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POSTURE HEARINGS

(NASA and FAA)

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HEARING

BEFORE THE

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

NINETY-SIXTH CONGRESS

SECOND SESSION

JANUARY 29, 1980

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POSTURE HEARINGS (NASA and FAA)

TUESDAY, JANUARY 29, 1980

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C.

The committee met, pursuant to notice, at 10 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua, chairman of the committee, and Hon. Ronnie G. Flippo, acting chairman of the committee, presiding.

The CHAIRMAN. The committee will be in order.

Today the Committee on Science and Technology begins a series of posture hearings with the heads of agencies and departments falling within the jurisdiction of the Committee on Science and Technology. Today our witnesses include Dr. Robert Frosch, the Administrator of the National Aeronautics and Space Administration, and Mr. Langhorne Bond, the Administrator of the Federal Aviation Administration.

We've had a chance to review the President's budget and are very pleased with the support for the Space Shuttle program and the two new starts—the Gamma Ray Observatory and the National Oceanic and Satellite System—which are included in the President's budget request for NASA. These two new starts are necessary to provide a balance in our space program activities. Providing the necessary funds to complete the Space Shuttle program at the expense of the other elements of the space program would be a mistake. Dr. Frosch, in reviewing your statement, it reflects another important first in that you have signed off on your first materials processing joint endeavor agreement with an industrial firm. I think the joint endeavor concept has broad positive implications as we as a Nation attempt to increase industrial productivity and innovation.

This morning the committee will examine the status of the Space Shuttle program, as well as the status of space science, space applications, and aeronautical activities.

During the past year we have witnessed a number of surprises with regard to the Space Shuttle program, including cost growth and schedule slip. The program has undergone several internal and external reviews resulting in a myriad of conclusions and recommendations. The committee is hopeful that the management changes, including increased emphasis in the financial management aspects, are achieving better program cost control, as well as satisfactory technical progress toward achieving the first flight and maintaining production orbiter delivery schedules.

We're very happy to have you here, Dr. Frosch.

Just prior to your statement I will ask Mr. Winn if he wants to insert his statement or make it.

Mr. WINN. Why don't you just insert it in the record, Mr. Chairman, to save time?

The CHAIRMAN. Without objection, Mr. Winn's statement will be inserted in the record.

[The prepared statement of Congressman Larry Winn, Jr., follows:]

I would like to concur with the Chairman's remarks. I also believe the NASA budget for fiscal year 1981 is a well balanced budget in the areas of basic and applied research. There will obviously be specific areas which may, in my opinion, require adjustments but, all in all, I am pleased with the overall budget.

It is also refreshing to see the aggressive support of the space shuttle program by the President; if this type of support could have been generated three years ago, I feel confident that we would not be facing as large a cost overrun as we are today. The proper priority has finally been established for shuttle. It is obvious that the Administration is aware that the space shuttle is a critical element for the Nation's space program and most importantly our defense program.

In spite of my support for the program in general, it does not relieve the budgetary concern which I have for the fiscal year 1980 supplemental request of $300 million. A year ago, we were faced with a supplemental request of $185 million. At that time the committee indicated that it would be quite difficult if we had to make another supplemental request; I still have that same opinion. I am personally concerned that additional cost and schedule growths may be lurking just around the corner. Presumably, these past two years, fiscal year 1979 and fiscal year 1980, have been of sufficient educational value to prevent making the same mistake in fiscal year 1981.

Another concern I would like to express is in regards to the space science program. In July 1977, this committee fought quite diligently for the funding of the Jupiter Orbiter Probe or Galileo mission. One of the most significant arguments we made was that it has to meet the January 1982 launch window. Now, as a result of the shuttle delays, the program has been restructured for a split launch in 1984 and the cost has grown by $154 million. This situation makes me wonder if the arguments that we made to the Congress were fair and accurate.

Another aspect of the space science program that concerns me is this rapid growth. I have heard discussions about beginning the solar electric propulsion system and a comet rendezvous mission in addition to the Gamma Ray Observatory. These are undoubtedly meritorious missions, but they are all dependent upon the space shuttle. I question whether it is wise to make long term space science commitments at this stage of the shuttle development—especially if it means delaying missions and incurring cost growths similar to the Galileo mission.

