by Mr. John H. Enders, who is with me today and who has a considerable background in aviation safety research.

Working closely with other OAST divisions, this branch is our agency's headquarters single point of contact for aviation safety research matters and is responsible for research program with other agencies, the military, and industry. Though we have established a

single NASA point of contact for aviation safety research matters, we face multiple points of contact in other agencies. This should not be construed to be a criticism, since their organizations are generally broader in scope and responsibility than is NASA's OAST. Coordination of some safety research programs which affect several departments or divisions in other agencies thus can be a complex task, but this has presented no serious difficulty to NASA.

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Inflight and postcrash fires have claimed victims who otherwise might have survived. The variety and complexity of aircraft fire situations argues against the likelihood of a single, simple solution. Rather, the approach must incorporate a variety of technologies, applied to the propulsion system, fuel system, aircraft structure and cabin interior.

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organizational arrangement which will simplify our coordination interface with non-NASA organizations on aviation safety matters.

Mr. Chairman and members of the subcommittee, I thank you for the opportunity to discuss NASA's views on this highly important topic.

Mr. HECHLER. Thank you, Mr. Jones.

Everyone who is an alumnus of the National Advisory Committee on Aeronautics always looks back with some nostalgia on that organization, its high spirit, its high morale and its good organization, and you alluded to the subcommittee on Aircraft Safety under NACA which evidently operated very effectively.

Do you think the current arrangements that NASA has are worthy successors in terms of centralizing and coordinating both within NASA and your relationships outside of NASA, your approaches to aircraft safety?

Mr. JONES. The NACA Subcommittee that I mentioned, and that you mentioned, had functions that now are being assumed by our RTAC Aeronautical Operating Systems, Panel. However, the responsibilities of that panel are broader than aviation safety.

Mr. HECHLER. Is that good or bad?

Mr. JONES. I am sure that the awareness that is required for aviation safety is enhanced by that broader view of things, but of course the broader responsibilities demand more time and provide less time to be addressed specifically by that group to the safety aspects of the problem, so I guess I really am not sure whether that is in the best direction or not for aviation safety, specifically.

Mr. HECHLER. Mr. Israel mentioned that although FAA had written interagency agreements with some dozen other agencies there was no actual written agreement as to the line of demarcation between FAA and NASA, and it struck me that he was relying, and FAA was relying more on just where the expertise was, or where the facilities were in making decisions about which agency ought to undertake certain R. & D. functions in aviation safety.

Does NASA have any kind of written understanding for itself as to how you divided the responsibility of FAA in this field?

Mr. JONES. Well, our main mechanism for coordination with the FAA——

Mr. HECHLER. That isn't what I asked. I am not looking for the mechanism. I wondered if you had any kind of a written piece of advice to yourself as to how you go about dividing responsibility; not how do you coordinate it.

Mr. JONES. As to dividing responsibilities with the FAA?

Mr. HECHLER. Yes. That is a little different than coordination.

Mr. JONES. Our main approach is to respond, to provide a technology program which responds to the needs which are identified to us by the numerous sources, including FAA, and the needs which we identify through our own advisory groups, and I guess the concept of those advisory groups really represents the way which we formulate our overall safety program.

Mr. HECHLER. Would you agree with Mr. Israel speaking for FAA that they pretty well decide these questions of which agency has the most expertise and facilities?

Mr. JONES. Well, I have to say that we responded to the requests from FAA on safety-related matters, particularly those which are operationally related and related to the problems that they face. As far as our own program is concerned, which is providing new technology, we seek very broadly the advice on how we constitute and how we direct that program.

Mr. HECHLER. Mr. Jones, when you spot a problem, in the area of aviation safety, do you seize the initiative or do you sit back and wait until you are called?

I don't want that to sound too much like an academic question, but I am trying to get the relationship clear in my own mind.

Mr. JONES. Mr. Chairman, let me give an example that may help answer that.

I think the point illustrated is very important in aeronautical safety research and technology.

The NASA contributions to the development of fire inhibiting materials really grew out of the expertise developed by researchers who were addressing the problem of thermal protection for atmosphere entry vehicles. The awareness and the recognition that there was direct application to fire safety in aircraft then directed that program within NASA to developing the polymeric materials that we have been testing in the fire program. What actually was accomplished in the way of new knowledge was how to synthesize polymers to have prescribed characteristics in a given situation. By this example, I would hope to show you that we are responsive and aware of the relationship of our advanced research and technology to safety matters.

Mr. Goldwater?

Mr. GOLDWATER. Thank you, Mr. Chairman.

Mr. Jones, in General Yeager's statement he says that the weakness of all of this effort is the difficulty of determining what research has been done and who did it, and he goes on to say, "I suggest that if the available aviation safety technology are identified and catalogued the problem of transferring it within the aviation community would be solved by the community members themselves."

What is your reaction to that statement? Do you think it is an accurate statement, that there is a problem in cataloguing and making available the information?

Mr. JONES. There certainly is a problem of cataloguing all of the available information, and certainly if all of the available information were catalogued and were immediately accessible, it would be beneficial.

The main problem exists because of the mass of information; that is deciding on the most important elements that should be included in a data system, a data bank. It is really the cost of putting all of the information in a system for needed retrieval, I think, that keeps us from doing that.

Mr. GOLDWATER. There seems to be a thread that runs through all of the concern expressed here that, yes, there are these interagency cooperative efforts, and that you get together at various times during the year and exchange information, but there is really no central coordination of the effort.

Wouldn't you, or do you feel that perhaps there is a need for some sort of cataloging and identifying in a central place that would

perhaps enhance the field of aviation safety? Or do you feel that there is sufficient transfer of information now?

Mr. JONES. I think first of all I would have to break that down into whether it is operational safety-related information or whether it is safety-related technology.

I mentioned the Aerospace Safety and Data Institute that NASA began in 1968. That Institute has as one of its objectives to maintain a safety data bank.

Mr. GOLDWATER. Does that include civil as well as military data?

Mr. JONES. Yes, but let me stress that it includes only selected technical areas at the present time, to see if such a system might be workable. It has taken us some time to develop the system, within that limited scope, to where it functions.

There is a significant problem of limiting the amount of descriptive material to where someone who wishes to address that data bank can look at the total scope of information available in a reasonable time, so it requires a considerable amount of effort to review documents and to abstract them in a meaningful manner.

I believe that system now is working in that limited scope.

I would like to call on Mr. Enders to add to this. There are recently published reports that have come out of that program.

Mr. Enders, would you care to address that?

Mr. ENDERS. Yes, sir.

The Aerospace Safety and Data Research Data Bank recently, this spring and early this summer, published some registers of experts in the safety field; for instance, here is a directory of workers in the fire field, which includes aviation fires, apartment fires, home fires. It is an up-to-date listing of people who are active in various aspects of fire research, cataloged by name, address, telephone number, their affiliation, cross-indexed as to the field of interest, so that a person who might want to know who is working, for instance, in the area of radiation of heat sources, has a whole list of people who he can then call upon to find his way through this real complex field.

Likewise, we have a similar register of experts for information on mechanics of structural failure.

Mr. HECHLER. Probably getting a lot of third-class mail.

Mr. ENDERS. Yes, sir.

Here is a Directory of Aerospace Specialized Information Sources." which is really a directory of other data banks, so we are in a position of knowing how to go about getting needed information.

As Mr. Jones pointed out, we have recently solved some of the computer software problems that plagued us early in the evolution of the data bank, and I think we are beginning to produce a useful product. And as our time and travel funds permit, our people are getting out briefing interested individuals and organizations on what the capability of this Institute and its data bank is.

The inquiries we are receiving now are not numerically impressive. They are running 6 to 10 a month, but they are substantive inquiries, requiring indepth analyses of certain problems in both space and aeronautics, so perhaps it is a beginning; perhaps it will prove to be a nucleus for something that might be expanded into what the order witnesses this morning were talking about.

Mr. GOLDWATER. What is your feeling about it? Do you think it should be expanded?

Mr. ENDERS. Only if the use of the data, Mr. Goldwater, proves to be productive. It is very difficult to anticipate what people are going to want to know about safety and, we have had a few false starts where we have had to go back to people who have inquired of our data bank resources earlier to convince them that we now have a software program that will respond to them. They tried us once and we failed to give them what they were looking for.

I think Mr. Green alluded to that earlier. He said that a Data Bank may be asked a question, the one question you don't have an answer to. If the data that we are accumulating, abstracting, and analyzing turns out to be of use, and used by others, then I think we should consider some sort of expansion.

Mr. GOLDWATER. Where do you get the input for that system?

Mr. ENDERS. The Data Bank at Lewis taps into most of the industry and other government agencies data sources. It also has access to the Federal clearinghouse for information, which contains a vast amount of technical data. Computer screening processes are used, followed by a subsequent professional sifting of information on the data that is yielded.

Mr. GOLDWATER. But you get input from all segments.

Mr. ENDERS. Yes, sir, civil, military, domestic, foreign. For instance, here is a bibliography of reports on Aircraft Fire Hazards and Safety, which goes beyond the Directory of Workers in the fire field, which I showed you earlier.

This is a collection of abstracts that were selected out of the vast amount of information. This takes a long time to do, it takes people who are knowledgeable in the field to glean from these reports what would be of interest to people doing research in the area. They list a brief abstract, they attempt to get it all on one page or at least a page and a quarter so the reader isn't overcome with the shear task of reading it; it has a list of pertinent figures and shows a source of related information, a little cross-index. These documents are available for your inspection here.

Mr. GOLDWATER. It seems to me that all this research and analysis in aviation safety is not going to really do any good unless you can actually get it into the construction of a new airplane or into operating procedures of aircraft.

What assurance do we have that this is being done? Say, for instance, general aviation manufacturers see this as a useful tool. Do they show an interest? Do they participate? Do they inquire, do you actually see some results built into, say, new general aviation aircraft?

Mr. ENDERS. From past research?

Mr. GOLDWATER. From past research.

Mr. ENDERS. Yes, I think we do. It is subtle.

Mr. GOLDWATER. It is like general aviation, NASA has done a great deal of work on materials and general aviation using these new materials, fire resistance materials.

Mr. ENDERS. I have had several general aviation manufacturer's inquires relayed to me by Mr. Winblade Director of our General Aviation Technology Office. They wanted to know more about the research on fire resistant materials because they wanted to apply these materials

not only for fire protection, but also for acoustic insulation, making the cabins quieter and providing padding for crash impact protection.

We are making safety R. & D. information available to others as we develop it. We can not enforce its use, of course. The FAA is following our program closely. In fact, there are representatives of both FAA headquarters and NAFEC, at our fire tests at Houston today. We are working on advanced materials which we hope will give FAA a springboard to base upgraded requirements on, and at the same time this information goes to industry to allow them to specify to their suppliers what new materials they might want to employ in aircraft. So, we hope that the results of this reserach are working both sides of the regulatory fence; advancing technology for the manufacturers on the one hand, and providing a basis for rational rulemaking, on the other hand, to relieve the pressures of forced premature judgment situations.

Mr. GOLDWATER. Is there any group or any people that reviews, takes a year-end inventory to see what new things have been learned and evaluated, whether in fact this material has gotten out to industry?

Does anybody pull all this together and supervise what has occurred over a period of time and what the results of those efforts were?

Mr. ENDERS. I don't think there has been a very good review in the recent past, though I am looking to the FAA's Biennial Airworthiness Review process which is now underway as perhaps a good indicator of how the industry is reacting to implementing new techniques and new technology into new aircraft. In this process, the FAA has proposed a review of specific Federal Air Regulations. The industry, other government agencies, and the public, are responding as to how they feel the regulations should be changed or not changed as the case might be. NASA has been invited to make its input, and we have made our comments to the FAA. So I think that the reestablishment of this cycle, where the whole industry, public, government regulators, and government researchers get together on a regular and frequent basis to see just where are we and what can we employ out of the R. & D. that has been done in the past months, I think this will be a very helpful situation and we hope that this will accomplish what you are asking for.

Mr. JONES. Mr. Goldwater, may I add to that, please?

Mr. GOLDWATER. Yes.

Mr. JONES. If you are speaking of the transfer of information on new technology in general, the Research and Technology Advisory Council Committee structure that we have within NASA serves as a two-way street of communication, because there are members from industry and the services on those committees as well. There is regular review of the technology programs in NASA, and that provides for information to feed directly into the industry and into the services, as well as providing means for obtaining advice from industry and the services on our program.

Mr. GOLDWATER. It looks like you could be spinning your wheels if you do all this work, and it is not finally implemented, or at least not taken advantage of. It occurs to me that there ought to be some way to evaluate your efforts and to see that in fact you are going in the right direction or you are doing the right thing to enhance aviation safety, both technically and procedurally. If in fact you are doing that, I suspect that is good.

Do you have any financial problems within your organization as far as this effort is concerned, funding problems?

Mr. JONES. As I pointed out in the written testimony, we are increasing the emphasis on safety technology. We have doubled the amount of funds that we have put into that area over the past 2 years. I think within the overall budgetary constraints under which we operate, we have a well balanced program that effectively addresses safety technology.

Mr. HECHLER. You don't have to be reticent. We are not talking about the President's budget right at the moment.

Mr. GOLDWATER. If you had more funds you could do more, are you saying that, or are you just saying that the program is adequate?

Mr. JONES. Well, I think the program has been expanding. I think that it is adequately addressing the areas that we have been able to identify.

Mr. HECHLER. Thank you, Mr. Goldwater.

Any other members of the committee have any questions they would like to ask?

If not—Mr. Wells?

Mr. WELLS. On the Aerospace Safety Research Data Institute, my first visit to that facility was in February 1969, shortly after it was inititated. To the best of my recollection there were some very glowing plans presented as to what it was going to accomplish in the aerospace community, not only in the general data but specifically in the safety area. Yet I take it we are here some 5 years later and it is still at a fairly low level, if you are talking in terms of inquiries at the rate of 8 or 10 a month. This seems to me to be rather limited kind of activity.

Mr. HECHLER. You said less than that. Didn't you say 6?

Mr. ENDERS. 6 to 10.

Mr. WELLS. 6 to 10.

Mr. ENDERS. Yes, sir.

Mr. WELLS. Does this capability, could it provide a nucleus for the kind of thing, just to nail this down a little more precisely, a nucleus for the kinds of things General Yaeger was talking about this morning as far as a national information system and what would it take to do it?

Mr. JONES. It might provide a nucleus for that.

As we pointed out, we have had some difficulty in developing the software to provide the proper screening of information for data to go into that as a data bank source, and I would like to reiterate that it only addresses limited areas of technology at the present time in order to make a practice different, but it is beginning to work.

I think it could be the nucleus for that, if one decided that it was worth doing, recognizing the cost that would be required to expand it to fulfill the broad spectrum of data access that General Yaeger referred to.

Mr. WELLS. You don't think NASA on its own could decide to do this? In other words, you would need an edict from "on-high" or elsewhere before you undertook such a task?

Mr. JONES. We would certainly have to convince ourselves that it would be an effective mechanism, that it is needed and that it would be used, before we would undertake that.

Mr. WELLS. Going back to one of the points, again. Let me ask: One of the specific recommendations that General Yeager made, which seems to make a great deal of sense. He said, referring to the national program, there are some obviously common problems that probably deserve a nationally coordinated research program; bird strikes, collision avoidance, lightning strike research, runway construction, severe weather conditions, et cetera. These were only a few.

To what extent have you been guided by the suggestions similar to these as to where you ought to focus the effort of your data institute in order to be able to respond to needs as articulated by General Yeager?

Are you listening to this kind of advice or request?

Mr. JONES. We are listening to that kind of request, yes, but not in the way in which we structure the information that is in the data bank that we have been discussing, because the areas to be covered were selected earlier, and we have not expanded those areas up to the present time. We are certainly using this advice to determine how we coordinate and how we seek information and how we pass information along to other interested organizations.

Mr. WELLS. So it is feasible to narrow it down to one specific problem area, lightning strike research. Is it possible to pull together the information being done in this country or even internationally, on lightning strike and be able to tell anyone who is interested what is going on, who is doing it, that could be done under the auspicies of this Institute?

Mr. JONES. Yes.

Mr. WELLS. It is feasible to do that?

Mr. JONES. It is technically feasible to do it.

Mr. WELLS. It is a matter of staffing, money, budgets, and the like?

Mr. JONES. Yes.

Mr. WELLS. Plus the decision to do it?

Mr. JONES. That is right.

Mr. ENDERS. May I make another comment, Mr. Wells?

Mr. WELLS. Yes.

Mr. ENDERS. When I said we were responding to 6 to 10 inquiries a month, I also should have mentioned that we don't wait for the inquiries to get information out either. For instance, about 3,000 of each of these have been sent out around the technical community so that people have a desktop data bank, if you will, the actual researchers.

Mr. WELLS. Thank you.

On page 13, which you passed by in your summary to save time, Mr. Jones, you referred to the establishment of a new panel on safety research within the Research and Technology Advisory Council structure which is going to be estaiblished within a few months.

Is this the lineal descendant of the subcommittee on aviation safety that Mr. Hechler referred to from the old NACA days, or what is this going to do that has not been done previously in your organization?

Mr. JONES. Mr. Wells, I pointed out that the descendant of that previous NACA committee is really the Aeronautical Operating Systems Panel.

Mr. WELLS. Excuse me, if I may interrupt.

The way the NACA Subcommittee was described, it drew upon all kinds of outside resources, such as civil, military, industry, and the like.

Mr. JONES. That is right, as does our currently established Aeronautical Operating Systems Panel, but it has a broader area of concern. The Safety Panel, which I mentioned, would be an ad hoc panel, and that panel would provide a comprehensive review of safety research needs and activities to help the parent panel to address properly or more fully, I should say, the safety problem. That would be an ad hoc, not a standing panel.

Mr. WELLS. We have had testimony both by the NTSB, and by Commander Johnson, this morning, as to the merit of perhaps additional joint recommendations for more joint organizational arrangements in the safety R. & D. area.

What is your view of the specific application of the joint technical group that was described by Commander Johnson in the civil area? We have had Mr. Israel's testimony that he didn't see that it had much application here.

What is your own view?

Mr. JONES. Well, I think it works, listening to Commander Johnson's testimony, it works well for the joint military services.

I think it works well there because they have a common need and a common responsibility among the several services.

I think it would be difficult to translate to a total government safety role, because of the broader aspects and the private sector involved, not to say that it couldn't be done, but certainly it would be more difficult. Particularly, I think, it would be difficult to establish it in a management role, as I understand it currently is functioning, rather than a coordinating one.

Mr. WELLS. As I understood the testimony, it is a part management, part coordinating and part information-gathering.

Commander Johnson, is that correct?

Commander JOHNSON. Yes, this is correct.

One thing, Mr. Wells, if I may add in here: The impetus of this type of program is a long range objective—5 years down the road, giving good guidelines to our people as to what we want in our survivability research and development. We don't have to ferret it out or wait for it to come from another source.

I am concerned from the civil standpoint of what we are presently trying to do. And I see the Mach 3 Transport that will go at high altitude, that is going to come. Are we going to be ready with safety, then, if we use the same approach that we have been historically trying to attack this problem?

I don't see it, unless there are positive guidelines given down with a 6-year type of program.

This is where this type of group really pays off.

Mr. HECHLER. Isn't it true that your group is more devoted to aviation safety for combat operations?

Commander JOHNSON. Yes, sir.

Mr. HECHLER. It seems to me that that is a fairly narrow scope, even though the mechanism may be a broad one. The objective is unfortunately a narrow one.

Commander JOHNSON. Yes, sir, Mr. Chairman, I agree with that, but we are also well aware of the spinoff into the safety arena, and we are sure this is better off, the foams, fire-retardant we have developed with NASA and Dr. Parker, compared. But this application engineering that was referred to by Mr. Goldwater is missing in the civil area where it is more strongly devoted in the military area because we put it in our specs, into our contracts.

I have not suggested that a joint group, as I mentioned in my final statement would be a panacea. I see certain areas where joint efforts would be a high payoff. There are other areas, because of responsibilities and things like this, that I don't see it would. The FEA R. & D. work is devoted to establishing regulations. I don't see where then that really gets into applications. I see where the NASA work is trying to get into the applications, but they can't get involved in the specifications.

So it seems to me we are running in a circle and bringing back the wheel.

I do feel very strongly that maybe some sort of joint cadre would help establish these guidelines, get the proper impetus going to the program and establish some of these down-the-road objectives that we really need to do.

I feel we are playing catch-up, sir.

Mr. GOLDWATER. Will the gentleman yield?

Mr. HECHLER. Yes.

Mr. GOLDWATER. What you are saying, then, is, perhaps some sort of joint meeting is to be held to identify areas, to research or to look into, taking into consideration the regulatory aspects of it as well as the technical capabilities?

In other words, NASA may only look at the technical side of it without any consideration of whether, from a regulatory or an application standpoint, it is a viable area to be looking into.

Mr. HECHLER. Do you know what is wrong? In early 1973 the administration abolished the National Aeronautics and Space Council. We haven't replaced that with anything at a level that is able to pull all these things together.

Would anybody like to react to that? Or does that filter down to your level at all?

Mr. JONES. Yes, sir, it does. And we interfaced with that group.

Mr. HECHLER. Wouldn't it be a good idea if we had an outfit like that that could start to pull these things together in the areas of aviation safety?

Mr. JONES. Mr. Chairman, I guess I just don't quite comprehend.

Mr. HECHLER. Providing it included military as well as civil.

We have had some discussion in the full committees concerning the organization of the Government for science, and I couldn't resist bringing that out.

Mr. WELLS. Mr. Chairman, may I quote the specific citation you are referring to? This is from the CARD study to which NASA and DOD were the joint preparers, and on page 27 of the CARD studies recommendations, the following appears:

> Other organizations that would be beneficial to the future of civil aviation would include the interchange of personnel among DOD, NASA, DOT and possibly CAB.

It goes on to explain about the value of interchanging people.

In addition it is recommended that the National Aeronautics and Space Council develop a permanent mechanism to review and recommend those policies affecting civil aviation that embrace civil agencies. In performing its policy role the NASC should engage the cooperation of leaders of industry.

This is at the heart.

Mr. HECHLER. So what happens, somebody read the CARD study and abolished the NASC.

Mr. WELLS. So, we are to understand that despite the abolishment of NASC and the recommendation for some overall review, that your coordinating with each other at your respective levels is adequate to deal with all the problems and controversies?

Mr. JONES. Mr. Wells, I certainly feel that there is good coordination going on at the present time. It is complicated and it is unwieldy, as we showed you from our charts.

If one could reduce the number of contact points required for effective coordination, I think that would be a valuable thing.

I guess I do have a little difficulty in translating the joint military group into the civil sector, because of the many other aspects of the problem related to civil aviation.

Mr. WELLS. I guess I would be less troubled, going back to Mrs. Burgess' testimony this morning, if she had not testified to three major concerns of the NTSB, one of which is: most of the research funds allocated to the area of safety should be oriented towards applied safety research and development, since safety problems do not result from lack of knowledge, but do result primarily from a lack of application of this knowledge.

We are left with this haunting question, then: Who is to push the application of the knowledge and where do the pressures come from? Is it strictly pull from industry, and if they don't pull it doesn't happen, since we apparently do not have much push from regulatory action in this area.

I only make this as an observation.

Mr. GOLDWATER. I think the point that the Commander makes is in the Military, they do all their analysis and research on safety, and then they build it right into the aircraft in their contract, so they are able to transfer knowledge into application. And yet in the civil aviation, NASA has all this research, but where does it go from there?

You have no way of applying what you learned. Neither does the NTSB. They come up with all these great recommendations, but where do they go?

It seems to me that perhaps the FAA, being more the application end of it, or the regulatory end of it, there is a definite need for better cooperation to get—to go from ideas and knowledge into actual application.