With these remarks, I would like to welcome the witnesses, Drs. Frosch and Lovelace. I look forward to your testimony.

[The statement of Congressman George E. Brown, Jr., follows:]

OPENING STATEMENT

Mr. Chairman, I share with the members of this Committee a desire to assure a vigorous and productive future for our civilian space program. Yesterday I introduced in the House the National Space Policy Act of 1980, which establishes policies and goals to guide the civilian space activities of the United States and provides for the planning and implementation of this program. I hope that this bill will help to inform a useful discussion of our current posture and future directions in space.

I was most pleased to learn yesterday from Dr. Press of the Administration's initiatives concerning the gamma ray observatory and the national oceanic satellite system. An active program in the space sciences is a major concern of the legislation which I have introduced. Another concern is an improved capability in satellite monitoring of land and ocean resources and increased international cooperation in promoting the benefits, for all nations, of remote sensing technology and satellite communications services.

Most of you have heard me speak, at one time or another, on the need for strategic policy planning at the national level in science and technology. Since the space program contributes a critical part of our national research and technological base, I consider it a matter of some importance that our space program be governed by well-thought-out policies and goals which look not just at today's needs and

capabilities, but also at tomorrow's possibilities. I hope that as we work our way through the authorization cycle we will find large areas of agreement in structuring a balanced and reasonable program for the next year and beyond.

The CHAIRMAN. Dr. Frosch, we're happy to have you here, and you may proceed.

Dr. FROSCH. Thank you, Mr. Chairman.

STATEMENT OF ROBERT A. FROSCH, NASA ADMINISTRATOR, ACCOMPANIED BY ALAN LOVELACE, NASA DEPUTY ADMINISTRATOR

Dr. FROSCH. I welcome this opportunity to present the President's budget for NASA in fiscal year 1981. This budget moves us into the 1980's in a strong position, across a broad front of vital activities in space transportation, space science, and in the practical applications of space technology and aeronautics.

In a moment I will ask Dr. Lovelace to review the highlights of last year—a year marked by exceptional productivity in the quest to understand the planets and far reaches of the universe. First, I would like to reflect on where we have been in the past two decades of space and aeronautical research and on what I see as NASA's role in the aeronautics and space world of the 1980's.

The 1960's were marked by the development and rapid expansion of space capabilities, capped, of course, by the first lunar landing in 1969, but extending across a broad spectrum of both manned and unmanned efforts. Major space activity was virtually the exclusive concern of the two superpowers—the United States and the Soviet Union. U.S. launch capability rapidly grew to a reliable family of expendable launch vehicles. We initiated an orderly, sequential program to explore our solar system. The capabilities of space systems to provide earthly benefits were demonstrated early, as weather and communications satellites proved their worth. NASA's most important aeronautics work continued, although attention focused more on the new regime of space flight.

On the whole, the 1970's may be viewed as a period of consolidation of these demonstrated strengths. Early in the decade we completed the planned lunar exploration and then conducted the Skylab and Apollo-Soyuz missions. The Shuttle program, initiated in early 1972, was the logical next step in the evolving capabilities of man to use the continuum of air and space on a routine basis. Our extraterrestrial observing capabilities in deep space improved remarkably, culminating in the recent spectacular and rich returns of scientific data from Jupiter and its moons. Our ability to observe our own planet and to monitor mankind's impact on its delicate ecological balance is now sufficiently developed so that operational remote sensing systems for land and water are a logical next step forward.

During the 1970's, the numbers and kinds of operational civil and defense space systems burgeoned, and space budgets of the rest of the Federal Government grew to exceed the NASA budget. A half-dozen new members joined the list of spacefaring nations, and many others came to rely on space systems as important parts of their national life. In aeronautics we enhanced the base established by the National Advisory Committee for Aeronautics and maintained during the 1960's, helping to sustain in concert with a vigorous private sector America's unparalleled role as world leader

in civil and military aviation. The 1970's brought us painful lessons about our non-renewable energy resources. As this committee knows, NASA has played a positive role in answering this challenge, exemplified by our developmental work in solar energy and by other activities where the fruits of our efforts in aeronautics and space have generated technologies applicable to problems of energy conservation and supply.

Where are we headed in the 1980's?

Every sign points to a decade of vigorous activity in both aeronautics and space. This activity will be international in character, highly sophisticated in its technology and rich in its contribution to scientific knowledge. It will have an important commercial dimension as the economics of space flight become increasingly attractive. Perhaps most importantly, the 1980's will be a decade when for the first time the life of almost everyone on Earth will be made significantly better by our ability to apply our skills in space to problems here on Earth.

In aeronautics, we expect a continuing strong demand for civil transport aircraft. In this decade, the free world market for new large transport aircraft has been estimated at over 5,000 aircraft, representing a total investment approaching $200 billion. International competition is rising sharply, but U.S. industry, strengthened by NASA-supported research and technology programs, should be able to continue to supply a major portion of this demand. Recent events underline the absolute need for the United States and our allies to maintain strong, second-to-none defense capabilities. This need will bring forth requirements for continued advances in space and aeronautics capabilities. We must make certain that NASA contributes, where and as appropriate, to our technological readiness to meet these challenges.

Satellites have become the basic mode of international telecommunications. By the end of the 1980's, they will carry the major fraction of worldwide domestic as well as international traffic, and by the end of the century total demand is projected to grow tenfold. Demand for satellite manufacture and launch, as well as for ground terminals and redistribution systems, will grow apace. Here NASA's R. & D. can point the way to the new generation of satellites essential for the 1990's.

Through NOAA, the United States will establish the first operational Earth resources remote sensing system building on the technology developed in NASA's Landsat project. This is the third major civil technological system transfer for which NASA has been responsible. The details of NASA's role in support of NOAA's initial system, and in creation of its successors, are being defined now. These developments, and the advent of their foreign analogs, portend another field of explosive growth ahead, both in the technologies of space systems and the techniques of information generation and dissemination.

The Space Shuttle and Spacelab will make possible the beginnings of true industrial experimentation to exploit applications of materials processing in space for new and improved processes and products. Symbolic of this promise is the fact that in this first month of the 1980's, we have signed our first agreement for a cooperative manufacturing activity with a private company.

Words like "astounding" cannot adequately portray what has happened over the past 20 years in the revolutionary growth of the several bodies of knowledge that we call space science. But if HEAO and Voyager amazed us last year, what will the Space Telescope, Galileo, the Gamma Ray Observatory, Spacelab and other space science initiatives bring in the decade ahead? In my view, none of us can fully comprehend what the data products of these new, incredibly powerful tools will mean to human knowledge and to our societies here on Earth by the end of this century. Thus, I see the 1980's as a period during which our Nation and the world will reap valuable scientific returns from the base so carefully built in the 1960's and 1970's, and build new tools for future returns.

But the greatest rewards, many unforeseen today, will be reaped from the seeds which are sown in the latter half of this decade as we begin to exploit fully the unique capabilities of the Space Shuttle. Already the Space Shuttle is fully booked in advance into 1984 for civil, defense, commercial, and international missions. The following years promise a period of exploration and achievement in space, made possible by applied research and technology—fields in which this country has always excelled. In concert with the aerospace community, universities, the commercial sector, and the international space community, NASA initiatives and expertise using the Space Shuttle as a focus will play a significant role.

Mr. Chairman, the President has proposed a NASA budget totalling $5.737 billion for fiscal year 1981, and a fiscal year 1980 supplemental appropriation of $300 million for Space Shuttle development. This budget, highlighted by major new starts in space science and in space applications, will preserve and build on NASA's basic strengths in a time of serious national economic stress and heightening international tensions. It reflects the administration's commitment to a strong, multifaceted space program in the 1980's. It supports the President's space policy goals of maintaining U.S. leadership in space science and applications, as well as exploiting fully the capabilities of the Space Shuttle for all national objectives. With congressional approval, this budget will support:

Initial test flights of the Space Shuttle, culminating a decade-long, highly sophisticated design, development, and test program.

A Shuttle orbiter production schedule that will meet critical civil and defense launch requirements.