I guess that is one of the reasons I asked you if you are seeing your efforts showing up in general aviation.

You answered, yes, it is, but it is really not anything, it is really only because the manufacturer decided that was a good idea, and it is cost-effective, and they were going to implement it. That doesn't mean they are to take advantage of recommendations of the NTSB or your findings or even what the military's recomendations are. Everybody seems to be doing a great job, but when it gets down to actual

application, there may be some question. Maybe there isn't, but I raise that because I am not sure that we are actually utilizing everything we are finding out.

Mr. JONES. That is the difficult part; to get the technology into use. And the best mechanism we have in NASA at the present time is to make sure that as quickly as possible it is brought to the attention of the manufacturer, because he is the one who translates it into a piece of hardware.

Mr. GOLDWATER. With the Military it is a closed loop. It works quite well.

Mr. JONES. It is much different.

Mr. GOLDWATER. You can have a closed loop as far as civil aviation, perhaps if you had the FAA more directly involved, and the NTSB.

Mr. HECHLER. Mr. Wells?

Mr. WELLS. No more questions, thank you.

Mr. HECHLER. You don't have a quotation from Petronius you can give us, do you?

Maybe when the recommendations of the Bolling Committee are carried out and this committee has civil aviation R. & D. and military R. & D. under its jurisdiction, you will find this committee to be a little bit more aggressive in the future

Mr. GOLDWATER. Are you stating that from any source of inside knowledge?

Mr. HECHLER. I have been merely reading the record, Mr. Goldwater, and I hope that my observation doesn't serve to compromise some of the recommendations of the Bolling Committee.

These hearings have been very useful in identifying problems in aviation safety, and we are going to continue to exercise aggressive oversight in this area.

If there are no further questions by all the other members of the committee, the committee will stand adjourned.

[Whereupon, at 3:55 p.m., the subcommittee was adjourned.]

APPENDIX

Questions and Answers Submitted for the Record

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, D.C.

REPLY TO ATTN OF: DEPUTY INSPECTOR GENERAL FOR INSPECTION AND SAFETY, USAF
Norton Air Force Base, California 92409 IGD(AFISC/SE)

22 NOV 1974

Mr. William G. Wells, Jr.
Committee on Science and Astronautics
House of Representatives
Suite 2321
Rayburn House Office Building
Washington DC 20515

Dear Mr. Wells

I am enclosing my answers to the additional questions posed in your letter of November 12, 1974.

It was a great honor for me to appear before the Subcommittee on Aeronautics and Space Technology. If there are any other questions I can answer, I would be most happy to assist you.

Sincerely

Charles E. Yeager

CHARLES E. YEAGER, Brig Gen, USAF
Director of Aerospace Safety

1 Atch
Questions and Answers

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Answers to Questions Posed to Brig Gen Charles E. Yeager by Mr. William G. Wells, Jr., Technial Consultant, Subcommittee on Aeronautics and Space Technology, on November 12, 1974.

1. Question: In your statement you show a dramatic reduction in the rate of major aircraft accidents since 1947. To what significant factors do you attribute this reduction?

Answer: It would be difficult to pick out particular factors as being most significant or to quantify any one factor's contribution. I believe the following were significant.

a. Assignment of experienced pilots to flight safety offices as their primary and full time duty. In our early years, this was an additional duty for one of the unit pilots.

b. Establishment of flight safety as a staff element reporting directly to the unit commander. This lent considerable emphasis and authority to flight safety programs.

c. Development of professional safety training programs. Since 1953 our flying safety officers have received professional training at the University of Southern California Institute of Safety.

d. Development of improved accident investigation techniques, reporting methods, and procedures for reviewing and resolving identified cause factors.

e. Retention of the concept of "privilege" for those portions of the accident investigation which could be used to assess blame or establish liability. This includes witness testimony, information received from manufacturers, and the investigator's analysis and conclusions. Although difficult to measure, I believe that the need to prevent future accidents clearly outweighs any requirement to support litigation arising from individual accidents. The two requirements are incompatible and the atmosphere of immunity in which we investigate, enables us to keep the prevention of other accidents as our only objective.

f. Additionally, of course, there has been steady technological progress in materials, manufacturing methods, human engineering, maintenance procedures, and aircrew training techniques. Some of this progress was undoubtedly inspired by flight safety experience and research.

2. Question: You refer to annual Joint Services Aviation Safety Conferences. How are the results of these meetings distributed?

Answer: The final report of the 13th Annual Joint Services Aviation Safety Conference (April 1974) was printed in 50 copies and distributed

to the respective military service safety centers and the U.S. Coast Guard. Copies were also sent to the appropriate offices of the other participants. This year, they included NTSB, FAA, NASA, Dept of Defense, Canadian Forces, and the University of Southern California Safety Center. Among the services, there has been follow-up correspondence on items identified for action during the conference.

3. Question: You make an important observation about the difficulty of determining what research has been done and who did it. What ideas do you have on the identification and cataloging of required information? Who do you think ought to have the responsibility?

Answer: I support the comments made by Mr. J. Lloyd Jones, NASA, in testimony before the Subcommittee on Aeronautics and Space Technology on the afternoon following my appearance. In describing the NASA Aerospace Safety and Data Institute, he pointed out the problems involved in subject selection and abstraction which are necessary preliminary steps in developing a useful data bank. In response to questions from Mr. Wells, he stated that, given the subject; the funds; and the direction, it is now technically feasible to identify and catalogue the information. I believe him and I believe that NASA should have primary responsibility for any such data bank.

4. Question: What is your relationship with the National Transportation Safety Board?

Answer: We have no official relationship with the National Transportation Safety Board. We have a regulation (AFR 127-11) which is common to all three services and the coast guard and concurred in by the NTSB and the FAA. It provides for participation in each other's investigations and exchange of accident information. As a practical matter, we assist each other whenever we can. When we have a crash data recorder to be analyzed or a tape recording which is garbled, we go to the NTSB for help. Occasionally, we possess some skill they lack and they will come to us. As an example, we recently furnished one of our engineers whose area of expertise happens to be lightning strikes to assist the NTSB in one of their investigations.

5. Question: In discussing the need for a national, coordinated safety R&D program, you suggest some specific problems that probably fall in the "national-coordinated" category. What ideas do you have on how to achieve national coordination for such specific problems as the ones you mention?

Answer: This is not an easy question for me to answer except in very general terms. Assuming that nationally coordinated research programs would use existing agencies and facilities, it seems to me that each subject would need to be dealt with individually. Collision avoidance, for example, is clearly a national problem. We have heard a lot about collision avoidance equipment, but I do not believe there is any basic research being done into the total problem of collision avoidance.

The FAA inaugurated a short term program of this type a few years ago. They demonstrated, as I recall, that they could not collect the type of information needed for the research without a grant of "privilege" or immunity from prosecution or release of information. That situation still exists and I believe that national research into this subject would have to begin with legislation to establish the ground rules. The problem of birdstrikes, on the other hand, would probably not require legislation, but would require funding. We know that there are at least four promising areas for research involving birdstrikes. One is improved aircraft construction techniques. Another is identification of birds through ground radar. A third is avoidance of birds by aircraft. The last, and most exotic, is the possibility that birds can be made to avoid aircraft. This type of research costs money, though, and it is somewhat beyond the resources of any one agency. Other subjects, such as runway construction or weather forecasting may not require either legislation or funding, but merely direction in the coordination of existing research activities.

6. Question: How do safety requirements find their way into R&D programs in the Air Force? How do you decide to go "outside?"

Answer: System Safety requirements become an integral part of Air Force R&D efforts through the normal requirements process, just as performance, reliability, or maintainability. The using command identifies peculiar safety requirements in the Required Operational Capability document. Standard requirements during R&D include: (a) analysis of the design to discover hazards (in accordance with MIL-STD 882), (b) review of historical accident data for design applicability, (c) compliance with principles contained in Design Handbooks, (d) inclusion of Armed Services Procurement Regulation clauses in contracts, and (e) adherence to miscellaneous specifications and standards (most of which resulted from prior mishaps). Additionally, safety personnel from interested Air Force commands participate in design reviews to identify hazards or requirements which have been overlooked.

The decision to go "outside" for system safety tasks during R&D is normally made internal to the particular program, based on recognition that the Air Force does not possess the particular expertise or necessary facility. Outside sources include other services, governmental departments, universities, and private industry.

DEPARTMENT OF THE NAVY
OFFICE OF LEGISLATIVE AFFAIRS
WASHINGTON, D. C. 20350

IN REPLY REFER TO

2 DEC 1974

Dear Mr. Wells:

This is in reply to your letter of November 12, 1974, to Commander M. L. Johnson, former Chairman of the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS), requesting answers to additional questions resulting from hearings before the Science and Astronautics Committee in July 1974.

Commander Johnson retired from active duty on September 1, 1974. Lieutenant Colonel Richard T. Remers, USAF, who has been working in the JTCG/AS since December 1972, has been appointed to succeed Commander Johnson as Chairman.

Colonel Remers has prepared answers to your questions. The questions and the answers thereto are attached as an enclosure.

If you need additional information or if we may be of service in the future, please let me know.

Sincerely yours,

E. H. WILLETT
Captain, U.S. Navy
Deputy Chief

Mr. William G. Wells, Jr.
Technical Consultant
Committee on Science and Astronautics
House of Representatives
Washington, D. C. 20515

Enclosure

Answers to questions posed by

House Science and Astronautics Committee Staff

Question 1: "While you provide a list of projects at the end of your statement which indicate transfer possibilities to civil aviation, could you explain how much transfer is actually taking place? What else could be done?"

Answer: Direct transfer is taking place in projects 5.1.1.7, Development of an Advanced Fire Fighting Agent; 5.1.1.10, Development of Void Space Filler Foams and Reticulated Foams for Fire and Explosion Suppression; 5.1.3.1, Development of Fire and Crash Resistant Aircraft Canopies and Windows and 5.1.3.6, Development of Extended Life Reticulated Foams. These projects are being carried out in NASA Laboratories at the request of and funded by JTCG/AS. Technical Publications resulting from these projects are unclassified and approved for unlimited distribution. Dr. John Parker and Mr. Richard Fish of NASA - AMES*, are chairman and member respectively of the JTCG/AS Materials Ad Hoc Committee. Technical publications resulting from all other listed JTCG/AS projects are automatically distributed to the relevant NASA and FAA offices and to US aircraft and engine manufacturers. Decisions to incorporate the JTCG/AS developed technology into civil aircraft are within the purview of the aircraft manufacturers and the FAA.

* NASA Installation located at Sunnyvale, California

The transfer of technology developed to enhance military aircraft survivability to applications for enhancing civil aircraft safety can best be accomplished by establishing a panel (composed of representatives of the Federal Aviation Administration (FAA), The National Transportation Safety Board (NTSB), The National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD)) to conduct periodic reviews of the newly developed technology and make recommendations to appropriate regulatory agencies for possible mandatory incorporation of new safety features in commercial aircraft.

Question 2: "Do you think some of the organizational arrangements that you have established would have application to the civil field?"

Answer: An organization closely parallel to that of JTCG/AS composed of members of FAA, NASA, and NTSB and sanctioned and funded by the heads of those agencies could prove very effective in coordinating the development of technology to improve the safety of civil aircraft. Pages 3 and 4 of Commander Johnson's prepared statement enumerate the principles upon which a successful coordinating group can be established. These principles are:

a. The Coordinating Group must be chartered and supported by the sponsoring Agency Heads.

(1) The Agency Heads must encourage the active participation of the R&D organizations within their agencies and make all facilities and personnel accessible to the Coordinating Group.

(2) The Agency Heads are the approving authorities for the Coordinating Groups' program plan and therefore retain ultimate control.

(3) The Coordinating Group is the Agency Heads' organization doing a highly necessary job for them. It should not be superimposed by an outside agency.

(4) The Chairman of the Coordinating Group must be provided direct access to the Agency Heads.

b. A small, highly motivated, highly qualified permanent central office staff must be manned by personnel who are members of the chartering agencies.

c. The overall plan for the accomplishment of the Coordinating Groups goals should be prepared and executed by personnel belonging to the participating agencies.

d. All projects should be conducted within or under contract to the R&D organizations belonging to the chartering agencies.

e. Funds should be provided to the Central Office for the execution of the plan.

(1) The power to control the flow of funds to the R&D organizations charged with the responsibility of performing the projects will enable the Coordinating Group to ensure that the actual conduct of the projects will be done in a way that will support the overall goals of the Coordinating Group and not be altered to support other programs.

(2) The funding of the projects, once agreed upon, should be sacrosanct to allow the execution of a well coordinated integrated multi-agency plan at a relatively constant level of effort. This will minimize the impact of the Coordinating Group's projects on the existing, ongoing agency projects and allow the directors of the R&D organizations to better plan for future requirements.

Question 3: "What is the extent of your joint work with NASA?"

Answer: The projects being jointly conducted by JTCG/AS and NASA are listed in the answer to question 1 above. As noted in the answer to question 1, two members of the staff of NASA - AMES are working members of JTCG/AS. NASA-LEWIS** is closely following the project to develop an advanced fire fighting agent and is expected to participate in the development of an engine nacelle fire simulator to be used by the Air Force Aeropropulsion Laboratory to assess the effectiveness of existing and newly developed fire detectors and fire suppression systems. A JTCG/AS sponsored Fiscal Year 1976 project to evaluate anti-misting fuel additives will be closely coordinated with NASA-LEWIS and FAA for applicability to civil as well as military aircraft.

Question 4: "Gen. Yeager suggests that Systems Safety Engineering offers great potential as a new approach to safety -- that is, it is better to design safety than to add it later. Does part of what you are doing fall in this category?"

Answer: The JTCG/AS employs a systems approach to Aircraft Survivability Engineering. An important end item of all JTCG/AS sponsored research and development and testing is the development of design criteria and design handbooks that can be used to build survivability into aircraft during the conceptual and subsequent design phases. This approach is by far the most cost effective, however, it is sometimes necessary to provide a retrofit capability to protect existing aircraft inventories.

** NASA Installation located at Cleveland, Ohio

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

December 3, 1974

REPLY TO ATTN OF: C:RVL:plg:N233984f

Mr. William G. Wells, Jr.
Technical Consultant
Committee on Science and
Astronautics
House of Representatives
Washington, D. C. 20515

Dear Bill:

This is in response to your November 12 letter to Mr. J. Lloyd Jones, forwarding additional questions on the one-day hearing on aviation safety research and development held in July.

Enclosed is a list of the questions and their answers.

Sincerely,

Gerald D. Griffin
Assistant Administrator
for Legislative Affairs

Enclosure

QUESTIONS AND ANSWERS

1. You mention a former NACA Subcommittee on Aircraft Safety which drew upon both military and civil organizations for its membership. What exists now in NASA comparable to that earlier group.

Answer: The RTAC, Panel on Aeronautical Operating Systems has cognizance over NASA aviation safety research.

2. What is the national role of the Aerospace Safety Research and Data Institute? How does its function relate to General Yeager's proposal for a better information system on Safety? Does the Institute include civil and military data?

Answer: The Aerospace Safety Research & Data Institute's missions and objectives are:

a. To support NASA, its contractors, other government agencies (civil and military), and the aerospace industry with technical information and consultation on safety problems.

b. To identify areas where safety problems and technology voids exist and to initiate research programs both in-house and on contract to aid in solving these shortcomings.

c. To prepare and compile state-of-the-art and summary publications in the safety research area.

d. To establish and operate a Safety Data Bank.

The functions of the Institute address mainly the research aspect of aerospace safety. The aims include the achievement of understanding of physical, chemical, and natural phenomena sufficient to rationally resolve aviation operational problems. General Yeager called for an information system much broader than the research aspect of safety, and the Institute's Data Bank could offer a pattern for the establishment of a more extensive repository of safety information by an appropriate agency.

The Institute's Data Bank includes data developed by both civil and military aviation researchers, and while the scope is yet limited, plans call for providing an increasingly comprehensive source of safety research information.

3. In your statement, you state your intention to form a new panel on safety research within the next few months. What is this panel expected to do that has not been done previously?

Answer: The RTAC, Panel on Aeronautical Operating Systems consists of a membership highly expert in dealing with air transport efficiency, fuel conservation and operational practices, topics which are of great interest to NASA and sorely needed at this time. A new panel of experts drawn from a broader safety technology community can provide NASA with constructive advice on specific needs for safety research and with an independent assessment of the on-going effort as a feedback by which our technology product can be improved. This panel could either be a sub-panel to the Panel on Aeronautical Operating Systems, or a standing Panel or Committee in its own right.

4. Do you see merit in the NTSB recommendations for more joint organizational arrangements in Safety R&D? What is your view on the applicability of the DOD Joint Technical Coordinating Group on Aircraft Survivability to civil aviation?

Answer: Joint organizational arrangements under some circumstances can be beneficial in coordinating the work of several different agencies. Too often, such arrangements mature into inflexible organizations which stifle the interchange of information. There is merit in establishing a framework for coordinative, cooperative activity among all agencies and departments having a role in Safety R&D, provided flexibility is maintained in the arrangements. The DOD Joint Technical Coordinating Group on Aircraft Survivability has done an apparently outstanding job within DOD. NASA supports and benefits from the JTCG/AS activity. However, it is constituted to support the military services which are self contained systems, i.e., specifier, buyer, regulator, and operator of the hardware. The services are under a single top organization, JCS, and thus coordination and cooperation can be somewhat assured. Applying this concept to civil aviation presents difficulties, since each civil agency has slightly specialized roles, and the buyer and operator reside within the private sector. It is not clear under present government-private sector philosophy just how such a concept would improve a more flexible arrangement. The new autonomy of the NTSB may provide a "top" organization which can coordinate the broad scope of safety information, safety practice, and safety R&D activity. Individual organizational autonomy must be preserved it seems, in order to assure initiative and high R&D productivity.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20591

NOV 2[illegible] 1974

Mr. William G. Wells, Jr.
Technical Consultant, Committee on
Science and Astronautics
House of Representatives
Washington, D. C. 20515

Dear Mr. Wells:

Enclosed is our response to the three additional questions, posed in the enclosure to your letter of November 12, that arose from the one-day hearing on aviation safety research and development held by the Subcommittee on Aeronautics and Space Technology in July. We trust these comments satisfactorily complement the actual testimony provided on that occasion.

If we can be of any further assistance, please let us know.

Sincerely,

DAVID R. ISRAEL
Deputy Associate Administrator for
Engineering and Development, AED-2

Enclosures

1. Q. In Section IX of the Subcommittee's September 1972 report, a number of safety recommendations were made by Governor Reed of the NTSB and ALPA. What response has the FAA made to those recommendations?

A. Since the recommendations by Governor Reed of the NTSB and the ALPA were made to the Subcommittee and were not addressed to the FAA, no formal written response was made by the FAA. The following information, however, describes FAA activity on these suggestions.

Governor Reed Recommendations (in quotes)

Air Carrier Research Needs (p. 262)

(1). "Crash safety - with emphasis on:
   a. Crash fire research and development
   b. Emergency escape and rescue from wide body jets."

The FAA has a vigorous effort underway to provide research data to support improved standards for cabin interior materials to prevent the spread of cabin fires and to limit the toxic products of combustion. Also being developed is a computer model of cabin fire in a wide body jet for better understanding of fire spread and toxic product distribution along the cabin, and for correlation of small scale laboratory fire tests of new materials with the full scale cabin fire environment. The feasibility of releasing fire extinguishants throughout the cabin to control fires is being tested. These efforts are fully coordinated with NASA's development of improved fire resistant cabin interior materials.

FAA is presently analyzing the airport crash fire rescue state-of-the-art and developments in the crashworthiness area as well as their impact on and relation to requirements for crash fire rescue services. We are assessing the relative importance of various crashworthiness and crash fire rescue system improvements. This assessment will provide direction to our ongoing R&D program which includes; testing a high capacity foam dispensing system on an airport fire truck, testing new foam firefighting agents, and designing a compact, efficient, multi-purpose, rapid response firefighting dispensing system.

(2). "Air navigation aids facilities and services - including airports. Clearly one of the critical safety problem areas in aviation--particularly as it pertains to IFR approach and landing accidents--involves the airport environment and its visual and electronic approach guidance facilities (or lack thereof)."

(3). "Human factors. In this area of concern, problems related to cockpit design and man/machine interface are considered to be in urgent need of attention."

In the area of air navigation aids and human factors, we agree that, since the majority of accidents occur in the critical area of approach and landing, more research is needed. We have successfully carried out R&D to the extent that it is now, or soon will be, possible to install ILS at almost any runway eligible for such installation. Lower cost visual aids also have been developed. Efforts are underway in the man/machine interface by use of a research-type flight simulator program being conducted for us by the USAF. Particular attention is being given to low visibility approaches.

FAA has located a Flight Simulation Branch at the NASA Ames Research Center to utilize the unique capabilities of NASA's aircraft simulators for studying the man/machine relationships pertinent to the development of certification standards for STOL aircraft, CTOL aircraft and supersonic (Concorde) aircraft.

"The study led the Board to conclude that safety research and development is needed in the following areas:
(1) General aviation aircraft stall/spin characteristics."

The FAA is using a unique variable stability aircraft at Princeton University to explore the slow flight and stall area to determine those dynamic flight characteristics of light aircraft that tend to induce stall/spin accidents and also that tend to prevent these accidents, so that the former can be avoided and the latter enhanced in light aircraft designs and design standards. Additional exploration is underway on the feasibility of using stall prevention devices in general aviation aircraft.

The FAA is concentrating on the normal certificated flight regime up to and including the stall, while at the NASA Langley Research Center research is underway on post-stall/spin flight characteristics.

"(2). The general aviation pilot--it was noted in the five year study that 83% of fatal accidents cited pilot error as a contributing factor."

FAA is analyzing detailed accident histories in a statistical manner to ascertain what aircraft design characteristics interact with the pilot in a manner that induces pilot error accidents. Also underway is a study of new pilot training procedures that lead to improved pilot performance in avoiding the stall.

"(3). Crashworthiness studies for general aviation aircraft. It is the Board's view that the adequate design consideration, aircraft accident survival with minimal or no injury, can be assured under dynamic crash force conditions far in excess of those limits to which aircraft are presently designed."

A joint FAA/NASA program is underway in general aviation crashworthiness. The FAA is completing the application of current state-of-the-art analyses techniques to predict dynamic crash response of a seat/man combination and is in process of extending this work to apply to the entire airframe structure. This work will lead to improved crashworthiness certification standards. NASA is involved with the improvement of these structural response analytical techniques.

Also underway by the FAA is a study on the feasibility of applying to light aircraft military developments in crashworthy fuel systems to minimize crash fire (after eliminating the military requirement for ballistic weapon protection).

ALPA Recommendations (p. 267-268 in quotes)

"We have been calling attention to the need for establishing priority not only for R&D to prevent catastrophic accidents from recurring, but also to press on with the implementation of hardware and systems which will enhance aviation safety. In this regard, we strongly urge and respectfully request that this committee lend its weight toward our efforts to expedite the association's 2-year and 5-year plan to utilize the installation of long overdue instrument landing system facilities at our Nation's airports having air carrier operations. The ALPA Proposal for Accelerated Installation of Airport Facilities, October 1971, is attached for the committee's reference. We would appreciate including this

document as part of the record. While this may be off the subject of the hearing, it does illustrate that the R&D conducted over 20 years ago to develop an instrument landing system has been completed, but we still have less than one-half of the ILS's needed--not only for preventing approach and landing accidents, but also for increasing the efficiency and safety of air carrier operations."