Continued emphasis on a broadly based space science program, featuring:

One, a new mission, the Gamma Ray Observatory, that will provide a major increase in our knowledge of the high-energy universe and of gamma ray sources like black holes.

Two, development effort on the restructured 1984 Galileo mission, to capitalize on the superb performance of Voyagers I and II at Jupiter.

Three, continued work on the U.S. spacecraft for the 1983 U.S.-Europe International Solar Polar dual spacecraft mission.

Important emphasis on space applications, including:

One, focus of our Landsat effort to support the President's recent decision on implementing a fully operational satellite-based land remote sensing system under Department of Commerce leadership.

Two, initiation of the National Oceanic Satellite System, a tri-agency program that will demonstrate operational global sea surface observation capabilities from space. NOSS will bring space remote sensing capabilities to the oceans, complementing similar atmospheric and land capabilities.

Three, expanded communications satellite research and development studies and advanced technology for experimental wideband satellite communications.

Four, continuation of our support to the Department of Agriculture in the AgRISTARS effort to improve early warning and crop inventory forecasting.

Advanced work on more efficient and effective aircraft, featuring:

One, a comprehensive research and technology base program.

Two, continued progress in energy efficiency for the next generation of transport aircraft with a new emphasis in advanced turboprop technology.

Three, vigorous flight test programs with the Tilt Rotor and Quiet Shorthaul Research Aircraft and the Highly Maneuverable Aircraft Technology Vehicle.

Four, important new thrusts in technology for advanced rotorcraft.

Five, emphasis on advanced variable cycle engine technology.

Six, increased effort on technology to prolong the life of aircraft turbine engines.

Finally, the proposed budget for fiscal year 1981 will support the critical in-house scientific, technical and administrative staffs and facilities necessary to assure successful national programs in aeronautics, space, and energy.

I would now like to ask Dr. Lovelace to review the highlights of the past year.

Dr. LOVELACE. Mr. Chairman, 1979 was a very busy year, full of accomplishments for the agency, and I would like to very briefly touch on some of the highlights.

It included the 10th anniversary of the Apollo lunar landing, as well as the safe Skylab reentry without any damage or injury, and furthermore it was another successful year of launches in our Expendable Launch Vehicle program. NASA launched nine payloads and seven for the Department of Defense. Of the nine payloads launched by NASA, three were NASA payloads, namely, the MAGSAT, the High Energy Astronomy Observatory, and the Stratospheric Aerosol Gas Experiment. The remaining six were reimbursable payloads from either other U.S. Government or commercial foreign agencies.

[Viewgraphs shown.]

Dr. LOVELACE. We also had many visitors to the agency. Probably at the forefront of that group was the Vice-Premier of China, Deng Xiaoping, shown here in the space transportation system simulator at the Johnson Space Center.

The year 1979 also saw three major milestones in our Expendable Launch Vehicle program. We have had 34 successful launches. The 50th Atlas/Centaur, the 100th Scout, and the 150th Delta have been launched. This provides for a very solid continued backup

support for our domestic and foreign user needs, transitioning into the Shuttle area.

Let me, with that transition, add my remarks on the Shuttle and point out to you some of the milestones accomplished in that program in the last calendar year.

You see here the Enterprise, the first orbiter, in the full stack configuration as the Space Shuttle will be launched, in this vertical, upright mode. You see in the center what we call the external tank, which holds the liquid oxygen and hydrogen. On either side of it are the two solid propellant boosters. Attached to this is the airplanelike structure called the orbiter, which has three Shuttle main engines in the aft fuselage that is supplied the fuel from the external tank.

The external tank is the only part of the system that is not reusable. The solid rocket boosters are recovered, refurbished, and reused, and, of course, the orbiter returns, lands, and is refurbished for succeeding flights.

The Enterprise was used for facility interface vertification testing with facilities at the Kennedy Space Center (KSC), from the Vehicle Assembly Building out to Pad A, for form and fit checks. The Enterprise is now on the west coast.

The first flight orbiter, Columbia, shown here arriving at KSC in March of last year on the back of a 747, is now in the Orbiter Processing Facility for final assembly and checkout.

Shown here is the installation of the flight instrumentation in the payload bay of the Columbia, and most of that work is now complete and is going very well.