> The technology now exists for provision of ILS at many more runways and production programs are in being to carry out such installations. Development programs which might lead to earlier solution of some of the problems referenced particularly apply to the Independent Landing Monitor which is addresses the "ground proximity warning" problem and "terrain warning" system cited by ALPA. Current work underway in these areas includes testing of a modified ground proximity warning system, investigation of means to alert the pilot when the sensor system determines that a problem exists, and evaluation of an experimental airborne forward-looking radar with which it may be possible to provide a sufficient "look ahead" capability to reduce unplanned ground impact.

"Concerning any future air traffic control system, the ALPA believes that the continuing tendency toward the concentration of control from the ground should be eliminated. Their view is that experience shows that a large part of the air space management responsibility should be returned to the pilot. Additional expedited research is required to determine the most efficient manner of distributing the responsibility of air space management."

> In keeping with its responsibility for safely operating the Nation's airways and ensuring efficient use of airspace, the FAA must constantly be aware of the capabilities of the various users of the airspace to ensure meeting this responsibility in an economical manner. Toward this end, the FAA maintains a continuing consultative process to ensure a proper relationship between cost and safety/service to all persons using the airways system and to the public-at-large. One part of this overall process involves a determination of whether to accomplish a given function on the ground, in the cockpit, or both. No simple or a priori approach exists; rather, each case must be considered individually. Current examples of functions that are primarily cockpit-oriented are area navigation (RNAV) and ongoing R&D

in Airborne Collision Avoidance System (ACAS) and the Airborne Traffic Situation Display. Similarly, Metering and Spacing (M&S) and Intermittent Positive Control (IPC) are examples of primarily ground-based systems.

In summary, we believe that the questions involved in determining the most efficient manner of distributing responsibility in airspace management are receiving proper attention.

"Concerning the very urgent problem of collision avoidance the ALPA believes that expedited flight testing, in a live environment, of the most promising collision avoidance systems should be undertaken. The ALPA called for the early realization of protection against mid-air collision by installation of proven hardware by regulation, stating that such effort is in the best public interest. Emphasizing its point, testimony was given that, based on qualified estimates, the cost of a mid-air collision between two jumbo jets would go a long way toward equipping the entire U.S. air carrier fleet with collision avoidance systems."

FAA is proceeding with concurrent investigations of ACAS and PWI (proximity warning indicator) as well as ground-based solutions. Current testing of leading ACAS systems will be completed in late 1975.

The official FAA position is:

ACAS

- A firm commitment to the premise that the ground-based ATC system is and will continue to be the primary collision avoidance system for the U.S.

- Ground-based separation assurance capabilities will be augmented in an evolutionary manner as rapidly as possible through increased use of regulatory measures; software augmentation to the ARTS III and NAS Stage A systems, such as conflict alert and radar advisory services; and, if warranted, Intermittent Positive Control (IPC) and possible Synchro-DABS, in conjunction with the implementation of DABS (Discrete Address Beacon System).

- FAA will complete investigation and testing of the McDonnell-Douglas Time/Frequency, RCA SECANT, and Minneapolis-Honeywell AVOIDS systems and will report the results to the Congress.

PWI

- Based on studies and tests to date, the FAA is not optimistic concerning the viability of available or proposed PWI systems.

- Major unresolved questions exist relative to desirable acceptable PWI performance, i.e., probability of detection, probability of false alarm, need for localization. These questions were investigated.

- FAA investigations and experience by other government agencies indicate that an effective PWI must be a cooperative system and that such PWI equipments cost in excess of current dollar projections for ACAS equipments.

"Concerning the problems of reduced visibility landings, the ALPA supported the National Transportation Safety Board recommendation for the development of a ground proximity system to warn pilots of excessive rates of descent, unwanted or inadvertent descent below minimum descent altitudes, or descent through decision heights."

The FAA is presently undertaking rulemaking action concerning requirements for a ground proximity warning device. As stated previously, tests are underway on a modified version of an existing proximity warning device. Also being evaluated is the feasibility of using airborne forward-looking radar as a means of warning the pilot of dangerous proximity to the ground.

2. Q. Do you have any additional comments on General Yeager's suggestions on:

   a. A better national safety information system.

   b. Possibility of national coordinated programs on specific safety problems.

   A. a. General Yeager stated, "there is no central authority that manages or requires routine exchange of flight safety research data" (p.3 of his statement) and also "The weakness, as I see it, is the difficulty of determining what research has been done and who did it" (p6).

   The FAA position on these points is that there is not a lack of transfer of safety information among practitioners in the many and varied fields that comprise aviation safety. Besides making use of current literature bibliographies, library acquisition lists, and other documented sources, FAA safety experts all are aware of those in industry and other government agencies who are working in their particular areas of safety and the nature of their work. Discussions at conferences and visits to other organizations further this effective cross-fertilization of ideas. Every effort is made to prevent similar parallel R&D work by coordination and joint-program activity.

   b. There is total agreement with General Yeager's statement, "In short, the bulk of aviation safety research needs to be responsive to problems, and I see no way to nationally coordinate this without adding an unnecessary management level and delaying the solution" (p.9-10)

It was pointed out in our statement before the committee that the FAA relies on numerous interagency agreements with NASA and the military services to coordinate federal aircraft safety research efforts. Industry coordination is accomplished by contract interaction in R&D work and by personal contact among safety experts during site visits and at technical conferences and meetings. In this sense there already exist national coordinated programs on specific safety problems.

3 Q. How does the FAA introduce its safety ideas into the design of future aircraft?

A. The FAA uses a variety of mechanisms to introduce safety ideas into future aircraft designs. The simplest form is issuance of an Airworthiness Directive requiring correction of a design deficiency or problem on a current aircraft. The knowledge of any deficiency is disseminated widely in industry so that the specific problem can be circumvented in new designs.

Publication of Advisory Circulars constitutes another avenue for spreading knowledge on both aircraft design practices and flight operations. These are informative in nature and their use in designs is recommended but not mandatory.

A third mechanism is FAA imposition of Special Conditions to the applicable Part of Federal Aviation Regulations (the commonly used description of the Parts of Chapter I; Title 14 of the Code of Federal Regulations). Special Conditions amend or add to the certification requirements for new aircraft, engine and propeller designs. They must be met in a manner satisfactory to the FAA prior to civil use of the new aircraft. Safety ideas thus can be incorporated but are limited to the specific aircraft design for which certification is being applied.

A more comprehensive means of incorporating safety ideas is by amending the Federal Aviation Regulations (FAR) Parts. This is done by issuance and publication in the Federal Register of a Notice of Proposed Rulemaking (NPRM) and creation of a Docket to which interested parties may submit their views. Evaluation of submitted views governs the FAA decision to issue the new rule, amend the new rule or withdraw the proposed rule.

Although the NPRM contains a detailed rationale for the issuance of a new rule or rule change, the rule, once issued, is often accompanied by other documents describing the means of compliance with the new rule that are acceptable to the FAA. This is an additional mechanism for describing new safety features. Also, NPRMs may be backed up by one or a number of reports produced by the FAA Aircraft Safety Research and Development Program that serve to support both the feasibility and the necessity of the rule.

A final mechanism consists of the Advance Notice of Proposed Rulemaking (ANPRM) which is used as an FAA exploratory tool to provide response from the aviation community on safety ideas that appear to provide an increased level of aviation safety but which are as yet embryonic. Responses bear heavily on any FAA decision to proceed further.

In conclusion, the FAA has available and uses a wide variety of means to introduce new safety ideas into future aircraft designs conceived by industry. FAA internal procedures and the consultative process provided during rule issuance assures that the safety ideas introduced are both feasible and reasonable and that they will result in material safety improvement in civil aviation.

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D.C. 20591

OFFICE OF MEMBER

December 2, 1974

Mr. William G. Wells, Jr.
Technical Consultant
Committee on Science and
Astronautics
House of Representatives
Suite 2321, Rayburn House
Office Building
Washington, D. C. 20515

Dear Mr. ~~Wells~~ Bill

Enclosed are the responses to the questions from the Committee on Science and Astronautics which you submitted to me on November 12, 1974. Should you have any further questions please let me know.

With my best wishes.

Sincerely,

Isabel

(Mrs.) Isabel A. Burgess
Member of the Board

Enclosure

Attachment

Responses to questions from the Committee on Science and Astronautics

1. The Military Airlift Command is the biggest air line in the world. What kinds of contacts or relationships do you have with the military?

The Federal Aviation Act of 1958 as incorporated in the DOT Act of 1966 provides for the participation in accident investigation of appropriate military authorities, including the Military Airlift Command (MAC). In the case of accidents involving both civil and military aircraft, the following interface exists between the Safety Board and MAC:

a. There is direct liaison between the Board and MAC headquarters during investigations involving civil aircraft utilized by the U. S. Air Force. There is a complete exchange of accident data in these cases. Each organization also honors requests of the other for specific accident data.

b. The Safety Board performs on request Flight Data Recorder and Cockpit Voice Recorder readouts for MAC on each aircraft incorporating these devices.

c. We maintain liaison with and provide for MAC participation in accident investigations involving civil aircraft under contract to MAC.

d. The Board provides investigation technical support, when requested, for accidents involving MAC aircraft.

e. The Safety Board maintains liaison with the office of the presidential pilot (89th Special Missions Squadron) concerning safety and accident information on similar type aircraft.

2. What is the NTSB process of following up on your recommendations? To what degree or extent do you experience disappointment that your recommendations do not result in changes or what you consider as necessary R & D?

At the present time, in aviation matters, the followup of recommendations is the responsibility of a designated safety recommendation staff. This staff reviews recommendations and response thereto. Responses are considered from the standpoint of degree of implementation and acceptability. However, there are times when we disagree with responses to our recommendations. A disagreement may stem from non-concurrence of the FAA with respect to the need for certain facilities, services and procedures or the requirement for expanded research and development. This will be elaborated upon further under the next question.

3. You state that "safety problems do not result from lack of knowledge but do result from a lack of application of this knowledge." Could you please expand your point.

The statement that "safety problems do not result from lack of knowledge but do result from a lack of application of this knowledge," is not applicable in all cases. There are many instances where a safety problem has been clearly identified and R & D work has shown a feasible solution; but for economic or other reasons a solution was not adopted.

4. Governor Reed made a number of challenging suggestions in his testimony before this Committee in January 1972.

a. He urged that an innovative and meaningful methodology for measuring all of the socio-economic implications and ramifications of safety R & D be undertaken. What progress has been made?

b. He thought there would be merit in the direct applications of joint government-industry programs to safety per se. Has the feasibility of this idea been examined or have any joint efforts been established?

c. Governor Reed suggested that the Board would like to see an increase in the scope of joint efforts and would welcome the opportunity to participate in any pilot programs or studies aimed at furthering safety objectives. What has happened in this area?

4a. We are not aware of any substantial progress in this area.

4b. It is considered that joint efforts are represented to a certain extent by the liaison we maintain with the aviation industry and with other government agencies (the military in particular through the Joint Services Safety Conferences).

4c. The Safety Board has applied these principles in its own operations, i.e., in the investigation of accidents and development of safety recommendations. As far as joint efforts are concerned, these are largely represented by the level and spirit of cooperation that the Board receives in response to its recommendations.

5. Are you satisfied with the safety R & D work going on in the general aviation area? The Board had earlier identified a number of areas where more work should be done: stall/spin problems; pilot error; and crash worthiness.

The Board recognizes that progress is being made in safety R & D work in the areas of stall/spin, pilot error and crash worthiness, and that additional work needs to be done. For example, our Special Study of Stall/Spin Accidents in General Aviation (adopted in September 1972) contained nine safety recommendations, at least half of which advocated additional research work. Although some of the research has been initiated, several projects are not yet completed and others are under study. In view of the continuing large number of general aviation accidents in which the assigned causal area includes the pilot, we believe that more work needs to be done in VFR/IFR transition, training, motivation, spatial disorientation, stability augmentation systems for non-instrument pilots, optimum instrumentation systems for IFR flight, and control system limitation devices to prevent pilot-induced inflight airframe failures. In connection with the subject of pilot training, the Board notes the recently revised 14 CFR 61, (Certification: Pilots and Flight Instructors) wherein the FAA has taken steps to train more proficient and therefore, safer pilots. In a parallel move, the FAA has also recently made effective the new 14 CFR 141 relative to pilot schools, which should revitalize the approved school program. The Board considers that these two revised sets of regulations will help to solve some of the difficulties in the piloting area. Concerning crashworthiness, we note that the subject is included in the agenda for the FAA's forthcoming (Dec. 2-11, 1974) First Biennial Airworthiniess Review to be held at the Sheraton Hotel in Washington, D. C.

6. On page 269 of the Committee's 1972 Report are listed ALPA recommendations to the NTSB. What comments do you have on the ALPA-recommended program?

The ALPA-recommended programs appearing in the Committee's 1972 Report were forwarded to the Safety Board in connection with the Southern Airways DC-9 accident at Huntington, W. Va. on November 14, 1970. Some of ALPA's recommended programs were incorporated in the Board's recommendations to FAA in our report of the Huntington, West Virginia accident. We are enclosing a copy of the Huntington report.

SA-422

File No. 1-0023

AIRCRAFT ACCIDENT REPORT

SOUTHERN AIRWAYS, INC. DC-9, N97S

Tri-State Airport

Huntington, West Virginia

November 14, 1970

ADOPTED: April 14, 1972

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-AAR-72-11

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7. Author(s)		8.Performing Organization Report No.
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15.Supplementary Notes

16.Abstract

Southern Airways, Inc., DC-9, N97S, operating as charter Flight 932, crashed during a landing attempt at the Tri-State Airport, Huntington, West Virginia, at approximately 1936 e.s.t., on November 14, 1970. All 75 occupants, including 71 passengers and four crewmembers, were fatally injured. The aircraft was destroyed.

The flight, chartered to transport the Marshall University football team and boosters from Kinston, North Carolina, to Huntington, West Virginia, was attempting a nonprecision instrument landing approach to Runway 11 at the time of the accident. The crash occurred following impact with trees on a hill approximately 1 mile west of the runway threshold. The elevation of the broken trees at the initial impact site was approximately 922 feet m.s.l.

The National Transportation Safety Board determines that the probable cause of this accident was the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent although the two most likely explanations are (a) improper use of cockpit instrumentation data, or (b) an altimetry system error.

17.Key Words Aircraft accident, charter operation, crew coordination, misuse of altitude information, vertical guidance in nonprecision approaches.		18.Distribution Statement Released to Public Unlimited Distribution	
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NTSB Form 1765.2 (11/70)

SOUTHERN AIRWAYS, INC., DC-9, N97S
TRI-STATE AIRPORT, HUNTINGTON, WEST VIRGINIA
NOVEMBER 14, 1970

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File No. 1-0023

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20591
AIRCRAFT ACCIDENT REPORT

Adopted: April 14, 1972

SOUTHERN AIRWAYS, INC., DC-9, N97S
TRI-STATE AIRPORT, HUNTINGTON, WEST VIRGINIA
NOVEMBER 14, 1970

SYNOPSIS

Southern Airways, Inc., DC-9, N97S, operating as charter Flight 932, crashed during a landing attempt at the Tri-State Airport, Huntington, West Virginia, at approximately 1936 e.s.t., on November 14, 1970. All 75 occupants, including 71 passengers and four crewmembers, were fatally injured. The aircraft was destroyed.

The flight, chartered to transport the Marshall University football team and boosters from Kinston, North Carolina, to Huntington, West Virginia, was attempting a nonprecision instrument landing approach to Runway 11 at the time of the accident. The crash occurred following impact with trees on a hill approximately 1 mile west of the runway threshold. The elevation of the broken trees at the initial impact site was approximately 922 feet m.s.l.

The Minimum Descent Altitude, below which descent is not authorized until the runway environment is in sight, for this instrument approach was 1,240 feet m.s.l.

The weather at the time of the accident was: 300 feet scattered, estimated 500 feet variable broken, 1,100 feet overcast, visibility five miles, light rain, fog, smoke, wind 360° at 4 knots, altimeter setting 29.67, ceiling ragged and variable 400 to 600 feet.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent, although the two most likely explanations are (a) improper use of cockpit instrumentation data, or (b) an altimetry system error.

Recommendations

The Board recommends that:

1. All segments of the aviation industry continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Particular emphasis should be placed on the accelerated development of area navigation systems with vertical guidance capability and on heads-up display systems.

2. The Administrator evaluate the need for the installation and use of ground proximity warning devices on air carrier aircraft.

3. The FAA continue to emphasize the importance of the provisions of Part 121.445 in its surveillance and inspection of flight operations under Part 121. Such emphasis is needed to assure that these operators are (1) using the best means available to enable pilots to qualify under 121.445, and (2) requiring pilots to show that they have acquired the requisite knowledge prior to completion of a flight release.

41-958 O - 74 - 12

1. INVESTIGATION

1.1 History of the Flight

Southern Airways Charter Flight 932 (SOU 932) 1/ was scheduled as a ferry flight from Atlanta, Georgia, to Kinston, North Carolina, to return members of the Marshall University football team, the coaching staff, and other passengers to Huntington, West Virginia, from Kinston. The flight was then scheduled to continue to Hopkinsville, Kentucky, and Alexandria and Baton Rouge, Louisiana. The crew consisted of a captain, a first officer, and two stewardesses. In addition, an operations employee was assigned as a charter coordinator.

The flightcrew was given a standard briefing by company dispatch and a charter kit of appropriate documents, including: (1) Jeppesen Manuals for high and low altitude airways, and approach charts for all major civil and military airports in the U.S.; (2) the current Airman's Information Manual, Parts I, II, and III; (3) a complete set of Sectional Aeronautical Charts; and (4) all the necessary flight forms for cargo loading, weight and balance, flight planning, daily inspection and maintenance, and credit cards. In addition, a copy of the Southern DC-9 off-line airport restrictions was carried by the charter coordinator, and another copy was kept on each aircraft. The stewardesses and charter coordinator boarded the aircraft with the flightcrew at Atlanta and the aircraft was ferried to Kinston.

The flight departed Atlanta at 1548 2/ and arrived at Kinston at 1642. The aircraft was refueled, but no maintenance was requested or performed. Seventy passengers boarded the aircraft and the flight taxied from the ramp at 1828 with a total of 75 persons aboard.

The captain filed an Instrument Flight Rules (IFR) flight plan to Huntington, via direct Raleigh-Durham, North Carolina, direct Pulaski, Virginia, direct Huntington, at Flight Level 260 (FL 260). The true airspeed was 473 knots and the estimated time en route was 52 minutes. The flight departed Kinston at 1838 and proceeded in accordance with the flight plan. Subsequent air traffic control transfers were accomplished and, at 1923, SOU 932 established contact with Huntington Approach Control by advis-

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1/ The primary difference between this charter flight and a regularly scheduled flight conducted under Southern Airways' operating certificate is the applicable landing minima. The Federal Aviation Regulations impose higher landing minima on the pilot of a charter flight, unless he is qualified at the airport and lower minima have been established for the airport in the air carrier's operations specifications. In this instance the normal minima for Runway 11 were increased from 1,240 feet and 1/2-mile to 1,240 feet and 1 mile.

2/ All times herein are eastern standard, based on the 24-hour clock.

ing, ". . . we're descending to five thousand." 3/ The controller cleared them for a localizer approach to Runway 11 and added, ". . . the surface winds are favoring runway twenty-nine, three five zero degrees at six, altimeter two niner six seven. . . ." The crew acknowledged this information and then the controller advised, ". . . the Huntington weather three hundred scattered, measured ceiling five hundred, variable broken, one thousand one hundred overcast, visibility five, light rain, fog, smoke, ceiling ragged variable four to six hundred."

At approximately 1933, the captain said that he would fly at 130 knots, and the first officer responded that he was checking the time, and the approach should take 2 minutes. At 1934, the crew reported passing the outer marker inbound, and they were cleared to land. The wind was then reported as 340°, 7 knots. Following a discussion of the approach lighting during which the crew requested "step three," the tower controller stated, "Roger, that's where they are, with the rabbit (sequence flasher). Advise when you want them cut." The crew's response, "Very good," was the last transmission received. At approximately 1936, tower personnel observed a red glow west of the airport. When no response to subsequent radio calls was received, the tower controller initiated the emergency procedures.

Witnesses in the vicinity of the Runway 11 localizer course generally agreed that the aircraft was low, but otherwise appeared normal. The weather was described as varying between mist and light rain with low clouds. Some witnesses also indicated that visibility was restricted due to fog. However, one witness who was approximately two-thirds of a mile west of the initial impact site observed the aircraft pass approximately 300 feet above him and disappear from view beyond the hill. He saw the hill outlined in "good detail" by a glow from beyond the hill, and heard an increase in jet engine noise prior to the crash. Another witness, who was approximately 700 feet east of the initial impact, stated that the aircraft rolled to the right, almost inverted, and crashed in a steep, nosedown angle.

The tower controller stated that he maintained a continuous watch for SOU 932 once they reported passing the outer marker. Although he did not see the aircraft, he did observe the fire and explosion from the crash. He did not recall any differences between the reported and actual weather prior to the accident.

3/ A transcript of pertinent cockpit conversation is included in Appendix D.

The last flight to operate into Huntington prior to SOU 932 landed on Runway 11 at 1848 and departed at 1907. The captain of that flight stated that the weather was essentially as reported to him, 300 feet scattered, 500 feet variable broken. They broke out of the clouds at minimums, west of the refinery (located approximately 2 miles west of the airport). The forward visibility was good, and the runway was in sight from this point until they landed, although they did encounter some widely scattered scud clouds.

The accident occurred during hours of darkness at 38° 22' 27" N. latitude and 82° 34' 42" W. longitude.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	4	71	0
Nonfatal	0	0	0
None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed by impact and ground fire.

1.4 Other Damage

The aircraft destroyed many trees on a hill approximately 1,300 feet west of the main wreckage site.

1.5 Crew Information

The crew was qualified for the flight. (See Appendix B for details.)

1.6 Aircraft Information

The aircraft was certificated and maintained in accordance with existing regulations. It was fueled with Jet A-1 kerosene. (See Appendix C for details.)

1.7 Meteorological Information

At the time of the accident, a low-pressure area was centered near southwestern West Virginia. A frontal system extended southward from

that area and the accident site was included in an extensive zone of low cloudiness and precipitation associated with these synoptic features.

The aviation area forecast for West Virginia, issued by the National Weather Service (NWS) office at Suitland, Maryland, valid for a 12-hour period, beginning at 1400, was, in part, as follows:

> Low pressure developing over the southeastern states and centered over northeastern Alabama, expected to move northeastward at 15 to 20 knots will lie over western North Carolina southwestern Virginia by 0200.
>
> Flight precaution recommended throughout forecast area because of lowering ceilings and visibilities and also because of occasional turbulence and possible icing.
>
> Over West Virginia . . . generally ceiling 1,000 to 2,000 feet overcast, 3 to 6 miles, haze, occasional ceiling 300 to 500 feet overcast, 1 to 2 miles, fog, scattered light rain. Conditions lowering more extensively after 1700, becoming more frequently ceiling 500 to 1,000 feet overcast, 1-1/2 to 3 miles, light rain, fog, and occasional ceiling 300 to 500 feet overcast, 3/4 to 1-1/2 miles, light rain, fog, with light rain to occasional moderate rain.
>
> Freezing level 6,000 to 8,000 feet over mountains . . . occasional moderate icing in clouds likely above the freezing level. . . .

The terminal forecast for Huntington, issued at 1145, and valid for a 12-hour period beginning at 1200 was in part as follows:

> 1200-2100, ceiling 500 feet overcast, 2 miles, light rain, fog, smoke, wind 030°, 12 knots, variable to ceiling 300 feet overcast, 1 mile, light rain, fog.

The next routine terminal forecast was issued at 1745, valid for a 12-hour period beginning at 1800 and was in part as follows:

1800-2300, 300 feet scattered, ceiling 500 feet broken, 1,000 feet overcast, 1-1/2 miles, light rain, fog, scattered clouds variable to broken.

The official surface weather observations for Huntington bracketing the time of the accident were as follows:

1855, 300 feet scattered, measured 500 feet variable broken, 1,100 feet overcast, 5 miles, light rain, fog, smoke, temperature 49°, dewpoint 47°, wind 360°, 4 knots, 29.67, ceiling ragged and variable 400 to 600 feet.

1945, 300 feet scattered, estimated 500 feet broken, 1,000 feet overcast, 5 miles, light rain, fog, smoke, temperature 49°, dewpoint 47°, wind 210°, 4 knots, 29.67, ceiling ragged, aircraft accident.

1956, record special, partial obscuration, estimated 500 overcast, 3/4-mile very light rain, fog, smoke, temperature 49°, dewpoint 47°, wind 290°, 5 knots, 29.67, fog obscuring 5/10 of the sky, ceiling ragged, intermittent very light rain.

The National Weather Service specialist who made the observations testified that ". . . I thought the visibility was remarkably good when I took my local (the 1945 observation), but about 10 or 15 minutes after that the fog formed very rapidly, and that's when the visibility came down. . . it was right over the field. It just seemed like it formed very rapidly and it just actually sank right over the whole field."

The Huntington 1900 radiosonde ascent showed saturated or virtually saturated conditions with stable air from about 2,000 to 5,000 feet and otherwise a moist adiabatic lapse rate. The freezing level was at 7,500 feet. The upper wind observation associated with this ascent was in part as follows:

Height (feet m.s.l.)	Direction (°true)	Velocity (knots)
Surface	360	7
2,000	075	12
3,000	130	18

A study of pressure patterns in the West Virginia area, at the time of the accident, was conducted for the Safety Board by the National Weather Service following the initial public hearing. The study showed that the dominant low-pressure area was elongated toward the northeast with surface pressures dropping at an average rate of 0.013 inch of mercury/hour. This would correspond to an indicated altitude increase of 13 feet/hour. The low-pressure area moved steadily northeastward with little change in intensity. Although there was an extensive area of light rain, no showery precipitation (possibly indicative of more rapid pressure variation) was reported within 250 miles of Huntington.

1.8 Aids to Navigation

The Tri-State Airport was equipped with an ILS localizer, but no glide slope. The localizer provided a nonprecision approach to Runway 11. The crew's Jeppesen Approach Chart depicting this procedure was dated December 27, 1968; however, the current approach chart at the time of the accident was dated November 6, 1970. (See Attachment 2.) The revised approach chart was incorporated in Southern's charter kits on November 13, 1970, by the chief pilot. Two kits were not available on that date because they were in use at the time, including the charter kit on N97S which had departed at approximately 0830 on the day the revisions were inserted. The basic differences in the two approach charts were: (1) an increase in the Minimum Sector Altitude 4/ from 2,500 feet to 2,600 feet m.s.l., for the sector west of the airport (180° clockwise through 360° inclusive); and (2) the addition of holding instructions to the missed-approach procedure text.

The Localizer-Runway 11 approach required a procedure turn south of the 114° localizer course within 10 miles of the outer marker, at 2,600 feet m.s.l. The outer marker minimum crossing altitude was 2,200 feet m.s.l., and further descent was then authorized to the Minimum Descent Altitude (MDA) 5/ of 1,240 feet m.s.l. The outer

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4/ Minimum Sector Altitude - provides 1,000-foot obstacle clearance within a 25-mile radius of a navigation facility (except localizers without a nondirectional beacon). A sector may not be less than 90° in spread, and the obstacle clearance must also apply in adjacent areas within 4 miles of the sector boundary. All altitudes are mean sea level (m.s.l.) unless otherwise indicated.

5/ Minimum Descent Altitude is the lowest altitude to which descent shall be authorized in procedures not using a glide slope. Aircraft are not authorized to descend below the MDA until the runway environment (runway threshold, or approved lighting aids or other markings identifiable with the runway) is in sight and the aircraft is in a position to descend for a normal landing.

marker and middle marker were located 4.6 and 0.6 miles, respectively, from the runway threshold. The localizer was offset approximately 0.7° to the south of the runway centerline. The offset was accomplished to place the antenna on stable ground where the electronic signal would remain within tolerances. A flight check of the facilities was accomplished by the Federal Aviation Administration (FAA) on November 15, 1970, and all were found satisfactory.

An instrument landing system was scheduled for installation and commissioning at the Tri-State Airport in June 1958. The localizer, middle marker, and outer marker installations were completed at that time, but there was insufficient terrain to provide adequate reflecting surface for the glide-slope antenna, within the existing criteria. Three applications for runway extension, which would also provide suitable terrain for the glide-slope antenna, were submitted to the FAA in Fiscal Years 1967, 1970 and 1971. The 1967 and 1970 requests were not approved because the necessary "matching funds" from the sponsoring agency were not available, and consequently the Federal funds were not committed. The 1971 request was still under consideration at the time of the accident.

Subsequent to the accident, concurrent negotiations involving the FAA, West Virginia State Aeronautics Commission, Wilcox Electric Company, Inc., and the Tri-State Airport Authority, resulted in the installation of a nonstandard glide slope for Runway 11, paid for by Federal funds only. Prior to installation, the FAA estimated that there was a 50 percent probability of success with the glide slope. A Wilcox Mark I, Series 8020 transmitter was placed 1,211 feet south of the runway centerline and 960 feet west of the Runway 29 threshold. The elevation of the site was 805.2 feet m.s.l. and the antenna was rotated 13.5° to align with the middle marker. This offset was required to place the site on suitable terrain, and resulted in an unuseable signal below 1,075 feet m.s.l. Consequently, there was no reduction in the minimum altitude authorized for the instrument approach. However, the signal generating capability of the facility to date has been as reliable as standard systems.

1.9 Communications

There were no known difficulties with radio communications.

1.10 Aerodrome and Ground Facilities

The Tri-State Airport was located on a hilltop approximately 2.5 miles southwest of Huntington, West Virginia, at an elevation of 828 feet

m. s. l. The only runway was Runway 11-29. It was 5,281 feet long and 150 feet wide, and was of concrete construction. Runway 11 was equipped with high-intensity runway lights, approach lights, and sequence flashers. All lighting was operating satisfactorily. There was no visual approach slope indicator (VASI) system installed.

There was very little level land extending beyond either end of the runway; however, there were other hills of similar size and elevation surrounding the airport. The highest obstacle in the area underlying the localizer course was a tree 6,700 feet east of the outer marker, at an elevation of 990 feet m. s. l. By contrast, the Ohio River and Big Sandy River passed within a few miles of the airport at elevations of approximately 500 feet m. s. l. in the north, west, and south quadrants. An area of bright lights surrounding a refinery was located on the west bank of the Big Sandy River just south of the localizer course, about 2 miles west of the runway threshold.

1.11 Flight Recorders

The aircraft was equipped with a Sundstrand flight data recorder, Model F-542, S/N 1047. The recorder unit had been exposed to extreme heat in the fire after impact, but the recording medium magazine was easily removed and the recorded foil surface was virtually undamaged. A readout of the last 10 minutes of normally recorded traces was prepared. The altitude trace was adjusted for an altimeter setting of 29.67 to indicate m. s. l. altitudes, but no other corrections were made to the data. Additional checks of the altitude trace were made as follows:

Location	Altimeter Setting	Recorded Difference	Tolerance
Atlanta Airport	29.71	- 18 feet	± 100 feet
Cruise FL 290	29.92	+ 200	± 450
Stallings Field (Kinston)	29.90	+ 88	± 100
Cruise FL 260	29.92	+ 235	± 400

The last 0.036-inch of foil travel contained sudden deviations in all recorded traces. This aberrant area, equivalent to 21.6 seconds of elapsed time during normal operation, included a 0.009-inch segment without the recording of any parameter trace. With the assistance of the manufacturer, various tests were conducted to duplicate the indications on the flight data recorder foil. Mechanical and electrical checks, g-loading on all three axes with indiscriminate interruptions of electrical

power, and attempts mechanically to impede or accelerate foil travel all failed to provide a satisfactory explanation for the aberrations. It was determined that the 0.009-inch skip was caused by a shock of unknown magnitude or origin. Also, though some scribe marks during the 0.036-inch travel were normal in appearance, there was no correlation between the recorded parameters, except that the downward excursions appeared to have been caused by a heavy shock in excess of 30g's.

The flight data recorder static pressure source is the aircraft alternate static system. This system is completely separate from the captain's and first officer's normal static pressure systems, except that it is available as a backup source for their instruments, if selected by them. The alternate static ports are located on either side of the aircraft centerline approximately 10 feet forward, and slightly below, the normal static port panels.

The aircraft was also equipped with a Collins cockpit voice recorder (CVR), Model 642-C-1, S/N 508. The unit had sustained considerable impact damage to the electronics package, but there was no damage within the stainless steel case of the tape magazine. There was considerabl "wow and flutter" on the tape, indicating a mechanical distress condition within the recorder. There was also marked interference from background noise and the cockpit speakers. A partial transcript of the readout is attached as Appendix D.

1.12 Wreckage

The aircraft initially struck trees on a hill 5,543 feet west of the runway threshold, and cut a swath 95 feet wide and 279 feet long through the trees on a bearing of 110°, 122 feet right of the Runway 11 centerline extended. Several sections of wing leading edge, one trailing edge flap moveable vane, and a flap track, all from the right wing, and three large sections of radome were located near the swath cut.

The main wreckage site was located 4,219 feet from the threshold of Runway 11, and approximately 225 feet south of the middle marker. The aircraft cut a swath 39° below the horizontal through the trees at the wreckage site and came to rest in an inverted attitude.

The ground elevation at the initial tree impact was 860 feet m.s.l., and the elevation at the break in the tree at this location was 916 feet 2

inches m. s. l. The highest ground elevation adjacent to the swath cut was 894. 5 feet m. s. l. Tree heights at this point measured 50 feet, which corresponded to a treetop elevation of 944. 5 feet m. s. l. The ground elevation near the crest of the hill in the center of the swath cut was 880 feet m. s. l. The break in a poplar tree at this point was 42 feet above the ground (922 feet m. s. l.) However, the U. S. Department of Agriculture Forest Service estimated that the tree was 71 feet (± 1 foot) tall before breakage, based on a study of other trees in the area. The MDA was approximately 290 feet above the estimated maximum elevation of the tree top. The swath cut between the initial tree impact and the break in the poplar tree was ±2°, measured from the horizontal. The distance between these two trees was approximately 152 feet.

Most of the fuselage was melted or reduced to a powder-like substance; however, several large pieces were scattered throughout the burned area. Examination of the various components indicated that the landing gear and flaps were fully extended at impact. The horizontal stabilizer setting was 5. 75 units noseup, which was in the normal range for the weight, and speed, in the approach configuration.

1. 13 Fire

A severe ground fire at the main wreckage site followed impact. Firefighting activity at the crash site was limited to containing brush fires in the area. There was no evidence of in-flight fire.

1. 14 Survival Aspects

This was a nonsurvivable accident.

1. 15 Tests and Research

In reviewing the circumstances of this accident, the Safety Board again took notice of tests conducted by the Douglas Aircraft Company (DACO) in May 1967. The tests were designed to study the effect of possible water ingestion in the static ports of the aircraft. Several DACO field service reports had indicated that during final descent on ILS approaches, with full flaps and landing gear extended, the altimeter was alternately "pausing" and then "jumping. " At each momentary pause and subsequent jump, the instantaneous vertical speed indicator tended toward zero. Most of the "jumps" were between 40 and 60 feet, but several were 80 to 100 feet in magnitude.

The initial tests were conducted in an altitude chamber. It was found that each port of a static plate entrained water by capillary action, and pressure differentials equivalent to about 35 feet in altitude, at sea level, were required to expel the water. A series of runs verified that any increase in the diameter of the orifice decreased the magnitude of the "jumps." Variations in the rate of descent affected the rate of "jumps," but not the magnitude.

Flow visualization tests were then conducted in the wind tunnel with 1/50-scale DC-9-10 and DC-8-55 models to identify any mechanism that might tend to concentrate water in the vicinity of the static ports. The testing covered both no-flap and 50°-flap configurations at angles of attack ranging from -8° to +8°. The observed flow was orderly, and the only deviation was around a high velocity region on the nose of the DC-9. This was later found to be due to model asymmetry.

Actual flight tests were conducted in light-to-heavy rain with a DC-9-30 in the following flight conditions: descent in the landing configuration for both the DC-9-10 6/ and DC-9-30, and descent in the clean configuration that was representative of both aircraft. Nine simulated ILS approaches were flown in the DC-9-30 landing configuration. 7/ Both the normal and alternate static systems were monitored throughout, and no instances of sticky altimeter operation were observed. Additionally, five typical descents were made in the clean configuration, at 2,500 to 3,000 feet/minute, through light to sporadically heavy rain. No evidence of sticky altimeter operation was detected on any system.

At the request of the Safety Board and the FAA, the National Aeronautics and Space Administration has undertaken a long term Static Pressure Measurements Project at the Lewis Research Center. This exploratory research project includes flight and ground testing to determine the flight and weather conditions which may lead to altitude misinformation. A secondary objective is to compare the water ingestion resistance of existing static ports with static ports being considered for future aircraft. The flight test portion of this project has begun, and ground tests will be predicated on the results of the flight tests.

6/ The DC-9-30 aircraft was modified to incorporate a simulated DC-9-10 static system. It was flown at Series 10 VRef +5 knots, with the gear down, 50° flaps, and slats closed, to gather the DC-9-10 data.

7/ Landing gear down, slats and flaps extended, and VRef +5 knots.

The captain's altimeter (type E42459 10 113, S/N 115) and the first officer's altimeter (type A40179 10 020, S/N 430), both from N97S, were taken to the manufacturer's facility where a detailed teardown was made. The captain's barometric setting counter was determined to be reading approximately 29.67. The synchrotel reading on a servoed angle position indicator was 3.65°. This was calculated to represent an indication of approximately 568 feet; however, the rotor being measured was free to rotate. The outer and inner drums of the assembly, which were held in proper alignment by light spring tension, were displaced so as to indicate an offset of approximately 600 feet. A small area of paint was missing from the drum at an indicated altitude of approximately 1,250 feet. This mark was very similar in size and location to the drum index, but there was no paint adhering to the underside of the drum index.

The first officer's altimeter was determined to have been set at a barometric setting between 29.73 and 29.24. The displacement from normal alignment between the outer and inner drum was equivalent to approximately 3,000 feet. No impact marks could be found on the altimeter dial, but a portion of the dial next to the drum window revealed an area, similar in shape to the pointer tip, which had been protected from heat damage evident on the surrounding area. The orientation of the protected area indicated that the needle would have to have been either distorted or dislodged prior to the heat damage in order to mask this area of the dial. The masked area was near the outer dial hash mark indicating "3".

A test program was conducted by the Kollsman Instrument Corporation to determine the effect on an altimeter of (1) a 135° roll about the longitudinal axis of the aircraft and (2) sudden stoppage from impact during a roll. The altimeter, mounted on an aluminum bar, 24 inches from the point of rotation, in a standard instrument panel cutout, was set at 875 feet and 29.67. It was rotated about the offset axis at varying speeds from 18°/second to 90°/second. No significant pointer travel was noted due to rotation. Next, the altimeter was allowed to free fall from various heights to a sudden stop. The stop was adjusted to strike the altimeter housing at the rear, midpoint, and panel on successive drops.

The indicated altitude increased to approximately 1,000 feet on each occasion, and was as high as 1,230 feet on one drop from a height of 10 inches. The test was discontinued at this point to avoid damage to the instrument because the estimated shock valves were approximately 50 g's, and the indicated valve compared favorably with that found on the captain's altimeter drum.

1.16 Other

The Southern Airways DC-9 Operating Manual established the procedures to be followed in their operation of DC-9 aircraft. The nonprecision approach was presented graphically with annotations describing crew actions to be taken at the appropriate times, as follows:

1. Complete in-range checklist 10 minutes prior to estimated time of arrival.

2. Select 15° flaps, extend slats, and slow to appropriate maneuvering speed prior to commencing approach.

3. Commence procedure turn 30 seconds past outer marker (depending on wind).

4. Select 25° flaps, extend gear, complete landing checklist and slow to appropriate maneuvering speed.

5. Over radio fix start descent to MDA, maintain previous maneuvering speed.

6. Select 50° flaps, slow to VRef + 5 knots when runway is sighted.

7. Reduce thrust slowly over threshold to obtain VRef speed, touchdown target is 1,000 feet from threshold.

The Before Landing Final Checklist was described, in part, as follows:

GEAR (Both pilots)	DOWN/3 GREEN DOOR LIGHTS OUT PRESSURE AND QUANTITY NORMAL
500' FLAG SCAN SPEED RATE DESCENT	CHECKED

The Southern Airways DC-9 Flight Manual required the pilot not flying the airplane to make the following callouts during approaches:

a. Any deviation below published transition altitudes.

b. 500' above field elevation and state "No Flags" or "Flags On" as seen on instrument.

c. 100' above minimums.

d. At minimums, call out "Minimums-Runway in Sight" or "Minimums-No Runway."

e. Any sink rate of 1,000 feet/minute or more.

The manual also stated that descent rates in excess of 1,000 feet/minute and flat approaches were to be avoided. The procedure for either a missed-approach or a rejected landing was the same:

1. Set takeoff power.

2. Rotate immediately to stop descent (minimum 10°) and simultaneously call flaps 15°.

3. Continue as in normal takeoff.

4. Do not raise gear until climb is established.

The radio altimeter system was described in Southern Airways DC-9 Operating Manual in general terms, including the following, "Two separate radio altimeter systems on the (Dash 31) . . . are provided to obtain precise altitude information above the ground at the minimum decision (sic) altitude (MDA). This information is essential to the pilot in his decision to land or initiate a go-around maneuver." The chief pilot for Southern Airways testified that this statement was misleading that it was excerpted from the DACO DC-9 manual, and was more applicable to precision approaches over level terrain than to nonprecision approaches of this type. He emphasized that Southern's pilots were cautioned in training against using the radio altimeter as a primary reference. In amplifying their training procedure, he also indicated that the pilots were trained to call out altitudes in terms of m.s.l. except the "hundred above" and "minimums" which were obviously referenced to MDA. The 500-foot flag scan was required on all approaches, whether visual or instrument, and a comprehensive standardization program was conducted. He stated that he was not aware that any company pilots deviated from this practice. He

estimated that more than half of the approaches made in their line operation were nonprecision.

On January 12, 1971, Southern Airways issued changes to their DC-9 Operating Manual as follows:

(1) A note was added to the Nonprecision Approach and Landing Diagram stating that, for a short approach where time expiration and MDA for the approach are expected to coincide, flaps may be extended to 50° at the approach fix.

(2) An additional callout at 500 feet above minimum altitude was added.

(3) The discussion on use of the radio altimeter was modified to include a warning that the system was unreliable over hilly or rolling terrain, and should not be used for altitude information.

Southern Airways' authority for charter operations was contained in its Operation Specifications. This authority required that any "off-route" operation be accomplished as prescribed by Part 121 of the Federal Aviation Regulations applicable to supplemental air carriers and commercial operators, and by the exceptions which were contained in their Operations Specifications. The exception applicable to IFR takeoff and landing weather minima required that, when the pilot-in-command was not qualified for the airport, he must use the weather minima and instrument approach procedures prescribed in Part 97 of the Federal Aviation Regulations. The minima established for a localizer approach, by this part of the regulations, were 350 feet and 1 mile. However, the minima specifically established for supplemental air carriers or charter operations at the Tri-State Airport were 412 feet and 1 mile.

The airport and route qualifications applicable to the charter flight in this instance were stated in Part 121.445 as follows:

"(a) Each supplemental air carrier and commercial operator shall establish in its manual a procedure whereby each pilot who has not flown over a route and into an airport within the preceding 60 days will certify on a form provided by the operator that he has studied and knows the subjects listed in paragraph (b) of this section in regard to the routes and airports into which he is to operate.

"(b) Each qualifying pilot shall show that he has adequate knowledge of the following:

(1) Weather characteristics appropriate to the seasons.

(2) Navigation facilities.

(3) Communication procedures.

(4) Kinds of terrain and obstruction hazards.

(5) Minimum safe flight levels.

(6) Pertinent air traffic control procedures including terminal area, arrival, departure, and holding and all kinds of instrument approach procedures.

(7) Congested areas, obstruction, and physical layout of each airport in the terminal area in which the pilot will operate."

In accordance with the company's Operations Manual, when the captain signed the flight release, he certified that he had studied and knew the subjects listed above with regard to the route and airports into which he intended to operate. There was, however, no procedure in the manual to provide for a showing by the captain that he had the requisite knowledge.

The airport and route qualifications applicable to scheduled flights of Southern Airways are contained in Part 121.443. This part contains the above-listed requirements of Part 121.445 and also includes the following:

(1) He must show adequate knowledge of position reporting points and holding procedures. This may be demonstrated in a properly equipped synthetic trainer.

(2) He must make an entry, as a member of the flightcrew, at each regular, provisional, and refueling airport into which he is scheduled to fly. The entry must include a takeoff and a landing, and the qualifying pilot must occupy a seat in the pilot compartment, and must be accompanied by a pilot who is qualified for the airport.

(3) The entry requirements may be waived if the initial entry is made under VFR weather conditions; or if the air carrier shows that such qualification can be made using approved pictorial means; or if the Administrator is notified that the air carrier intends to operate into an airport near one into which the pilot concerned is currently qualified, and the Administrator finds that such qualification is adequate for the new airport, considering at least the pilot's familiarity with the layout, surrounding terrain, location of obstacles, and instrument approach and traffic control procedures at the new airport.

The original negotiations between Marshall University and Southern Airways resulted in initial rejection by Southern Airways because of the takeoff weight limitations of their aircraft. The subsequent negotiations resulted in a reduction in the weight of passengers and baggage to be carried from approximately 19,500 pounds to 17,500 pounds, and the charter flight was scheduled. The flight was then offered for bid to the pilots and assigned on the basis of seniority, the same as regularly scheduled flights.

The flight was dispatched initially from Atlanta for the entire charter sequence to Baton Rouge. At Kinston, the captain contacted the dispatcher in Atlanta and an update was accomplished by telephone. Both releases anticipated a landing on a wet runway at Huntington, and the 15 percent additional runway requirement was included in the landing distance computations.

The same aircraft, dispatchers, flight planning services, and supervising personnel were used in the charter operation as in the regularly scheduled service. In addition, a charter coordinator was assigned to assist the flightcrew in administrative matters generally involving ground operations. The coordinator's duties involved supervising and expediting ground operations, arranging for fueling, completing weight and balance forms, etc. In the performance of these duties, he normally communicated directly with the captain shortly before landing. Although he was permitted to enter the cockpit under these circumstances, he was not authorized to occupy the jumpseat. In this instance, the charter coordinator was in the cockpit during the instrument approach, and discussed the fueling at Huntington. He also commented, "Bet'll be a missed-approach" approximately 16 seconds before impact.

During the investigation, considerable attention was focused on the height of the trees on the hill where initial impact occurred. It was determined by an FAA Runway Obstruction Survey, dated December 1, 1970, that several trees on the hill penetrated the ILS approach surface 8/ and therefore constituted obstructions to air navigation as defined in Part 77, Subpart C, of the Federal Aviation Regulations. However, these standards are used in (1) administering the Federal-Aid Airport Program, (2) transferring property under Section 16 of the Federal Airport Act, (3) providing technical advice in airport design and development, and (4) imposing requirements for public notice of construction or alteration of structures where notice will promote air safety. The criteria used in the establishment of flight procedures and aircraft operational limitations are contained in Part 97 and the U. S. Standard for Terminal Instrument Approach Procedure (TERPS). Paragraph 954 of TERPS requires that the minimum obstacle clearance in the final approach area 9/ shall be 250 feet for a localizer approach. The trees did not violate this requirement.