In addition, we, of course, installed the three Shuttle main engines that I spoke about earlier. After the completion of their first certification series, we had to remove them. We found some soft welds in the nozzles of these engines, due to some out-of-specification weld wire being used in the manufacturing process.

The next picture shows that those engines have now been removed from the Columbia and are in repair at KSC. That's going very well, in fact, ahead of schedule. We anticipate that they will be returned and reinstalled in the orbiter in March.

The thermal protection system remains one of our most difficult problems. Here you see the Columbia with a number of missing tiles. These are the tiles that cover the orbiter to protect it from the thermal loads of launch and reentry. We have the very difficult problem of dealing with the mechanical and thermal loads, on a set of nonhomogeneous and unconventional structural materials. That represents for us probably the longest technical pole in our tent.

This is one of the tests that we're using on the tiles. We will, in effect, proof test all of the tiles on the vehicle. If we cannot do that we will remove them and test them off the vehicle and otherwise insure that they will meet both the thermal and mechanical loads. Even though our selection of the flight profile for the first manned orbital flight will be relatively benign, we feel it prudent to insure the integrity of the thermal protection system before we proceed with that first flight.

This shows you other parts of the system we are assembling at KSC. This is the external tank for the first flight, which is now in the Vehicle Assembly Building at KSC.

The next slide shows a picture of the two solid rocket boosters which will be strapped to the tank. One is in the lower part of that picture. And the other is just being capped, in the center, fully stacked after mating them with the external tank, they will await the completion of the work on Orbiter 102, Columbia.

This is the first Spacelab flight article which is virtually complete in its fabrication. The fiscal year 1981 funding is required authorization to purchase the second flight article, which will then support our Spacelab missions through the 1980's.

This slide shows the first crew, John Young and Bob Crippen, going to the Orbiter Processing Facility to conduct a series of Orbiter integrated tests. This exercises the onboard software in the flight orbiter with its subsystems and interfaces with the ground computers and software, simulating launch, on-orbit, and mission phases. These tests were all successfully completed.

Then we transition into our aeronautics program and go from one set of unconventional vehicles to another set. Here you see the XV-15, or the Title Rotor, which in 1979 accomplished its first full conversion from a hovering mode into an airplane flight mode. Thus far, we have achieved a 207-knot forward speed out of the designed 300-knot design capability, and we will continue to open up that enevelope in future testing during this year.

I might point out that this is a joint Army/NASA program, in which the Navy has now joined us which will provide some very fundamental aerodynamic understanding of a concept for vertical V/STOL operations important to our military.

A second concept is HiMAT. We showed you this vehicle last year. We have this year completed the first initial set of flights. It is a remotely piloted vehicle in which the pilot is on the ground.

It is a high performance aircraft, embodying the latest set of aeronautical concepts, and is a joint program with the U.S. Air Force, and again will provide a set of technologies that we believe will be important to next generation fighter aircraft.

A third research aircraft that flew in 1979 was what we call the Oblique wing aircraft. It is an aircraft capable of rotating the wing from the zero position that you see in this picture to 60 degrees when it is in higher speed flight. We believe, from our prior wind tunnel tests and prior test programs, that we can reduce fuel consumption at these higher speeds by possibly as much as 50 percent, and so this is a very important flight test program that has civil and military aircraft importance.

Overall, our long-range program in energy conservation for aircraft is proceeding very well, and we look for much of that technology to go into the inventory this year.

Let me turn to the application of space science to solving our problems here on Earth by talking a little bit about our space application programs.

In 1979 we had a very important series of experiments jointly with NOAA and with the National Science Foundation and, in fact, we were fairly lucky to collect some very important data during some events in the Red River Valley down near Wichita, these data were collected from ground stations, from low-flying NASA aircraft, from our high altitude aircraft, as well as from the GOES Satellite. We believe they are giving us the indicators, or the

precursors, of severe storms, and will be the forerunner for a series of more extensive experimentation that will take place this year and the following year.

Also in our environmental program we have collected some data on the Intertropical Convergence Zone, where we believe there is a strong upwelling of the troposphere into the stratosphere. This is one of the major mechanisms by which pollutants in our atmosphere are driven up into the ozone layer in the stratosphere. In this program data is collected by our high flying research aircraft, such as the U–2.