A pen recording was made of the outer marker identifier signals as they were recorded in the CVR tape, to assist in locating the flightpath of SOU 932 through the radiation pattern. For the purpose of this evaluation, it was assumed that the receiver sensitivity of the DC-9 was the same as that of the FAA flight-check aircraft. It was also assumed that the identification tone had reached its maximum signal strength when the recorded signal stopped. Based on the calculations, it was determined that the aircraft was approximately 1,850 feet south of the outer marker transmitter when the signal stopped. Any variation in these assumptions would, of necessity, place the aircraft closer to the transmitting antenna than depicted on Attachment 1.

8/ Part 77.27(b) defines ILS approach surface as a surface longitudinally centered on the extended centerline of an ILS runway beginning at each end of the primary surface and extending outward and upward at a slope of 50 to 1 for a horizontal distance of 10,000 feet and at a slope of 40 to 1 for an additional 40,000 feet. This surface is the width of the primary surface at the beginning and expands uniformly to a width of 16,000 feet at a distance of 50,000 feet from the end of the primary surface. The primary surface of Runway 11 was 1,000 feet wide and extended 200 feet beyond the threshold at each end of the runway.

9/ Paragraph 930(1) gives the dimensions for the final approach area as 50,000 feet long measured outward along the final approach course from a point 200 feet outward from the runway threshold, and 1,000 feet wide at that point expanding uniformly along the localizer course to a width of 16,000 feet at a point 50,000 feet from the beginning point.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The aircraft center of gravity was within allowable limits. Based on the aircraft performance capability, there was sufficient runway available for N97S to have landed under the conditions existing at Huntington at the time of the accident.

The crew was properly certificated and qualified for the flight. The aircraft had been maintained in accordance with existing company procedures and the Federal Aviation Regulations. The investigation disclosed no malfunction or failure in the aircraft structure, primary flight controls, or powerplants.

The Board reviewed the charter arrangements, operations specifications, and regulations governing the dispatch and conduct of this flight. Although the flight was conducted in accordance with the prescribed procedures, there is one area which is of concern to the Board. An equivalent level of safety for "off route" operations, of the type involved in this accident, is theoretically achieved by the increased landing minima applicable to such operations. However, the crew requirements for "off route" airport qualification do not require the same degree of qualification as that required for scheduled operations. The reason for this is that it would not be practical to require an actual entry into every possible "off route" airport, nor would it be practical to have on hand the approved pictorial display for every possible "off route" airport. Nevertheless, the Board believes that a more positive means for determining that a pilot is qualified to make an initial entry into an "off route" airport should be established by the FAA and the air carriers. The company's operations manual provides that all a pilot is required to do for qualification is to sign a flight release form indicating that he has studied and knows the items enumerated in FAR 121.445. By comparison, FAR 121.443, which applies to scheduled operations, requires that the pilot-in-command, before making his initial entry into an airport under IFR conditions, must demonstrate that he has adequate knowledge, by actual entry into that airport, by entry into a nearby airport, by synthetic trainer, or by use of approved pictorial displays.

There is no evidence in this case to indicate that the crew had not sufficiently familiarized itself with the Huntington airport, surrounding terrain, and the approach and landing procedures. At the same time, there is no way to assure that the crew had actual knowledge of the foregoing prior

to departure, since they were not required to demonstrate positively such knowledge. Accordingly, the Board believes that the procedures should be revised to require that pilots demonstrate by some means (e.g., an oral or written test or examination other than signing the flight release) that they are familiar with the "off route" airport into which they will operate. 10/

The flightpath and profile (Attachment 1) show that the aircraft descended through the MDA approximately 2 miles from the end of the runway and that such descent was not corrected in time to avoid impact with the trees. The major thrust of the investigation was focused on uncovering the reason or reasons which might explain this descent.

The relatively stable descent depicted by the flight recorder altitude trace does not suggest that a loss of control or autopilot "runaway" was experienced during the approach. However, conversation between the pilots at approximately 1931 and 1934 expressed concern with the performance of the autopilot. The captain's comment at 1931, ("that thing captured! How did it capture?") expressed surprise that the autopilot had apparently captured a glide slope signal when there was no signal. The glide slope capture probably resulted because the captain turned the autopilot NAV SELECT switch to ILS rather than to either MAN G/P or NAV LOC, which should be used on a localizer approach. Since the autopilot controls the aircraft on the glide slope by maintaining a null signal, the total absence of a glide slope signal, as in this case, would have resulted in an automatic 700 to 800 feet/minute descent. Subsequent increases in the rate of descent indicate that the NAV SELECT switch was turned to a proper position. The later comment at approximately 1934, ("This autopilot ain't responding just right - - - - sluggish") indicates dissatisfaction with the performance of that component, but the captain did not specify in which axis, or in what manner, it was "sluggish." An analysis of heading and altitude traces of the flight recorder indicates that the autopilot was used to maintain a course inbound on the localizer and to descend the aircraft during at least two periods of the instrument approach. Notwithstanding the captain's comments, both of which were made while the flight was in the vicinity of the outer marker, there is no indication of any hazardous situation. Although the captain's attention to the operation of the autopilot to the extent reflected by these remarks could have detracted from his normal instrument scan, there is no evidence to suggest that the autopilot was misused or that it had any direct bearing on the accident.

10/ A recommendation to the above effect is set forth hereinafter, in the Recommendations section.

One area which the Board carefully considered is the extent to which the final stages of the descent were influenced by visual reference to lights on the surface. Conversation between the captain and first officer during the 10-second period preceding MDA passage indicates that they were beginning to see the lights on the ground, or at least the glow of the lights. It is possible that the sighting of these lights, in combination with the knowledge that they were approaching the bottom of the lowest cloud layer, could have induced the captain to continue the descent below MDA in order to see the runway environment at the earliest moment. The descent, in fact, did continue through this period, and ground witnesses observed the aircraft clear of clouds in this area.

It is also possible that the conduct of the approach could have been affected by a visual illusion produced by the difference in the elevation of the refinery and the airport. Approximately 2 miles from the runway, the flight was approaching the bright lights surrounding the refinery and, as noted above, the crew was discussing at least the glow, and probably fleeting glimpses, of ground lights through the broken clouds. As the descent continued, the opportunity for ground reference through scattered clouds would have increased. Below approximately 1,100 feet m.s.l., the reported cloud base, the only restriction to visibility should have been the fog, smoke, and light rain.

If the approach lights or sequence flasher lights were sighted while the refinery lights were still in the field of vision, with no appreciable lights between, the pilots would have mentally visualized both light sources at the same elevation as the nearer lights. Therefore, the height above both lights would appear to be about 700 feet, whereas the actual height above the approach lights would have been only 400 feet, due to the 300-foot difference in elevation between the refinery and the approach lights. After the aircraft passed the refinery, the preconceived image would have been retained and the visual cues would have told the crew that they were approximately 300 feet higher than desired.

The remaining evidence, however, strongly suggests that the crew never obtained visual contact with the approach lights or with any part of the runway environment. The visual illusion discussed above, for example, would have prompted an increase in the rate of descent, which significantly is not reflected on the flight data recorder. Even more important, there were no comments on the cockpit voice recorder pertaining to ground lights other than those mentioned as the aircraft passed over the refinery. If any lights associated with the runway environment had been sighted, it can be presumed that some mention of the sighting would have been made. Certainly,

such a presumption is far more likely than the explanation that the runway environment was sighted, but that such sighting was either sufficiently obvious to negate the need for a callout or was indicated and acknowledged by nonverbal signals.

The recorded conversation also indicates that the crew was not aware that the aircraft had descended below MDA. The first officer's comment at 1935:06.8 ("We're two hundred above") is most logically construed as a reference to MDA. The following comment by the charter coordinator (Bet'll be a missed approach") can be taken to mean that the flight was approaching MDA, yet the runway environment was still not in sight. 11/ The next statement on the recorder ("Four hundred") most probably means that the aircraft had reached MDA, which is 400 feet above the airport elevation. Such an interpretation is consistent with the following remark of the captain ("that the approach?"), which indicates that he was asking, perhaps rhetorically, whether they had reached the farthest point to which the flight could legally descend. The first officer responded "Yeah," which again implies that the MDA had been reached and the runway environment was not in sight. The available evidence also indicates that a level off or missed-approach was then initiated. The swath cut through the trees, ground witness statements, and the flight recorder altitude trace all show that the descent was stopped, power was added, and a gradual climb was commenced. Furthermore, the first officer called out airspeed in terms of a number ("Hundred and twenty-six") instead of a reference speed ("bug plus---"), which is indicative of a go-around rather than a continuing approach.

In view of the foregoing, the Board concludes that the crew never sighted the runway environment and was not aware that the flight had descended through actual MDA.

From a study of the conversation and activities reflected by the voice recorder, it is apparent that, while the approach was conducted in a systematic manner, the crew deviated from some of the required procedures. With respect to required callouts, there was no mention that the gear was down and locked by either pilot. The first officer did not call 500 feet above the field elevation with a check of instrument flags, speed, and rate of descent as required on the Before Landing Final Checklist. There was a call, "We're two hundred above," but this did not preclude the required

11/ Although the charter coordinator was not a pilot, it is likely that he would be familiar with the MDA altitude, due to previous conversations in the cockpit, and would also be able to read altitude from the cockpit instruments.

calls at 100 feet above minimums and at minimums, with a positive statement at the latter point as to whether or not the runway was in sight. Finally, there was no report that the rate of descent exceeded 1,000 feet/minute, although the rate of descent for the 10-second period prior to the level off was 1,350 feet/minute. 12/

Apart from the first officer's deviations with respect to callouts, the captain also deviated from prescribed procedures by failing to level off the aircraft at or above what he believed to be MDA. Thus, when the first officer called out "Two hundred above," the captain should have anticipated reaching MDA, and should have taken action to assure that the aircraft would be levelled off by the time the aircraft reached MDA. Instead, the captain did not start to rotate the aircraft until several seconds after the "Four hundred feet" callout, with the consequence that the aircraft sank an additional 90 feet before the descent was finally arrested. 13/

It is difficult to assess the impact of the above deviations on the descent of the flight below MDA. Although strict adherence to optimal approach procedures is of critical importance in executing a nonprecision approach under actual instrument conditions and might have made a difference in this instance, it nevertheless appears that the crew was aware of altitude, as reflected by the cockpit conversation, and in fact initiated a go-around when they believed they had reached MDA.

The remaining and critical question is why the descent through MDA was not recognized by the crew. After carefully studying the evidence bearing on this question, the Board is of the view that there are only two reasonably possible explanations.

The first of these possibilities is that the crew was using the barometric altimeters to determine their height above MDA and the vertical speed indicators to monitor the rate of descent during the approach, but that these instruments were providing erroneous information. It is

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12/ The standard procedure of selecting 25° flaps until the runway was in sight also was not followed, since the flaps were apparently lowered to 50° at the outer marker. However, this decision by the captain was basically sound, as demonstrated by the subsequent change in Southern's procedures.

13/ The flight recorder altitude trace reflected an altitude of 1,005 feet m.s.l. when the "Four hundred" callout was made, whereas, the initial impact with the trees occurred at 916 feet m.s.l.

possible that a static system error caused the barometric altimeter to read higher than the actual altitude of the aircraft and produced a decrease in the indicated rate of descent on the vertical speed indicator. In these circumstances, the pilot would reduce power and possibly lower the nose of the aircraft in order to regain the desired rate of descent. This in turn would result in the aircraft's being lower than indicated on the altimeter, and descending at a rate greater than that displayed on the vertical speed indicator.

The existence of an error such as that described above is consistent with certain indications on the flight data recorder. For example, there are several increases in the rate of descent recorded by the flight recorder during the final approach indicating that the captain may have been attempting to compensate for the lower-than-actual rate of descent. Since these descent rates were all in excess of 1,000 feet/minute, the absence of any required callout would support the premise that the vertical speed indicator was reflecting a rate of descent lower than the actual descent rate. Moreover, during the last 10 minutes of flight, there were two instances in which the flight recorder reflected descents which resulted in overshoots followed by gradual returns to the desired altitude. We recognize that these overshoots may have resulted from either the pilot's technique in the manual operation of his flight controls or the use of the aircraft autopilot. It is possible, however, that these overshoots could be symptomatic of a lagging of the aircraft instruments due to an error within the static systems. It is also conceivable that there could be an error in one or all static systems such that it would manifest itself while the aircraft was descending but not after levelling off. The first of these descents was 175 feet and resulted in an overshoot of 50 feet. The second descent, which occurred at 6 minutes 7 seconds before impact, was 575 feet with a resultant overshoot of 150 feet. Both of these overshoots were corrected by a gradual climb back to the desired altitude. The ratio of the amount of overshoot to the total descent is 0.286 and 0.261, respectively, or 26 to 29 feet for each 100 feet of descent. The final descent of 1,200 feet with an apparent overshoot of 318 feet results in an error ratio of 0.265 or 27 feet per 100 feet of descent, which closely parallels the error ratios of the two earlier overshoots.

With respect to physical evidence pertaining directly to the barometric altimeters, it appears that both were correctly set at 29.67, thereby eliminating any indicated error from that source. The displacement of the outer and inner drums, 600 feet and 3,000 feet for the captain's and copilot's barometric altimeters, respectively, was the result of impact forces' overcoming the light spring tension holding them in place. Since the drum assemblies of both altimeters were essentially identical, the variation in displacement is attributed to the difference in impact forces encountered.

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Other damage to the internal mechanism of each barometric altimeter precluded positive determination of their operating capability prior to impact. Nevertheless, if the mark at the 1,250-foot point on the captain's altimeter drum was made at initial impact, the altimeter was reading 300 feet high. Similarly, the marking on the first officer's altimeter could be construed to indicate an error of approximately 300 feet. To place the significance of these markings in proper perspective, however, it should be noted that tests conducted subsequent to the accident demonstrated that the 300-foot difference could have been caused by impact forces.

Finally, evidence supportive of an altimeter error can be derived from the cockpit voice recorder. During the final stages of the descent, the first officer made four altitude callouts. All of these callouts except the first, which was made by reference to the ground, were approximately 200 feet higher than the actual altitude of the aircraft as reflected by the flight data recorder. 14/ Since the barometric altimeter is the primary source of altitude information, it would be reasonable to assume that these callouts were made by reference to that instrument.

The foregoing discussion constitutes one possible explanation for the unrecognized descent through MDA by demonstrating how an error in the static system could mislead the pilots by causing erroneous indications on the barometric altimeters and the vertical speed indicators. If such an error did, in fact, occur, then the altimeter would have read 200-300 feet high, which in turn would account for the fact that the crew did not arrest the descent until the aircraft reached an altitude of approximately 916 m.s.l. or over 300 feet below MDA.

There is one remaining factor which must be considered in evaluating the likelihood of an error in the static system instruments. Since an error in the static system would also affect the indicated airspeed, the Board calculated the effect of a static system error sufficient to cause an indicated altitude error of approximately 300 feet. The calculation assumed that a static pressure difference existed between ambient and that sensed by the altimeter so that when the altimeter indicated 1,240 feet, the actual altitude was 916 feet. By use of a calibrated airspeed of 130 knots 15/ and the

14/ For a comparison of these altitudes, see the chart set forth below on page 29.

15/ The figure of 130 knots was selected since the evidence confirms that the airspeed instruments were indicating speeds of that magnitude. The captain stated that he was going to fly the [Footnote continued]

United States Standard Atmosphere Table, pressure ratios were determined and applied to the existing QNH 16/ for the altitudes 1,240 and 916 feet. The pressure required at the Pitot head to generate an indicated airspeed of 130 knots at 1,240 feet was also calculated.

It was then assumed that the aircraft descended to 916 feet and that the static system continued to sense a static pressure equivalent to 1,240 feet, and the pilot controlled his aircraft so as to maintain an indicated airspeed of 130 knots. This would require a constant Pitot system pressure. With these conditions, it was found that at 916 feet, when the indicated airspeed was maintained at 130 knots, the actual airspeed would have been 100 knots. 17/

Inasmuch as an actual speed of 100 knots is very close to the stalling speed of the aircraft in the landing configuration, it is highly unlikely that such a condition would escape the notice of the pilots. It is therefore significant that no mention of any such problem was made during the approach. The accuracy of the airspeed instruments is further verified by the time taken to fly from the outer marker to the point of impact. In view of the above, the Board concludes that both the indicated and actual airspeeds were in the area of 130 knots during the approach.

The only explanation which would reconcile an inaccurate barometric altimeter with an accurate airspeed indicator is that there was an error in the Pitot system which roughly offset the error in the static system. The Board, however, is not aware of any phenomenon, atmospheric or otherwise, which could produce such an offsetting error, nor was there any evidence thereof uncovered during this investigation. In this connection, it should be noted that long-term research is underway to determine whether flight and weather conditions can lead to misinformation from instruments connected

[Footnote continued] approach at 130 knots, and the first officer's callouts were within ± 7 knots of that figure. This approximate value was also recorded by the airspeed trace on the flight data recorder.

16/ QNH is the altitude above sea level based on station barometric pressure.

17/ The above calculations are set forth in detail in Appendix E. As further calculated in that appendix, a static system error which would cause a 200-foot altimeter error would produce a corresponding airspeed error of -17.5 knots (i.e., when the airspeed indicator read 130 knots, the actual airspeed would be 112.5 knots).

to the static system. But until this or other efforts produce positive evidence of a phenomenon which could cause offsetting errors of the type discussed above, the Board cannot conclude that a static system error is supported by sufficient evidence to be termed a causal factor in this accident.

The second reasonably possible explanation for the unrecognized descent below MDA is that the first officer was using the radio altimeter as the primary source of altitude reference, and the crew was thereby misled into believing the aircraft was higher than it actually was because the ground surface in the approach area is at some points substantially lower than the field elevation. 18/ Support for this theory can be derived from an analysis of the altitude callouts on the cockpit voice recorder. There were at least four references to altitude after the flight passed the outer marker inbound. Since the crew had no way of determining the elevation of the terrain below them, the values could have been either read directly from the radio altimeter or calculated mentally by subtracting the field elevation from the barometric altimeter reading. The following tabulation shows (1) the first officer's callout, (2) the flight recorder indication, (3) the terrain elevation at that point, (4) the calculated radio altimeter reading, based on the flight recorder altitude minus the terrain elevation, and (5) the flight recorder altitude reading minus the field elevation (828 feet).

Callout (a.g.l.)	Flight Recorder (m.s.l.)	Terrain (m.s.l.)	Calculated Radio Altimeter (m.s.l.)	Calculated Barometric minus Field Elevation (a.g.l.)
1,000 feet	1,842 feet	600 feet	1,242 feet	1,014 feet
ay, ah, 700	1,330	500	780	502
200 above (612 feet)	1,224	530	694	396
400 feet	1,005	690	315	177

Any reliance on these figures must include recognition of their limitations. The computed flightpath of the aircraft may be affected by such

18/ The radio altimeter, unlike the barometric altimeter, indicates the height of the aircraft above the terrain over which the plane is flying.

variables as winds aloft and flight recorder accuracy. Any lateral adjustment to the flightpath may change the height of the aircraft above the hilly terrain. The time correlation between the flight recorder and cockpit voice recorder may not be exact and could alter the analysis. The individual delay, anticipation, or approximation in each of the callouts could have some bearing on the tabulation. Finally, there is no way of determining whether those variables which could be involved would offset each other or would be cumulative. However, with respect to the tolerances, the aircraft was apparently flying parallel to a 600-foot contour line at the time of the 1,000-foot callout, and the flightpath would have to be shifted approximately 350 feet horizontally before a difference of 100 feet in the terrain clearance would be indicated on a radio altimeter. The second and third callouts occurred when the flight was near the flat terrain of the riverbed and the flightpath would have to be shifted approximately 700 feet horizontally before the terrain clearance would appear to change 100 feet. When the final callout was made, the flight was crossing perpendicularly to a steep ridge which rises sharply to an elevation of approximately 700 feet on the east bank of the river. The flightpath must be shifted at least 400 feet horizontally before a change of 100 feet would be indicated in the terrain clearance. 19/

Analysis of the tabulation suggests that all but the initial callout of "A thousand feet above the ground . . ." could have been made with reference to the radio altimeter, but even it was couched in terms generally associated with the radio altimeter. The readings that would derive from subtracting the field elevation from the barometric altimeter reading are consistently about 200 feet low, and assuming that the barometric altimeter was accurate, the first officer would have been reporting different values if he had been using that method. On the other hand, the altitude values derived by reference to the radio altimeter are all within 100 feet of the altitudes reported by the first officer. Moreover, the final exclamation recorded prior to the commencement of the sound of impact ("HUNDRED") accords with the altitude which would have been reflected by the radio altimeter at that time and therefore is further evidence that the first officer may have been using that instrument during the approach. 20/

Southern's training program distinguished between the use of radio

19/ It is not possible to determine accurately the aircraft position longitudinally on the flightpath when a radio altimeter reading might have been made that resulted in an altitude call.

20/ It is also possible that the word "HUNDRED" was not a reference to altitude, but rather was the first part of an airspeed callout.

altimeters in instrument approaches over level and irregular terrain. However, the Southern Airways DC-9 Operating Manual did not make such a distinction, but rather accentuated its use for all instrument approaches by stating that, "Two separate radio altimeter systems . . . are provided to obtain precise altitude information above the ground at the minimum decision [sic] altitude (MDA). This information is essential to the pilot in his decision to land or initiate a go-around maneuver." Notwithstanding the fact that the crew may have been formally trained to use the radio altimeter as a secondary reference, the tabulation comparing the available altitude references indicated that the first officer may have relied on the written material and was using the radio altimeter for altitude information.

If the first officer was making altitude callouts by reference to the radio altimeter, as hypothesized above, the remaining question concerns the extent to which the captain relied upon, and was misled by, such callouts. Sound operating procedures dictate that the captain should have been using his barometric altimeter during the approach, and therefore should have been aware of the disparities between altitudes reflected by that instrument and the first officer's callouts. Why these disparities were apparently not detected by the captain is difficult to explain. It is possible that he, like the first officer, was relying on his radio altimeter. A second possibility is that he was not using his barometric or radio altimeter, but rather was relying solely on the first officer for altitude information. Finally, he may have been including his barometric altimeter in his instrument scan, but was concerned with other items during the final stages of the approach to such an extent that he did not notice any variations.

On the other hand, there are several weaknesses to the theory that the radio altimeter was being used for altitude information. First, and perhaps most important, the radio altimeter is not intended for use during an approach over unknown or uneven terrain, and it is therefore difficult to accept that qualified, experienced pilots would resort to that instrument in conducting the approach at Huntington. The theory also assumes an unlikely dual human failure in that the captain was either also using his radio altimeter or did not recognize the differences between the barometric altimeter and the altitude information called by the first officer and was relying on the latter. Finally, the rates of descent between the calls of "Seven hundred feet," "Two hundred above," "Four hundred," and rotation, if made from reference to the radio altimeter, do not correspond to the rates of descent recorded by the flight data recorder for the same periods.

This variation is demonstrated in the following calculations. By using the terrain elevation established by the flightpath analysis for the position

of the aircraft at the time the reference calls were made, and adding these calls to that elevation, the following tabulation shows (1) the first officer's callout, (2) the flight recorder indication, (3) terrain elevation, and (4) the altitude, if a radio altimeter was being used (terrain plus the callout).

Callout	Flight Recorder	Terrain Elevation	Terrain Plus Callout
700 feet	1,330	550	1,250
200 above	1,224	530	1,130
400	1,005	690	1,090
Rotation prior to tree impact	925		

Based on the above points, the following rates of descent would be required:

Between Calls	Rates of Descent (feet/minute) Flight Data Recorder	Terrain Plus Callouts
"700 feet" to "200 above" (5.2 seconds)	1,223	1,385
"200 above" to "400" (11.4 seconds)	1,153	211
"400" to point of rotation (3.7 seconds)21/	1,297	2,189

It is noted that the rates of descent calculated for the flight recorder data are in an increasing pattern and relatively close to the overall rate described by the flight recorder. The rates of descent based on the calculated radio altimeter callouts show close correlation for the initial callout, no correlation for the second callout, and in the final segment, the descent rate is approximately double the overall rate.

After carefully weighing the conflicting points set forth above, the Board concludes that the theory under consideration -- namely, that the unrecognized descent through MDA was the result of using the radio altimeter

21/ Analysis of aircraft performance data, the flight data recorder, and the cockpit conversation leads to the conclusion that aircraft roatation was initiated approximately 2 seconds after the callout at 400 feet. Rotation took approximately 1.7 seconds. During this 3.7 seconds, the aircraft descended approximately 135 feet.

for altitude reference -- is not supported by sufficient evidence to be termed a causal factor in this accident.

One final matter, airport facilities, warrants comment. Many of the circumstances of this accident are typical of the approach/landing accidents that occur during nonprecision approaches. As a result, the Board examined the environmental conditions that existed in this case to determine what aids would have assisted the pilot in making a nonprecision approach.

The terrain under the approach path was irregular with numerous hills of varying heights. There were few lights along the approach path excepting those of the refinery which were to the right of the inbound track. The lower clouds were ragged and the restrictions to visibility included darkness, rain, fog, and smoke. The pilot had his barometric altimeter, vertical speed indicator, airspeed indicator, and radio altimeter to aid him in establishing the desired descent profile. However, the pilot had little, if any, information instantly available to him regarding the elevation and character of the terrain below the aircraft or the flightpath related thereto.

External navigational aids used to provide vertical guidance to a pilot during an instrument approach include Precision Approach Radar (PAR), ILS glide slope, and VASI system. There was no PAR installed at Huntington nor was the installation of one under consideration. The FAA policy was to provide VASI systems primarily where no other electronic guidance was either planned or available. Since Huntington had been actively negotiating for a glide slope since 1957 no VASI system was installed. In this case, the VASI system would have been useful if the pilot had been able to see the first 1,500 feet of the runway. However, if the pilot had not visually acquired contact with that much of the runway he would not have been able to use the VASI system for vertical guidance.

It is also possible that the nonstandard glide slope which was installed subsequent to the accident might have prevented this accident in that the pilot would have been provided with a primary electronic indication of his position relative to the desired glide path. This cross-check against the altimeter information available would have alerted the crew to any discrepancy between the intended and actual descent. Additionally, if the aircraft remained on the glide slope, it would have arrived at the MDA approximately 2,500 feet closer to the hill where initial impact occurred, and it would have had to descend at an unusually steep angle of about 10° to strike the trees from that point.

In view of the apparent success of the nonstandard glide slope at Huntington, it is unfortunate that such an installation was not made sooner. However, the experience gained with this installation should provide a basis for possible application to other airports where standard installation criteria cannot be met without major construction.

2.2 Conclusions

(a) Findings

(1) The pilots were properly certificated and qualified to conduct this flight.

(2) The aircraft was certificated and maintained in accordance with the existing FAA rules and company procedures, and was properly equipped for the intended flight.

(3) The flight was conducted in accordance with the provisions of FAR 121.445 and with company procedures applicable to "off route" charter flights.

(4) The charter arrangements between Southern Airways, Inc. and Marshall University were adjusted and the aircraft was loaded within the operational capability of the aircraft.

(5) The carrier used the same aircraft, pilots, dispatches, flight planning services, and supervising personnel in this operation as they used in their regularly scheduled service.

(6) The flight release to the Huntington airport anticipated that the runway would be wet, and was predicated on the availability of sufficient runway as required by FAR 121.195(b).

(7) The aircraft weight and center of gravity were within limits for the intended landing at Huntington.

(8) The runway length at the Huntington airport was adequate for the intended landing, under the existing circumstances.

(9) The instrument approach aids at Huntington, which provided lateral but not vertical guidance to the runway, were operating properly at the time of the accident.

(10) The airport lighting system, which included high intensity approach lights, sequence flashers, and high intensity runway lights, was in operation and properly set at the time of the accident.

(11) The minima for this approach (minimum descent altitude of 1,240 feet m. s.l. and minimum visibility of 1 mile) were the same as those prescribed for any nonscheduled flight into Huntington. These minima were adequate for the intended operation.

(12) The weather reported at the field at the time of the accident was 300 feet scattered, measured 500 feet variable broken ceiling, 1100 feet overcast, visibility 5 miles in light rain, fog, and smoke; however, the weather in the approach area was worse.

(13) The investigation disclosed no malfunction or failure in the aircraft structure, primary flight controls, or powerplants.

(14) There was no physical evidence of a defect or contamination in the static system tubing or parts; a static system error is extremely unlikely unless there was an offsetting error in the pitot system.

(15) The captain was using the autopilot throughout the approach and there was no evidence of a significant autopilot malfunction.

(16) Based on the recorded cockpit conversation, the crew was familiar with the approach procedures at Huntington and with the MDA on the approach being flown.

(17) The crew deviated from the optimal approach procedures in several respects; however, the effect of this deviation on the accident cannot be assessed inasmuch as the cockpit conversation indicated the crew had altitude awareness.

(18) The flight descended through the MDA of 1,240 feet m. s.l. approximately 2 miles from the end of the runway and the descent continued for over 300 feet before the crew initiated a missed approach or go-around.

(19) The copilot's call of "Four hundred" is construed to mean that an altimeter indicated that the aircraft was at the MDA.

(20) The crew was unaware that the aircraft had descended through the actual MDA.

(21) The crew sighted the glow from the refinery lights during the approach, but never obtained visual contact with any part of the runway environment.

(22) The probable reason for the unrecognized descent through MDA cannot be determined; the two most likely explanations are (a) an error in the static system which caused the barometric altimeters to indicate a figure higher than the actual altitude, or (b) reliance by the crew on the radio altimeter as a primary altitude reference while executing an approach over uneven terrain.

(23) The accident might have been prevented if there had been available the nonstandard glide slope which was installed at a later date.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent, although the two most likely explanations are (a) improper use of cockpit instrumentation data, or (b) an altimetry system error.

3. RECOMMENDATIONS

Although the Safety Board has been unable to determine the probable reason for the unrecognized descent below MDA in this instance, the Board wishes to reiterate its concern with the general problem of landing and approach accidents and to reemphasize its interest in the various preventive measures which might prove useful in reducing the rate of these kinds of accidents. There is a need for all segments of the aviation industry to continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Area navigation systems, now in the final proving stages of development, will apparently provide descent guidance capability within the aircraft and should be standard equipment on all future transport category aircraft. The retrofitting of aircraft in the inventory should be expedited as much as possible.

The Safety Board also notes and supports the FAA in its issuance of Air Carrier Operations Bulletin No. 71-9 which emphasizes the common faults noted in nonprecision approaches and proposes several recommendations to eliminate these faults. (See Appendix F.)

In view of the foregoing, the Safety Board recommends that:

1. All segments of the aviation industry continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Particular emphasis should be placed on the accelerated development of area navigation systems with vertical guidance capability and on heads-up display systems.

The Board, on February 13, 1968, supported a Notice of Proposed Rule Making which would require the installation of an altitude warning device for turbojet powered civil airplanes. The basis for this support, cited in the letter, was a series of aircraft accidents involving air carrier aircraft that had been involved in controlled crashes into the ground or water. Of the five accidents cited, three occurred during the final approach to landing. In the other two cases, the aircraft were descending in preparation for an approach and landing.

On January 17, 1969, writing with reference to accidents which occur during the approach and landing phase of flight, the Board recommended, among other things, the development and installation of audible and visual altitude warning devices and the implementation of procedures for the use of such devices. The FAA response to this recommendation was to cite its rule making dated September 1968, which required the installation of altitude alerting devices in all turbo powered civil aircraft. This device would provide both aural and visual indications to warn pilots when they approach selected altitudes during climbs,

descents, and instrument approaches. However, the Board has found that this device as installed and operated does not provide any information regarding the aircraft proximity to the ground during the final approach phase of a landing approach.

On November 10, 1971, in an aircraft accident report, NTSB-AAR-71-14, the Board recommended that a ground proximity warning device be developed for use during the approach and landing phase of flight. The Board further recommended that appropriate operating procedures be developed and implemented.

The Administrator's response to this recommendation stated in part: ". . . With respect to the recommendation to develop a ground proximity warning system for use during approach and landing, we believe the present instruments and procedures are safe and adequate. This presupposes that proper cockpit disciplines are maintained . . . We are, however, reassessing our system requirements for nonprecision straight-in approach systems with a view to providing additional assistance to the pilot in the form of accurate position information which will make his evaluation of the visual approach segment less susceptible to human error . . ." (See Appendix G.)

Finally, on February 25, 1972, Board Report NTSB-AAR-72-4 contained a recommendation that the Administrator require all air carrier aircraft to be equipped with a functional ground proximity warning device in addition to the barometric altimeters. The Administrator's response continued to support the earlier position quoted above. (See Appendix G.) In addition, the FAA advised the Board that they were developing new criteria which they proposed to apply to nonprecision approaches. One criterion involves establishing a final approach descent fix. This fix would be located at a point on the final approach from which a normal descent path of approximately 3^{o} from MDA to touchdown could be commenced, provided the required visual reference was established. Pilots would be required to maintain an altitude at or above the MDA until passing this descent fix. Another criterion the FAA proposed will be to provide VASI for each runway served by a nonprecision approach. The VASI will provide vertical guidance at normal descent rates for the visual segment of the approach.

The Board believes that these two items will aid in preventing accidents that occur during nonprecision approaches and believes that these proposals are timely and appropriate. The Board also urges the FAA, wherever physically possible and within the limits of available resources, to convert approaches from nonprecision to precision at qualified airports through the installation of an ILS. In this connection, even the installation of a nonstandard glide slope, such as the one currently in use at Huntington, is a substantial improvement in the aids available to a pilot in making his approach descent.

With regard to the Administrator's response to our recommendation that he reevaluate his position regarding the installation and use of ground proximity warning devices, the Board notes that the decision is based on the assumption that "proper cockpit disciplines are maintained." We have found in several cases of this type that cockpit disciplines were disrupted by unusual actions or events and the crew was distracted from its task of monitoring the aircraft altitude. We believe that a ground proximity warning device would serve to bring the crew's attention back to the altimeters as the aircraft approached preselected altitudes during an instrument approach. Therefore, the Board again recommends that:

2. The Administrator evaluate the need for the installation and use of ground proximity warning devices on air carrier aircraft.

After consideration of the airport qualifications established by FAR 121.443 and 121.445, the Board concludes that the requirements of 12.445 are less specific than those in 121.443. The Board believes that Part 121.445, or the carrier procedures promulgated thereunder, could be more specific, particularly in the manner by which the pilot is required to show that he has the requisite knowledge. Therefore, the Board recommends that:

3. The FAA continue to emphasize the importance of the provisions of Part 121.445 in its surveillance and inspection of flight operations under Part 121. Such emphasis is needed to assure that these operators are (1) using the best means available to enable pilots to qualify under 121.445, and (2) requiring pilots to show that they have acquired the requisite knowledge prior to completion of a flight release.

Finally, the Board wishes to acknowledge and express continuing support for the long term Static Pressure Measurements Project undertaken by the National Aeronautics and Space Administration at the Lewis Research Center. The Board believes that these tests and similar efforts by other organizations will provide significant data on the flight and weather conditions which might lead to static system contamination and altitude misinformation, a subject which is invariably raised in connection with landing and approach accidents. The Board therefore urges that such testing be expedited and will await with anticipation the results thereof, which hopefully will shed some light on an area that has too many unknowns.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

April 14, 1972

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident at approximately 2025 on November 14, 1970, from the Federal Aviation Administration. An investigating team was immediately dispatched to the scene of the accident. Working groups were established for Operations, Air Traffic Control, Weather, Witnesses, Human Factors, Structures, Systems, Powerplants, Maintenance Records, and Flight and Voice Recorders. Interested parties included the Federal Aviation Administration; Southern Airways, Inc.; Douglas Aircraft Division; McDonnell-Douglas Corporation; Air Line Pilots Association; and Pratt & Whitney Division, United Aircraft Corporation. The on-scene investigation was completed on November 23, 1970.

2. Hearing

A public hearing was held at Huntington, West Virginia, on December 14 - 16, 1970. Parties to the Investigation included the Federal Aviation Administration; Southern Airways, Inc.; Douglas Aircraft Division, McDonnell-Douglas Corporation; and Air Line Pilots Association. The hearing was reconvened June 23 - 25, 1971, in Washington, D. C.

3. Preliminary Reports

A summary of the testimony which was taken at the first public hearing was published by the Board on January 25, 1971. An additional summary was released on July 28, 1971.

APPENDIX B

Crew Information

Captain Frank H. Abbott, Jr., aged 47, was employed by Southern Airways, Inc., on July 21, 1949. He held airline transport pilot certificate No. 507765 with ratings in DC-3, DC-4, DC-9 and M-202/404, and commercial privileges in single-engine land airplane. He also held a flight instructor certificate with airplane and instrument ratings. He had accumulated approximately 18,557 total flying hours, including 2,194 hours in the DC-9. He completed his last proficiency check on October 14, 1970, and his FAA first-class medical certificate was issued on October 22, 1970, with the limitation that the holder shall wear correcting lenses while exercising the privileges of the certificate.

First Officer Jerry R. Smith, aged 28, was employed by Southern Airways, Inc., on April 12, 1965. He held commercial pilot certificate No. 1581568 with airplane single-engine land and instrument ratings. He had accumulated approximately 5,872 total flying hours, including 1,196 hours in the DC-9. He completed his last proficiency check on July 14, 1970, and his FAA first-class medical certificate was issued on November 5, 1969, without limitations. It was still valid as a second-class medical certificate at the time of the accident.

Captain Abbott and First Officer Smith had rest periods of approximately 20 and 18 hours, respectively, prior to reporting for duty for this operation. At the time of the accident, both had been on duty five hours, of which two hours, 21 minutes, were flight time.

Stewardess Pat Vaught was employed by Southern Airways, Inc., on June 11, 1962. Her last recurrent training was completed on October 21, 1970.

Stewardess Charlene Poat was employed by Southern Airways, Inc., on March 28, 1964. Her last recurrent training was completed on October 22, 1970.

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APPENDIX C

Aircraft Information

N97S, a McDonnell-Douglas DC-9-31, was delivered to Southern Airways on June 20, 1969. It had been flown a total of approximately 3,667 hours prior to the accident. Pratt & Whitney JT8D-7 engines were installed as follows:

Position	Serial No.	Total Time	Total No. Cycles
1	P-657140D	5,030.8	8,473
2	P-657297D	4,533.9	8,120

The aircraft weighed 95,795 pounds 8/ at takeoff and the center of gravity (c.g.) was 18.4 percent MAC. The maximum allowable weight limits were 97,344 pounds for takeoff (based on runway length) and 93,254 pounds for landing on a wet runway at Hungtington. The c.g. limits were 6 percent MAC and 32 percent MAC. The computed landing weight was 89,235 pounds with a c.g. of 17.12 percent MAC. In accordance with company procedures, the actual weights of the passengers were used in the computation of total passenger weight.

The actual stopping performance for the DC-9-30 was computed by DACO for the following conditions: (1) landing weight 89,235 pounds, (2) field elevation 828 feet, (3) runway wet and gradient zero, (4) threshold speed 126 knots and contact speed 1.25/1.30 times threshold speed, (5) temperature 49°, (6) 80 percent worn tires, and (7) both engines at maximum continuous reverse thrust until 60 knots and then 1.2 EPR reverse thrust. Corresponding landing distances were also computed, assuming touchdown 1,000 feet from the start of the runway.

Tailwind (knots)	0	3	5
Stopping Distance	2,634	2,686	2,712
Landing Distance	3,634	3,686	3,712

8/ This weight is based on the actual operating weight of the aircraft, rather than the published aircraft operating weight. Consequently, it is slightly higher than the 95,263 pounds computed by the crew.

APPENDIX D

TRANSCRIPTION OF COCKPIT VOICE RECORDER TAPE -- DOUGLAS DC-9, N97S, HUNTINGTON, WEST VIRGINIA, NOVEMBER 14, 1970, DCA 71-A-5

LEGEND

%	-	Break in continuity
CAM	-	Cockpit area microphone sound source
RDO	-	Radio transmission from N97S
-1	-	Voice identified as captain
-2	-	Voice identified as first officer
-3	-	Voice identified as additional crewmember
-?	-	Voice unidentified
HTS	-	Huntington Approach Control
IND	-	Indianapolis Center
*	-	Unintelligible word or phrase
()	-	Words within parentheses are subject to further interpretation
CRW	-	Charleston Tower

TIME	SOURCE	CONTENT
1916:59.9	RDO-1	Charleston Tower, this is Southern nine thirty-two.
	CRW	Southern nine thirty-two, Charleston Tower.
	RDO-1	We're going over to Huntington, we passed just south of Charleston. What kind of weather you got down there now?
	CRW	Charleston weather estimated ceiling six thousand broken, visibility four, ground fog and smoke.
	RDO-1	What's your spread?
	CRW	Temperature five zero, dew point four nine.
	RDO-1	Thank you.
	RDO-1	Look like it's going to hold up a while?
	CRW	Sure thing.
	CAM-2	Sounds like a gal.
	CAM-1	It is.
	CAM-1	Broken up here at Charleston.

TIME	SOURCE	CONTENTS
	CAM-2	Yeah, it's gotten a lot better. Maybe it's gotten better over here, it's not too far away.
		% % %
	CAM-1	You might try it again.
	RDO	Sound of tuning of ADF.
		% % %
1919:00.2	RDO-2	Southern nine thirty two out of eleven thousand five hundred.
		% % %
	CAM-1	Approach plate's two years old.
	CAM-2	Yeah * * * *
	CAM-2	On these charter kits they don't keep those things up like they're supposed to.
	CAM	Sound of laughter.
	CAM-1	How many miles you got to Pulaski?
	CAM-2	About to run out * * *
	CAM-2	It's pointing that way, Frank. Can't get a code on it, though.
	CAM-1	Let's run the rest of the in-range check.
	CAM-1	How many miles you got on it? I can't * * * it's gone off.
	CAM-2	Yeah, it's gone off.
	CAM-2	(Bugs) one two three.
	CAM-1	Put Charleston on yours * * *
	RDO-1	Center, Southern nine thirty two.
1921:57.3	IND	Southern nine thirty two, descend and maintain five thousand, say again.

TIME	SOURCE	CONTENTS
1922:02.7	RDO-2	Okay, Southern nine thirty-two, we're out of eight now, we're going to five, and approximately how far do you show us from the Huntington Airport?
1922:09.7	IND	Nine thirty-two approximately twenty miles south-east of Huntington Airport.
	RDO-2	Roger.
	IND	Southern nine thirty two squawk zero four zero zero, contact Huntington Approach Control one two zero point niner, radar service terminated.
	RDO-2	One two zero point nine, good day sir.
	CAM-1	Here we go.
	RDO-2	Huntington Approach, Southern nine thirty-two, we're descending to five thousand.
	HTS	Southern nine thirty two, Huntington Approach Control, you're cleared for an approach, correction, you're cleared for a localizer one one approach, the surface wind's favoring runway two nine, wind three five zero degrees at six, altimeter two nine six seven, report leaving five thousand. I'll give you the weather shortly.
	RDO-2	Okay, we got the altimeter and we'll check with you leaving five thousand, we plan on approach to one one.
	HTS	Roger.
	RDO	Sound of ILS localizer identification.
	HTS	Southern nine thirty-two, the Huntington weather three hundred scattered, measured ceiling five hundred variable broken, one thousand one hundred overcast, visibility five, light rain, fog, smoke. Ceiling ragged, variable four to six hundred.
	CAM-?	Phew!
	RDO-2	Very well, thank you sir.
	CAM-1	Very well!

TIME	SOURCE	CONTENT
	CAM	Sound of laughter.
	CAM-1	Very well?
	CAM-2	Four hundred and twelve.
	CAM-1	Yeah, and a mile visibility.
	CAM-2	He said the visibility was * *
	CAM-2	I'll ask him again.
	RDO-2	What's your visibility again?
	CAM-1	* * * and twenty-six hundred from all directions.
	HTS	Visibility five, light rain, fog, smoke.
	RDO-2	Right.
	CAM-1	Right on the --------- right on the minimums * * *
	CAM-1	See if you can get that thing tuned in a little bit better, sort of wavering.
	CAM-2	All right.
1924:15.7	RDO-2	Southern nine thirty two is out of five.
	HTS	Out of five, report outer marker outbound.
	RDO	Sound of ILS outer compass locator identification.
	CAM-2	Localizer is one oh nine nine, ---- one fourteen inbound.
	CAM-1	Wonder how many miles it is to Kanawha?
	CAM-2	Stand by.
	CAM-2	Charleston's not but about fifty miles.
	CAM-1	You got Charleston set on yours?
	CAM-2	Charleston's set on * * * about thirty * * *
	CAM-1	Damn close.

TIME	SOURCE	CONTENT
	CAM-2	Ought to be getting pretty damn close 'cause he gave us twenty miles right back there. That's been four or five minutes.
	CAM-2	You're getting slant ---- slant range on it.
	CAM-2	* * *
	CAM-2	Marker's identified.
		% % %
1926:24.5	CAM-2	Forty-two DME. How many you got?
	CAM-1	Thirty-seven.
	CAM-1	Coming over middle marker.
1926:43.1	CAM-2	Middle marker there.
	CAM-3	Frank, you want full fuel load out of here?
	CAM-1	Might as well.
	CAM-2	Minimum is nineteen ---- wonder how much they'll charge us?
	CAM-3	Well, we get contract price, whatever that is, whatever we pay for it.
	CAM-2	We got a mile or two to go, Frank, 's all.
	CAM-?	Yeah.
	CAM-1	We're showing on the localizer.
	CAM-3	Hope we don't have this all the way in. It's rough.
1927:58.9	CAM-2	There she is.
	RDO-2	Southern nine thirty two, we're over the marker now, proceeding outbound.
	HTS	Southern nine thirty-two, roger, report the marker inbound.
		(Note: Underlined words above and below spoken simultaneously)
	CAM-1	Slats and five.

TIME	SOURCE	CONTENT
	RDO-2	Very well.
1928:11.0	CAM-1	Slats and five.
1928:35.6	CAM-1	(From the) lights on the ground (it looks like) fog.
	CAM-2	Makes it sorry, doesn't it?
	CAM-1	You checked the missed approach?
	CAM-2	All right, you pull up to twenty-seven hundred feet by the east course of the ILS to Shoals, Shoals Fan Marker, report Shoals then straight out * * *
	CAM-?	*
	CAM-1	*
	CAM-2	Sound of laughter.
	CAM-2	Well, I don't know.
1930:03.0	CAM-2	(I believe) half those lights should be off to our left. Kinda hard to say, though.
1930:43.6	CAM-1	We're in a rainshower, all right.
	CAM-2	Yeah, I know it.
1930:49.6	CAM-1	We sure are. The temp (is dropping).
	CAM-2	Yeah, ah, that rain is (mixed) in with fog.
	CAM	Sound of windshield wipers commences.
	CAM	Sound of landing gear in transit commences
	CAM-2	Okay, you got the no smoking, ignition, radar standby, auto shutoff armed, waiting on the gear ----- got the spoilers?
	CAM-1	Armed.
	CAM	Sound of click similar to that of arming spoilers.
	CAM-2	Checked, out.
1931:26.2	CAM-1	That thing captured! How did it capture?

TIME	SOURCE	CONTENT
	CAM-2	Yeah, it ought to.
	CAM-1	You getting a glide slope capture and you ain't got a glide slope.
	CAM-?	*
	CAM-2	I might capture on the, ah, on ILS, ah, Frank, regardless of glide slope. I don't have no capture, though.
1931:49.8	CAM-1	Okay, give me, ah, twenty-five *
	CAM-2	Yeah, it's good, it's got the capture.
	CAM-?	*
	CAM-1	I got it cut off there now.
	CAM-2	Got twenty-five flaps, all is squared.
	CAM-1	We ought to be over the outer marker at twenty --- two hundred feet *
	CAM-2	Yeah.
	CAM-3	I'm sorry, Frank.
	CAM-1	You going to call out minimums?
	CAM-2	Yeah, I sure will. I'll sing 'em out to you.
	CAM-2	As you get on down it, ah, this rough air ought to give us a little break.
	CAM-1	Well, if it's like he said, it's not blowing any harder than he says it is, why ----
	CAM-2	Down draft.
	CAM-1	It took us down to the marker level.
	CAM-?	Yeah, that's enough.
	CAM-?	Yeah.
1933:17.9	CAM-1	Must be a little rainshower.
1933:19.9	CAM-2	Back in the soup.

TIME	SOURCE	CONTENT
	CAM-1	Jerry, I'm going to be flying about one thirty.
	CAM-2	I'm going to check the time for you. It'll be about two minutes from the, ah, outer marker *
1933:43.4	RDO	Sound of outer marker begins.
1933:47.9	RDO	Sound of outer marker ceases abruptly.
	RDO-2	Southern nine thirty-two the marker inbound.
	CAM-?	*
	HTS	Southern nine thirty-two is cleared to land. You can advise on the lights, the wind is now three four zero degrees seven.
1933:59.1	CAM	Sound similar to click of flap selector.
	RDO-2	Okay, the lights be good about step three, I guess.
	HTS	Roger, that's where they are, with the rabbit. Advise when you want them cut.
	RDO-2	Very good.
1934:09.2	CAM-2	On the bug.
	CAM-3	* rough.
	CAM-1	This autopilot ain't responding just right ---- sluggish.
	CAM-2	Yeah.
	CAM-1	Might catch up.
	CAM-2	Okay, I got the time for you.
1934:32.4	CAM-2	A thousand feet above the ground, rate and speed good.
	CAM-2	Speed a little fast, looks good, (1934:45.2) got bug and twelve.
1934:55.4	CAM-1	See something?

TIME	SOURCE	CONTENT
	CAM-2	No, not yet. It's beginning to lighten up a little bit on the ground here at, ay, ah, (1935:01.6) seven hundred feet.
1935:03.2	CAM-2	Bug and five.
1935:06.8	CAM-2	We're two hundred above.
1935:10.6	CAM-3	Bet 'll be a missed approach.
1935:18.2	CAM-2	Four hundred.
1935:19.3	CAM-1	That the approach?
	CAM-2	Yeah.
1935:21.3	CAM-2	Hundred and twenty-six.
1935:25.7	CAM-2	HUNDRED
1935:26.5	CAM	Sounds of impact begin.
1935:32.5		End of recording.

EFFECT OF STATIC SYSTEM RESTRICTION OR BLOCKAGE ON AIRSPEED INDICATION

The magnitude of the error in indicated airspeed which will exist as a result of a static system pressure error is calculated for two assumed values of indicated altitude error.

Condition 1:

The nonstandard day QNH altimeter setting is 29.67 inches Hg. The altitude of the aircraft is 916 feet m.s.l. (which corresponds to altitude of initial impact). The indicated altitude is 1,240 feet m.s.l. (which corresponds to the published minimum descent altitude).

If this error is a result of a pressure difference between ambient and that measured within the aircraft static system, the corresponding indicated airspeed error is found as follows:

The airspeed indication is based upon the following equation:

$$q_c = P_t - P_a = P_{asl}\left[1 + 0.2\,(V_c/a_{sl})^2\right]^{3.5} - P_{asl} \qquad (1)$$

Where: q_c = differential pressure, inches Hg.

P_t = free stream total (Pitot) pressure, inches Hg.

P_a = ambient (static) pressure, inches Hg.

P_{asl} = standard day sea level pressure, 29.921 in. Hg.

V_c = calibrated airspeed, knots

a_{sl} = sea level speed of sound, 661.48 knots

Substituting V_c = 130 knots into equation (1) yields

$$q_c = .8168 \text{ in. Hg.}$$

or $$P_t = P_a + .8168 \text{ in. Hg.} \qquad (2)$$

APPENDIX E

From the United States Standard Atmosphere Table:

P_a/P_{asl} for 1,240 feet m.s.l. equals .9560

For a nonstandard day when QNH = 29.67 in. Hg.

P_a for 1,240 feet m.s.l. = .9560 x 29.67 = 28.364 in. Hg.

Also P_a/P_{asl} for 916 feet m.s.l. equals .9673

For the same nonstandard day:

P_a for 916 feet = .9673 x 29.67 = 28.700 in. Hg.

Thus for the airspeed indicator to read 130 knots when the static system senses a pressure of 28.364 in. Hg. (1,240 feet), the Pitot system pressure must be (from eq. 2)

$$P_t = P_{a_{1,240}} \div .8168 = 28.364 \div .8168$$

$$P_t = 29.1813 \text{ in. Hg.}$$

Assuming that the aircraft now descends to 916 feet m.s.l. and the static system continues to sense a pressure equivalent to 1,240 feet m.s.l. (28.364 in. Hg.), if the pilot controls the aircraft so that his airspeed indicator continues to read 130 knots, the Pitot system pressure P_t must also remain constant (29.1813 in. Hg.).

To determine the actual aircraft velocity, i.e., the airspeed that would be indicated if the static system was sensing the correct pressure corresponding to 916 feet (28.700 in. Hg.), find q_c:

$$P_t = 29.1813 \text{ in. Hg.}$$

$$P_{a_{916}} = 28.700 \text{ in. Hg.}$$

or $$q_c = P_t - P_{a_{916}} = 29.1813 - 28.700$$

$$q_c = .4813 \text{ in. Hg.}$$

Substituting into eq. (1) and solving for V_c yields:

V_c = 100 knots

Thus for conditions stated, the actual velocity of the aircraft would be 100 knots, an error of -30 knots.

Condition 2:

For the same nonstandard day, QNH altimeter setting equal 29.67 inches Hg., the actual velocity of the aircraft is calculated for a corresponding altitude error of 200 feet.

From equation (1) above, for V_c = 130 knots

q_c = .8168 in. Hg.

P_a/P_{asl} for 1,240 feet m.s.l. equals .9560

$P_{a_{1,240}}$ = 28.364 in. Hg.

From the United States Standard Atmosphere Table:

P_a/P_{asl} for 1,040 feet m.s.l. equals .9629

For the QNH = 29.67 in. Hg. condition:

P_a for 1,040 feet = .9629 x 29.67

$P_{a_{1,040}}$ = 28.570 in. Hg.

From condition (1) above:

$P_t = P_{a_{1,240}} \neq .8168 = 28.364 \neq .8168$

P_t = 29.1813 in. Hg.

Assuming that the aircraft descends to 1,040 feet m.s.l. and the static system continues to sense a pressure equivalent to 1,240 feet m.s.l. (28.364 in. Hg.), if the pilot controls the aircraft so that

his airspeed indicator continues to read 130 knots, the actual aircraft velocity is found as follows:

$$P_t = 29.1813 \text{ in. Hg.}$$

$$P_{a_{1,040}} = 28.570 \text{ in. Hg.}$$

or $$q_c = P_t - P_{a_{1040}} = 29.1813 - 28.570$$

$$q_c = .6113 \text{ in Hg.}$$

Substituting into eq. (1) and solving for V_c yields:

$$V_c = 112.5 \text{ knots}$$

Thus for conditions stated, the actual velocity of the aircraft would be 112.5 knots, an error of -17.5 knots.

AIR CARRIER OPERATIONS BULLETIN NO. 71-9

SUBJECT: Training Emphasis on Non-Precision Approach Procedures and Interpretation of Low Visibility Weather Reports.

Recent air carrier accidents which occurred during non-precision approaches pin point the need for action to improve this type of operation. A study was initiated sometime back with a goal to examine existing criteria and make recommendations for changes to criteria. The study group must determine if improvements can be made which will aid the pilot in making a decision to descend below MDA during a non-precision approach. Meanwhile, there is a need to reemphasize training in non-precision approaches as well as improving the knowledge and understanding of the implications of reported low visibility weather.

Accident investigators from the NTSB and inspectors from the Washington Office have questioned air carrier pilots about the meaning and implication of reported obscuration in weather sequences. The pilot response reflected inadequate knowledge of the subject. Of particular interest is the fact that partial obscuration is described in the remark section and can be anything from 1/10 to 9/10 coverage and still be considered partial. The implication of a 7/10 or 8/10 obscuration is that a pilot could reasonably expect to encounter restrictions to visibility as he descends from a position below cloud level toward the runway environment. However, pilots questioned were not aware of this because they did not relate the remarks information to the obscuration.

In view of the lack of knowledge on the part of the pilots interviewed, operations inspectors should assure that training programs adequately cover weather sequences and interpretations that may be made from the low visibility data supplied on the weather sequence.

The FAA Academy has prepared a paper on non-precision approaches which contains excellent material to assist in upgrading the professionalism required during a non-precision approach. The material is reproduced in part as follows:

THE NON-PRECISION INSTRUMENT APPROACH
—— MORE PRECISION IS NEEDED ——

The ability to conduct the non-precision approach in a professional manner has given way in large part to the computed and automated approaches; i.e., flight director and autocoupled approaches. The instrument pilot of today is being trained in a manner which emphasizes the philosophy of the precision

ILS approach to Category I, II and III procedures and weather minima, but de-emphasizes the basic non-precision instrument approach procedures. His training no longer stresses the need for precise timing, closely controlled rates of descent, thorough knowledge of the procedure, and the basic skills and techniques of using the raw data information displayed in the cockpit. As a result, he has become in far too many cases, something less than a professional in conducting the non-precision approach.

What can be done to reverse this trend? One way would be to re-emphasize the need to know and practice the basic skills and techniques associated with the non-precision approach. Another could be to recognize the need for more precision during the so-called non-precision approach. Even a name change for this type procedure(s) may be in order. Perhaps we should stop using the philosophy of non-precision and face up to the need for standards that all phases of flight should be based upon precision and professionalism. Still another area in the conduct of non-precision approach has to do with the attitude, cockpit discipline and crew coordination of the flight crew. Recent events strongly indicate a widespread lack of appreciation for the importance of these factors. Substandard attitude, discipline and coordination are apparent to the degree that many approaches are being flown in a hit-or-miss fashion rather than in a disciplined by-the-book procedure. The results in far too many instances have been making newspaper headlines. This area in particular is in great need of added emphasis.

In addition to the preceding points, more operational knowledge of the construction of the non-precision approach as spelled out in the TERPS Handbook 8260.3A, is needed. Such things as obstruction clearances, descent gradients, final course alignment criteria, and the primary boundaries of the approach segments are need-to-know factors for the professional airman.

What are some of the shortcomings and common faults frequently noted in the execution of non-precision approaches?

1. Failure to conduct comprehensive briefing on the approach procedure and techniques to be used.

2. Failure to execute the procedures as published; i.e., cutting the procedure short, especially when the initial phase is on top of the restriction to visibility. This corner cutting carries over into the final approach phase where all at once everything piles up and the crew is not always equal to the task.

3. Failure to cross-check altimeters and other flight instruments during the initial and final approaches.

4. Using procedures and techniques which give the pilot too much to do at the start of the final approach segment; i.e., checking the final approach fix passage; calling for gear down and before landing

checklist; calling for approach or landing flaps as appropriate; commencement of timing if required; commencement of the required descent rate; establishment of correct airspeed; etc., - at least six things which must be accomplished in short order. Experience has shown that one or more of these items are often unintentionally delayed or forgotten, usually to the degradation of the overall quality of the approach.

5. Failure to tune and properly identify the approach facility(s).

6. Failure to precisely note FAF passage.

7. Failure to commence timing at the FAF.

8. Failure to promptly commence a properly controlled and correct rate of descent so as to arrive at MDA in a position to sight the runway environment and continue a normal approach to a landing so as to avoid excessively high rates of descent at any point during the final approach segment.

9. Inattention to the details of the task at hand; e.g., conversation and actions concerning unrelated and irrelevant things.

10. Opposite corrections to tail ADF bearings.

11. Poor quality of ADF maintenance and upkeep; e.g., the oft-heard remark that, "the ADF is no good in the modern jets," when all it likely needs is to be written up and carefully repaired.

12. Lack of appreciation or knowledge for the different scale values of the localizer and VOR as displayed on the Course Indicator.

13. Failure to carry out proper crew coordination procedures. Especially, when the copilot is flying the Captain often fails to execute the normal copilot functions and duties.

14. Not staying on instruments; i.e., both pilots looking out for the runway threshold rather than one staying on instruments and the other cross-checking and looking out for the runway environment.

15. Inattention to precise course interception, and cross-checking on secondary instruments.

16. Failure to level off at or slightly above MDA.

17. Persistence in continuing a substandard approach rather than promptly executing the missed approach. There seems to be a strong-feeling false pride against executing a missed approach.

18. Not using a stabilized approach concept.

19. Not preplanning how to conduct the approach so as to fly the airplane through the window (key point) at MDA approximately one mile from the runway threshold.

20. Not striving for a high degree of accuracy and precision in the conduct of the non-precision approach.

21. Not giving due consideration to the possible adverse effect of remote-source weather and altimeter setting information.

RECOMMENDATIONS.

1. Emphasize the need for more discipline, crew coordination and precision in the various non-precision approaches.

2. Develop new and more specific crew-concept procedures for all non-precision approaches similar to the procedures being used on the full ILS approaches. Following are some examples which apparently are appropriate.

   a. Complete in-range checklists and comprehensive instrument approach briefing prior to initiating the approach. Careful calculation of final approach ground speed.

   b. Extend landing gear and approach flaps and complete before-landing checklist after intercepting inbound course and prior to FAF passage. Establish altitude at the minimum recommended value so as to avoid subsequent high rates of descent.

   c. Use established altimeter, flight instrument and warning flag cross-check procedures just prior to the FAF.

   d. Note FAF passage, start timing and promptly commence predetermined rate of descent. Set landing flaps if appropriate.

   e. Make altitude and course deviation callouts during final descent.

   f. Carefully monitor timing and descent so as to arrive at or slightly above MDA prior to the KEY POINT (Normally one mile from the runway threshold). The KEY POINT may be determined by timing (usually 30 seconds prior to MAP), by DME, by cross bearing, or other type fix.

   g. POSITIVELY monitor MDA limits and do not descend below until the runway environment is in sight and the airplane is in position for a NORMAL approach to a landing. Assuming a HAT

of 300' to 400', this should occur at the KEY POINT and approximately one mile from the threshold.

Abandon the approach and execute the missed approach procedure if the approach is substandard or if g. above is not possible. It is NOT necessary to carry out the timing to the final MAP.

3. Consider revising the instrument procedures and approach plate display by establishing a KEY POINT FIX (KPF), approximately one mile from the threshold or farther out where MDA and visibility minima are above standard. The fix may be determined by DME, MM, NDB, intersection, or by timing.

4. Calculate and display on approach plates the timing from FAF to the Key Point Fix (KPF).

5. Calculate and display on approach plates the recommended rate of descent required on final approach to reach MDA at or before the KPF.

APPENDIX G

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NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D.C. 20591

January 17, 1969

Mr. David D. Thomas
Acting Administrator
Federal Aviation Administration
Department of Transportation
Washington, D. C. 20590

Dear Mr. Thomas:

Accidents which occur during the approach and landing phase of flight continue to be among the most numerous. They are again highlighted by some of the events of the past month that have aroused nationwide interest in air safety. Most approach and landing accidents have been attributed to improper operational procedures, techniques, distractions, and flight management. In many cases vertical/horizontal wind shear, forms of turbulence, and altimetry difficulties were, or could have been contributing factors. The phenomenon of breaking out into visual flight conditions and subsequently becoming involved in patches of fog, haze, rain, blowing snow and snow showers and other visibility obscuring forms of precipitation seems to be fairly common occurrence. The sensory illusion problem associated with night approaches over unlighted terrain or water is another likely factor about which more is being learned daily.

Other related factors are the handling characteristics of our transport type aircraft in day-to-day operations, the absence or outage of glide slope facilities, cockpit procedures, possible effects of snow or rain on dual static port systems as they could affect altimetry accuracy, and altitude awareness. These are all factors which may exist singularly or in combination. The inability to detect or obtain positive evidence, particularly such evidence as ice accretion or moisture which becomes lost in wreckage, makes it difficult, if not impossible, in many cases to reach conclusions based upon substantial evidence. It is clear that had all ground and airborne navigational systems been operating accurately and had the flight crews been piloting with meticulous reference to properly indicating flight instruments, these accidents would not have occurred.

In this light, and with the number and frequency of approach and landing phase accidents under similar weather and operating environments, we believe that certain immediate accident prevention measures need to be taken. We believe that preliminary to the successful completion of our investigations into the factors and causes of the recent rash of accidents, renewed attention to, and emphasis on recognized good practices will tend to reduce the possibilities of future accidents.

Pilots, operators and the regulatory agencies should renew emphasis on -- and improve wherever possible -- cockpit procedures, crew discipline, and flight management. It is recommended that both the air carrier industry and the FAA review policies, procedures, practices, and training toward increasing

crew efficiency and reducing distractions and nonessential crew functions during the approach and landing phase of the flight. It is specifically recommended that crew functions not directly related to the approach and landing, be reduced or eliminated, especially during the last 1000 feet of descent. Accomplishment of the in-range and landing check lists as far as possible in advance of the last 1,000-foot descent will allow for more intense and perhaps more accurate cross checking and monitoring of the descent through these critical altitudes.

It is also recommended that during the final approach one pilot maintain continuous vigilance of flight instruments - inside the cockpit - until positive visual reference is established.

In order to induce a renewed altitude awareness during approaches where less than full precision facilities exist, it is recommended that there be a requirement that during the last 1000' of final approach the pilot not flying call out altitudes in 100-foot decrements above airport elevation (in addition to airspeed and rate-of-descent). To further enhance altitude awareness within the cockpit, it is recommended that there be a requirement to report indicated altitude to Air Traffic Control at various points in the approach procedure such as the outbound procedure turn and at the outer marker position.

Consistent with and in support of the concept inherent in your Notice of Proposed Rulemaking No. 67-53, the Board urges the aviation community to consider expediting development and installation of audible and visible altitude warning devices and the implementation of procedures for their use. Additional improvements, although desirable now, are attainable only through continued research and development.

The reassessment of altimetry systems with particular regard to their susceptibility to insidious interference by forms of precipitation needs to be the subject of attention by the highest level of aeronautical research facilities and personnel. Toward this end, we are meeting with members of your staff, the National Aeronautics and Space Administration and various segments of the aviation community to initiate an assessment of possible failure modes and effects within the static system.

The possibility of development of additional altitude warning systems - external to the aircraft -needs to be explored by the aviation community. One such possibility would be a high intensity visual warning red light beam - projected up along and slightly below the desired approach glide slope - to warn of flight below the desired path.

Likewise, development is needed in the fields of radio/radar, and inertial altimetry and CRT/microwave pictorial display approach aids as possible improved replacement of the barometric altimetry system in the near future.

Modified use of existing approach radar should be further studied with regard to its adaptability as a surveillance--accident prevention--tool for nonprecision instrument approach.

During the time that we press for answers as to the causes of a number of these recent accidents, the Board urges increased surveillance, more frequent and more rigorous inspection and maintenance of altimetry systems by both the air carrier operators and the FAA; and urges also that the FAA reexamine certification requirements and procedures to determine if there is a possibility of a single failure mode of nominally dual systems which, when combined with an already existent passive failure or inadequate cockpit procedures, can invalidate dual failure protection features.

Whereas these problems have been highlighted by air carrier accidents, they should not be construed as being unique to air carrier aviation. The Safety Board considers that they are applicable to all forms of air transportation.

We know that your Administration, as well as other responsible segments of the aviation community, have been working extensively in all of these areas.

We appreciate your continuing emphasis on the safety of air carrier operations as evidenced by recent communications with your inspectors and airline management.

Your views regarding the implementation of our suggestions will be welcome.

Sincerely yours,

Joseph J. O'Connell, Jr.
Chairman

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

FEB 6 1969

Honorable Joseph J. O'Connell, Jr.
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D.C. 20591

Dear Mr. Chairman:

I have your letter of January 17, 1969, which contained suggestions and recommendations for the prevention of accidents during the approach and landing phase of flight.

My letter of January 28, 1969, commented on a number of the items covered in your January 17 letter. Therefore, I will not repeat them here, except to reiterate that our immediate concern and followup actions are directed to the areas of adherence to established procedures, altitude awareness, winter operating procedures, and cockpit discipline and vigilance.

Our comments concerning the matters discussed in your letter are as follows:

1. Reduce distractions and non-essential crew functions during approach and landing. Instructions to our inspectors require them to review on a continuing basis cockpit check lists and procedures to assure that minimum checking will be done during the more critical periods of flight such as departures, approaches, and landings.

2. Use of in-range and landing check lists. We believe the airlines require all cockpit check procedures, particularly the in-range check list, to be completed well before the last 1,000 feet of descent. However, we will request our inspectors to doublecheck and take action where warranted.

3. Cockpit vigilance. The instructions to our inspectors referred to in item 1 above also require them to assure that cockpit check procedures are arranged so that the pilot flying devotes full attention to flight instruments. As stated in my letter of January 28, 1969, crew vigilance and cockpit discipline is one of the areas stressed in my wire to the airline presidents.

4. Altitude awareness. Over two and one-half (2½) years ago, instructions were issued to our inspectors to be sure the airlines emphasized in training and included in company manuals altitude awareness procedures to be used during climbs, descents, and instrument approaches. This is one of the areas on which we asked our inspectors to place emphasis during the accelerated inspections mentioned in my January 28 letter.

Your letter recommended that during the last 1,000 feet of the final approach the pilot not flying be required to call out altitudes in 100 foot increments. The altitude awareness procedures that we have asked the carriers to adopt require the pilot not flying to call out, during the final 1,000 feet of the approach, 500 feet above field elevation, 100 feet above minimums, and minimums. We believe this procedure is preferable, since it serves to keep cockpit conversation to a minimum and at the same time, assures pilot altitude awareness. This procedure also reduces pilot workload.

5. Pilot reports to ATC of altitudes during instrument approaches. Adoption of this suggestion would significantly increase frequency congestion and increase crew and controller workload. We believe our efforts in the areas of pilot training and education will prove to be the most beneficial course of action.

6. Altitude alerting devices. I appreciate your support of the rule which became effective on September 28, 1968, which will require by February 28, 1971, both visual and aural altitude alerting signals to warn pilots of jet aircraft when approaching selected altitudes during climbs, descents, and instrument approaches.

7. Altimetry systems. With respect to your suggestion that an assessment be made of possible failure modes of altimeter static systems, we plan to participate with NASA and the aviation industry to assist in such a program. Development and testing to validate such improvements will be required. At this time, we know of no practical replacement for the barometric altimeter.

8. Additional altitude warning systems. Your suggestion concerning visual glide path warning would not provide complete information concerning the optimum glide path as does the Visual Approach Slope Indicator (VASI) systems which are installed at many runways throughout the country. We plan to continue to install these systems in accordance with current criteria within the limits of funds appropriated for this purpose.

9. Development to replace barometric altimeter systems. The use of inertial altimetry could be investigated, but must be considered as a long range R&D program. CRT/microwave pictorial display (radar mapping) has been evaluated by the military as an additional approach aid monitor. The FAA as yet does not have detailed information, since this equipment, until recently, was classified. However, we plan to obtain additional information and will look into the matter further.

10. Modified use of existing approach radar. I would appreciate receiving from you additional details on the modified use you had in mind, so that we can more properly evaluate and respond to your suggestion.

11. Inspection and maintenance of altimeter systems. On January 29, 1969, representatives of our Flight Standards Service met with ATA's Engineering and Maintenance Advisory Committee to review and discuss altimetry problems. The airlines are monitoring the operation of these systems and reviewing their maintenance procedures. ATA advised us at this meeting that few troubles are being experienced or reported by the flight crews. This is confirmed by our analysis of the MRR reports. Nevertheless, ATA has agreed to reactivate its Altimetry and Static System Maintenance Subcommittee to further explore this area and intends to review and update material previously published on this subject.

12. Certification of altimeter systems. On August 16, 1968, we issued a Notice of Proposed Rule Making proposing revisions to Part 25 of the Federal Aviation Regulations to require in systems design means to assure continued safe operation following any single failure or combination of failures not shown to be extremely improbable. Industry comments are now being reviewed and analyzed.

Your interest in these problems is appreciated and I can assure you we will continue to press for solutions to them.

Sincerely,

D. D. Thomas

D. D. Thomas
Acting Administrator

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20591
EXTRACT FROM AIRCRAFT ACCIDENT REPORT

SOUTHERN AIRWAYS, INC.
DOUGLAS DC-9-15, N92S
GULFPORT, MISSISSIPPI
FEBRUARY 17, 1971

REPORT NUMBER: NTSB-AAR-71-14

RECOMMENDATIONS

The Board finds that altitude alerting equipment now installed on air carrier aircraft is not used as a ground proximity warning device which has been previously recommended and, therefore, the Board recommends that the Federal Aviation Administration:

1. Develop a ground proximity warning system for use in the approach and landing phases of operation which will warn flightcrews of excessive rates of descent, unwanted/inadvertent descent below Minimum Descent Altitudes, or descent through Decision Height. It would be desirable if the equipment now installed could meet this need; and

2. Develop and implement appropriate operational procedures to provide this type of warning to flightcrews for use during the approach and landing phase of flight.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

APPENDIX G

OFFICE OF
THE ADMINISTRATOR

15 NOV 1971

Honorable John H. Reed
Chairman, National Transportation
Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

This is in response to the recommendations contained in Report Number NTSB-AAR-71-14, an aircraft accident report concerning a Southern Airways DC-9 at Gulfport, Mississippi, on 17 February 1971 and referred to in your letter dated 3 November 1971.

With respect to the recommendation to develop a ground proximity warning system for use during approach and landing, we believe the present instrumentation and procedures are safe and adequate. This presupposes proper cockpit disciplines are maintained. On this flight the Captain stated that during the approach he read the altimeter at 300 feet. The voice recorder transcript shows the Captain called 150 feet and advised the copilot who was flying the aircraft to "bring it up." The report brings out that the radar altimeter was set for 400 feet and the yellow warning light was observed by the pilot. We believe the pilot was well aware that he was below the Minimum Descent Altitude (MDA). We fail to see how a ground proximity warning could have contributed further to what we believe was already known.

We are, however, reassessing our system requirements for nonprecision straight-in-approach systems with a view to providing additional assistance to the pilot in the form of accurate position information which will make his evaluation of the visual approach segment less susceptible to human error.

With respect to the recommendation to have operational procedures to provide ground proximity warning, the agency has, for many years, had an altitude awareness program. Operators develop and publish in their manuals company procedures to insure altitude awareness during approaches. Southern Airways did have such a procedure, but it was not followed during the approach in question. Additionally, as the nonprecision straight-in-approach system is revised we will consider new or additional procedures to implement the system.

2

With respect to the recommendation to commission the full ILS at Gulfport, grading needed to solve the siting problem is being accomplished by the sponsor. We expect the system to be commissioned in early 1972.

Sincerely,

(signed) K. M. Smith
Acting Administrator

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

15 MAR 1972

Notation 650

Honorable John H. Reed
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

This is in response to the recommendations contained in your Report Number AAR-72-4, an aircraft incident report, involving a Northeast Airlines, Inc., DC-9 at Martha's Vineyard, Massachusetts, on 22 June 1971.

As you state these recommendations parallel those regarding the Southern Airways DC-9 accident at Gulfport, Mississippi. Our position in this regard is the same as stated in our letter of 15 November 1971 concerning the Gulfport accident. We believe that current instrumentation and procedures are safe and adequate assuming that proper cockpit disciplines are maintained. In this incident, as in the Southern accident, according to your reports the company altitude awareness and callout procedures for nonprecision approaches were not followed. Thus, it appears that if these procedures had been followed, the incident would not have happened.

Nevertheless, we have reassessed our system requirements for straight-in nonprecision approaches and are developing new criteria which we propose to be applied to these type approaches. One criterion which we are working on involves establishing a final approach descent fix such as a fan marker or other suitable facility for each straight-in nonprecision approach procedure. This descent fix would be located at a point on the final approach from which a normal descent path of approximately 3° from MDA to touchdown can be commenced, provided the required visual reference is established. The pilot would be required to maintain an altitude at or above the MDA until passing the descent fix. Another criterion which we propose will be to provide VASI for each runway served by this type approach. The VASI will provide visual vertical guidance at normal descent rates for the visual segment of the approach. These new criteria should result in a greater degree of altitude awareness throughout the procedure.

Sincerely,

J. H. Shaffer
Administrator

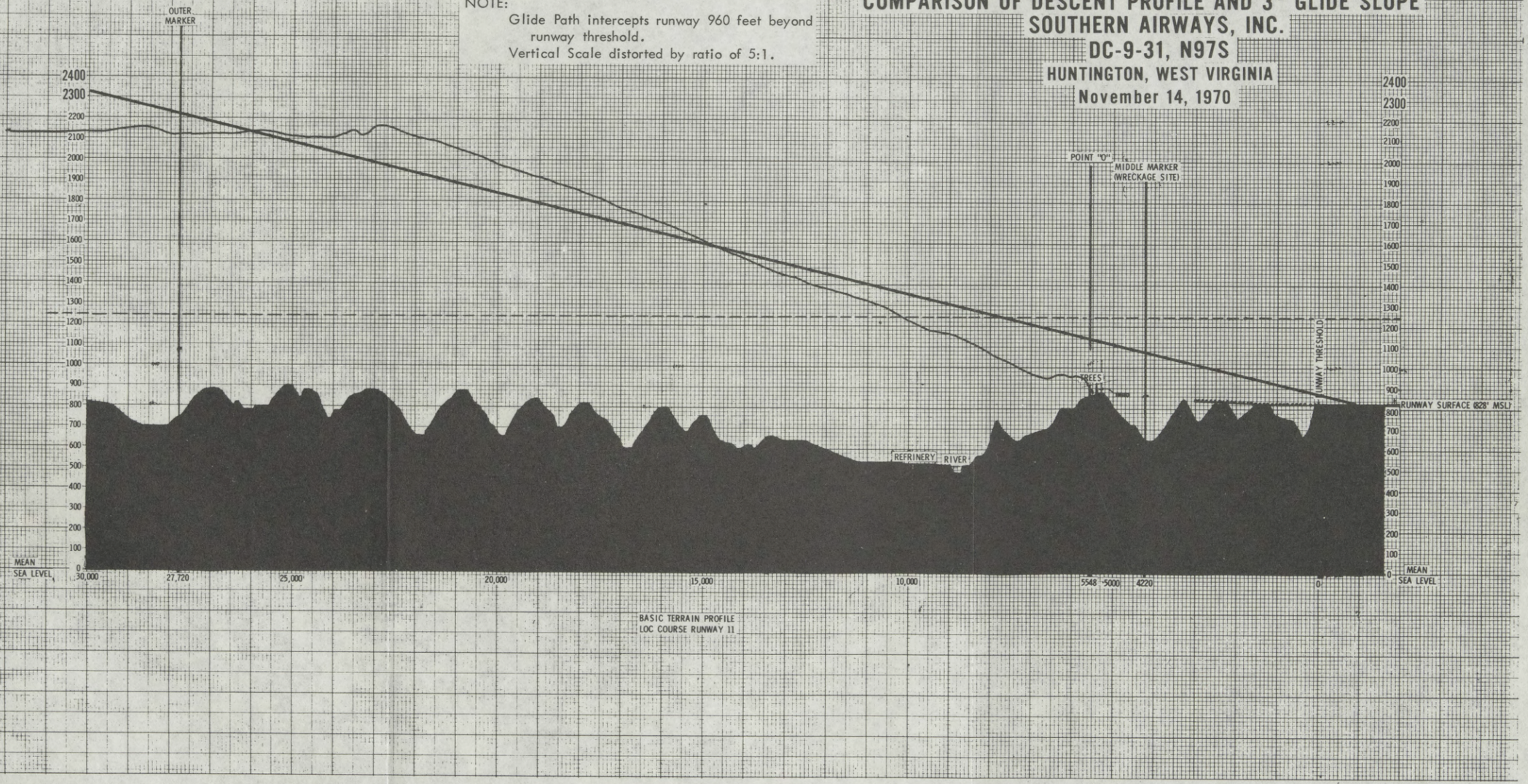
ATTACHMENT 3

---- MINIMUM DESCENT ALTITUDE
——— 3° GLIDE PATH
———— DESCENT PROFILE

NOTE:
Glide Path intercepts runway 960 feet beyond runway threshold.
Vertical Scale distorted by ratio of 5:1.

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.

COMPARISON OF DESCENT PROFILE AND 3° GLIDE SLOPE
SOUTHERN AIRWAYS, INC.
DC-9-31, N97S
HUNTINGTON, WEST VIRGINIA
November 14, 1970



BASIC TERRAIN PROFILE
LOC COURSE RUNWAY 11

41-958 O - 74 (Face p. 242) No. 3

Jeppesen Approach Chart — NOV 6-70 — (11-1)

HUNTINGTON, W. VA.

TRI-STATE

HUNTINGTON Tower 118.5 122.5G
(OP NOT CONTINUOUS)

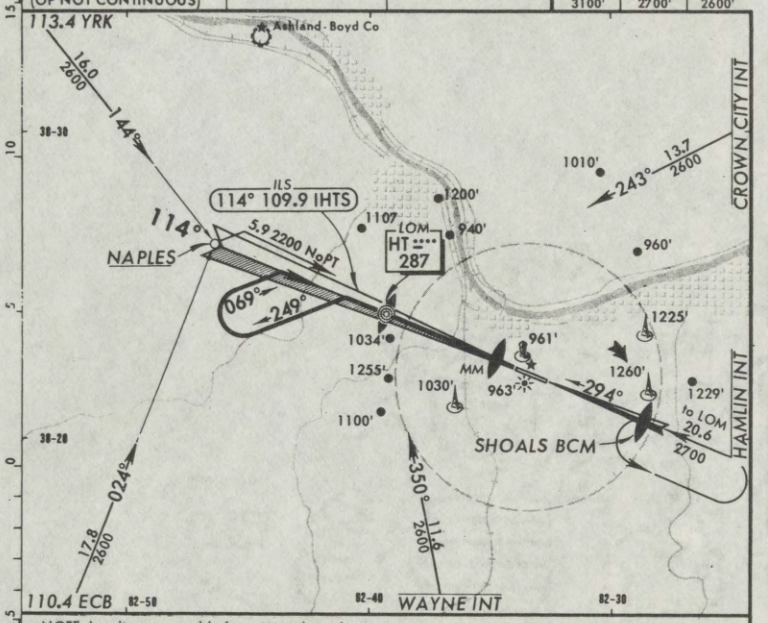
Apt. Elev. 828'
Var. 02° W

Eff Nov 12 LOC Rwy 11
NDB Rwy 11

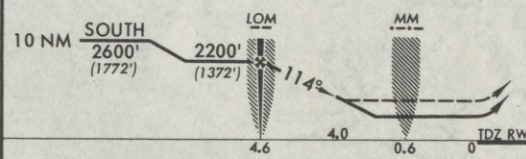
Approach	Departure	Ground
120.9 (OP NOT CONTINUOUS)		121.9 121.9 Cpt

LOC 109.9 IHTS

MSA 360° - 090° 3100' | 090° - 180° 2700' | 180° - 360° 2600'



NOTE: Localizer unuseable from MM inbound.
Localizer crs intercepts runway centerline at MM.



PULL UP to 2700 feet on EAST course ILS to SHOALS BCM and hold EAST, LEFT turns, or as directed.

	STRAIGHT-IN LANDING RWY 11					CIRCLE-TO-LAND	
	MDA 1240' (412')				MDA 1340' (512')	LOC MDA	NDB MDA
	MM out	ALS out	ALS & MM out	NDB	NDB ALS out		
A						1280' (452') -1	1340' (512') -1
B	1/2	1/2	1 3/4	3/4	1	1320' (492') -1½	1340' (512') -1½
C							
D	3/4	1		1		1380' (552') -2	1380' (552') -2
ALL Non Skd	MDA 1240' (412')				MDA 1340' (512')	Non-Skd 1480' (652') -2	Non-Skd 1480' (652') -2

Gnd speed-Kts	60	80	100	120	140	160
LOM to MAP 4.6	4:36	3:27	2:46	2:18	1:59	1:44

Air Carrier Jets: SFL or HIRL out-not less than 3/4.
1 1 mile HIRL also out.

CHANGES: MDA's, pull up holding.

Jeppesen Approach Chart — DEC 27-68 — (11-1)

HUNTINGTON, W. VA.

TRI-STATE

HUNTINGTON Tower 118.5 122.5G
(OP NOT CONTINUOUS)

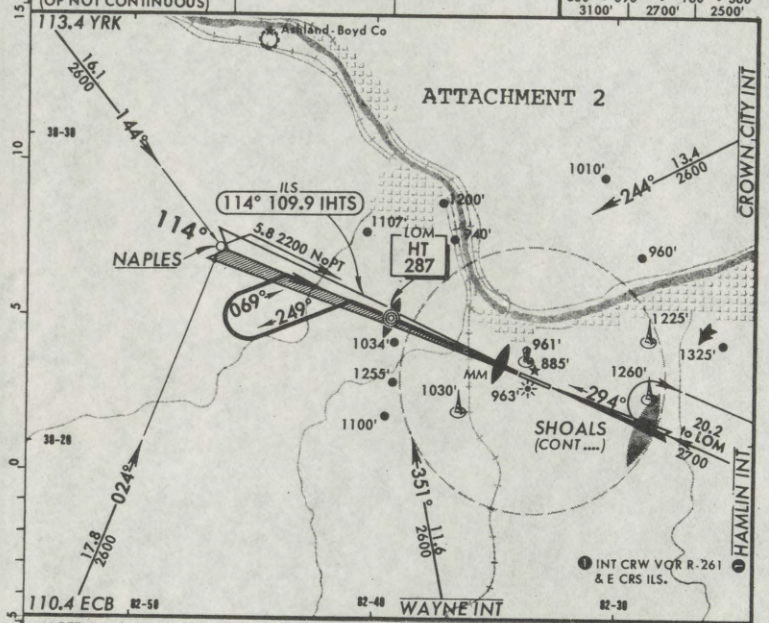
Apt. Elev. 828'
Var. 02° W

Eff Jan 2 LOC Rwy 11
NDB (ADF) Rwy 11

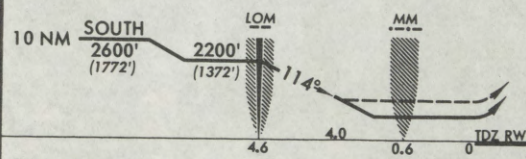
Approach	Departure	Ground
120.9 (OP NOT CONTINUOUS)		121.9 121.9 Cpt

LOC 109.9 IHTS

MSA 360° - 090° 3100' | 090° - 180° 2700' | 180° - 360° 2500'



NOTE: Localizer unuseable from MM inbound.



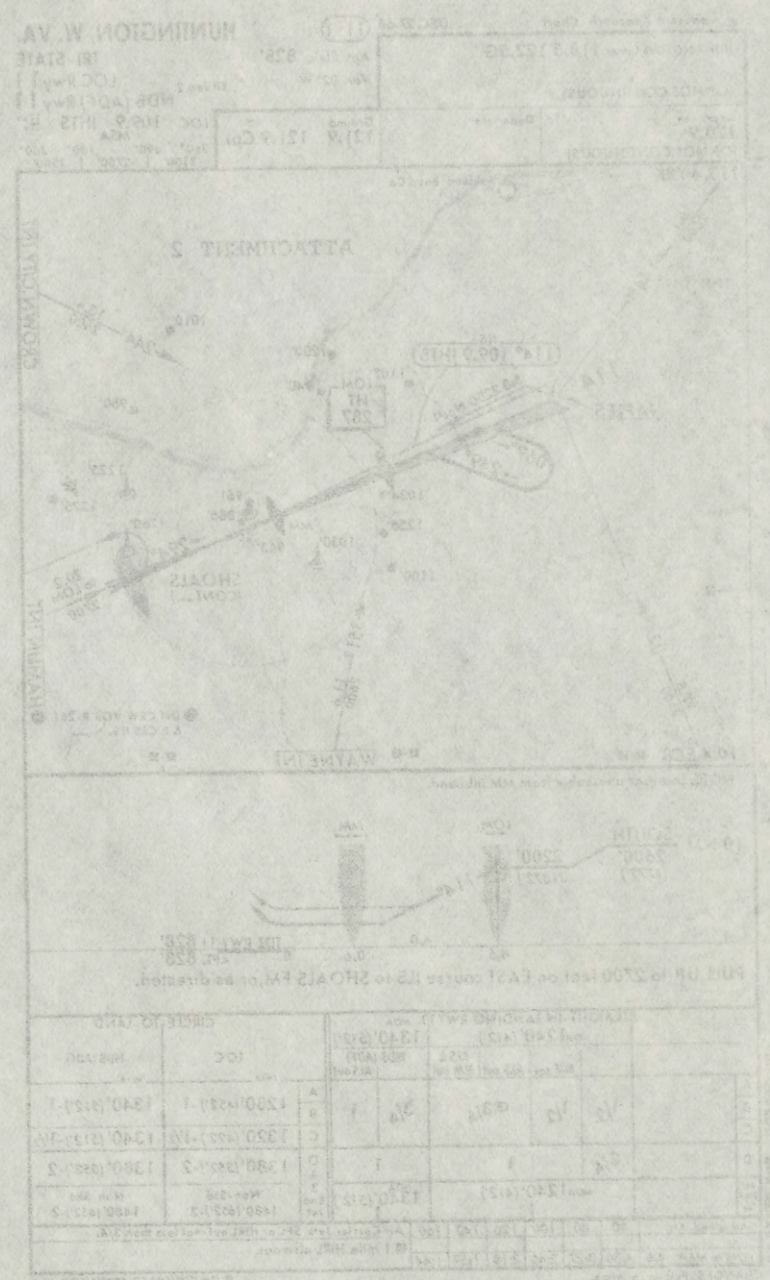
PULL UP to 2700 feet on EAST course ILS to SHOALS FM, or as directed.

	STRAIGHT-IN LANDING RWY 11					CIRCLE-TO-LAND	
	MDA 1240' (412')				MDA 1340' (512')	LOC MDA	NDB (ADF) MDA
	MM out	ALS out	ALS & MM out	NDB (ADF)	NDB (ADF) ALS out		
A						1280' (452') -1	1340' (512') -1
B	1/2	1/2	1 3/4	3/4	1	1320' (492') -1½	1340' (512') -1½
C							
D	3/4	1		1		1380' (552') -2	1380' (552') -2
ALL Non Skd	MDA 1240' (412')				MDA 1340' (512')	Non-Skd 1480' (652') -2	Non-Skd 1480' (652') -2

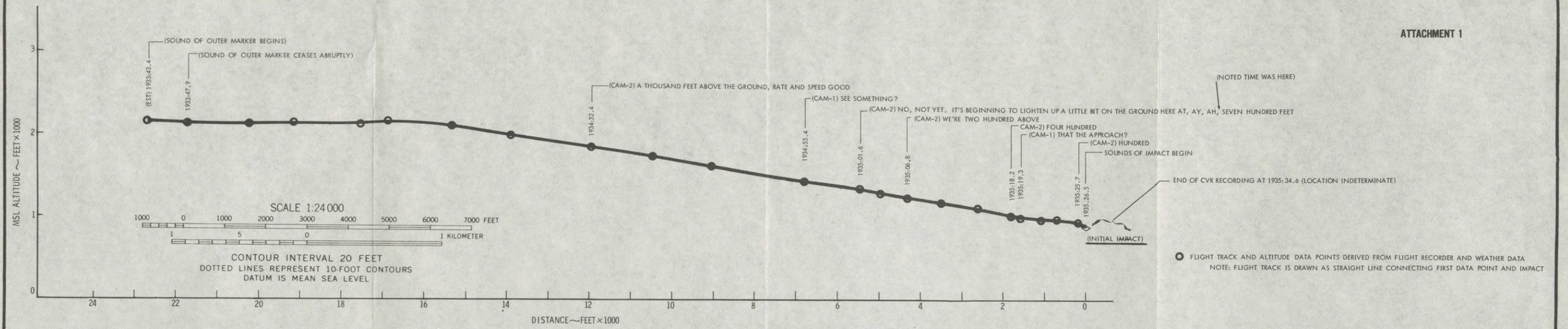
Gnd speed-Kts	60	80	100	120	140	160
LOM to MAP 4.6	4:36	3:27	2:46	2:18	1:59	1:44

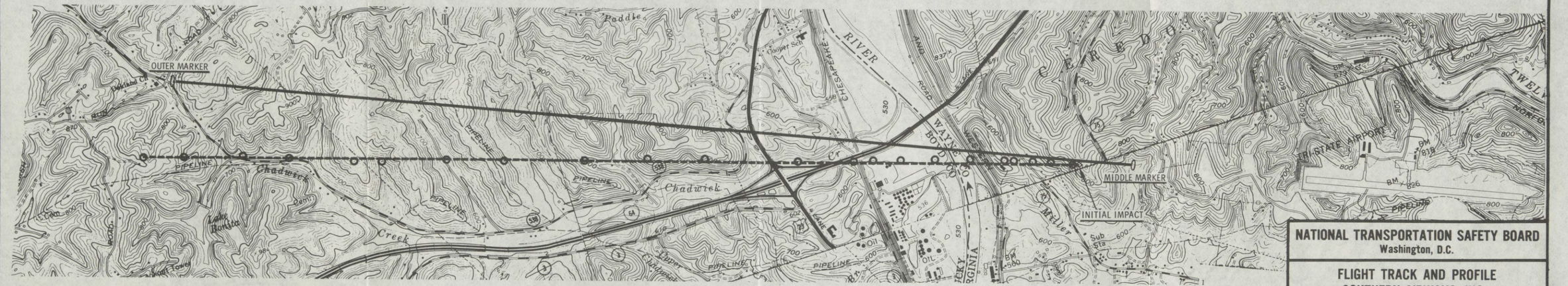
Air Carrier Jets: SFL or HIRL out-not less than 3/4.
1 1 mile HIRL also out.

CHANGES: Pull up, minima.



ATTACHMENT 1





NATIONAL TRANSPORTATION SAFETY BOARD
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FLIGHT TRACK AND PROFILE
SOUTHERN AIRWAYS, INC.
DC-9-31, N97S
HUNTINGTON, WEST VIRGINIA
November 14, 1970

41-958 O - 74 (Face p. 242) No. 1