SEASAT, although it is not operating any longer, provided the data that has been convincing to us that for the first time we can get surface wind direction and speed from space observations.

This a meteorological formation off the Gulf of Alaska, which actually reaches down to the coast of California. You can see the meteorological flags that have been superimposed on this image to show the wind speed and direction.

The Coastal Zone Color Scanner—that's on NIMBUS, is capable of detecting color changes in the water, and here, in fact, demonstrating its ability to pick out the oil slick from the Gulf of Mexico oil blowout. Those two, combined with other data, have convinced us of the need for the operational demonstration of the National Oceanic Satellite System that Dr. Frosch referred to a moment ago.

Magsat was launched in 1979. This is a satellite capable of measuring the magnetic field around our planet. You see here the first plot of these data in terms of lines of constant magnetic force. We believe this data will prove useful in our geological research as well as the ability to locate mineralized areas on the Earth's surface.

Turning to Landsat-type applications, we have completed, or have ongoing, many demonstration projects around the world and with 36 of our States, and they range, as shown on this view-graph, from the interest in oil and gas, to irrigation, to coastal resources, and to land cover classification.

A particular example, completed this last year, is in the State of Iowa in which the data shown on the left in the 1973 and 1978 Landsat photos, we combined with data from conventional sources, shown on the right side, leading to the final set of data and the ability to predict the erosion potential for an area. This will allow Iowa to do better land management and to convert the appropriate ground into tillable soil without undergoing the risk of high erosion.

We continued, of course, to apply our technology in the energy area, and this is an update on the wind energy turbine generator programs. In 1979 we put in place the Block Island, R.I. 200 kW station, and also started operations on the 2,000 kW Boone, N.C. station. Following that will be the 2,500 kW machine at Bonneville Power Administration in the State of Washington, and a demonstration with the Department of Interior at Medicine Bow, which, if successful, could lead to a system of some 50 machines.

We also have played a major role in the use of solar photovoltaic ground power installations, and we showed you last year the Schuchuli Indian Reservation, which is a 3.5 kW station. This, incidentally, is showing itself to be cost-effective with the diesel grid that

they are using up there now. That has been extended, and you see in the lower righthand corner the 60 kW station system at the Air Force's Mount Laguna remote radar installation.

We have over the last several years reduced the cost of ground solar power from a peak watt cost of about $30 down to $10, and our goal is by the end of the decade to try to drive that down to 50 cents.

We have also applied our technology to personal transportation systems, specifically the automobile. Here you see an example of an experimental electric car that has been developed by General Electric, Chrysler, and the Jet Propulsion Laboratories. It is in test now. It has achieved something like 75 miles of start-stop normal driving with a two-passenger load before recharging. We will see a continuation of the test to improve life and performance in this area.

Let me turn to the space science area.

I mentioned that we launched HEAO-3. HEAO-1, which was its sister satellite, and was launched earlier, has been a virtual cornucopia of scientific data, a little bit of which is shown here. Most recently, it has discovered what apparently is a large gas bubble, with a temperature of something like 3.5 million degrees Fahrenheit. It is 6,000 light-years away, radiating in the X-ray. Perhaps therein lies some keys to the understanding of how stars and supernova are formed. I'm sure Tim Mutch in the following hearings will have more to say about this.

We also must say that 1979 was truly the year of the planets. Here you see a picture of Jupiter as Voyager approached it, and in the next picture you see four of the major Galilean satellites: Europa, the brightest, Callisto, Ganymede, with a collection of both old and new craters, and, of course, Io, the satellite with probably the newest surface. This chart also shows four of the many major discoveries, starting with a further real understanding of the giant red spot in the upper atmosphere of the planet Jupiter; the discovery for the first time of a ring around Jupiter that's shown in the upper righthand corner; the aurora barely visible, in the lower righthand corner, discovered on Jupiter's dark side, probably the largest and most intense ever detected, some 18,000 miles long, as well as the bright spots that you see, which are really powerful lightning storms in the upper atmosphere of the planet; and again Io in the lower lefthand corner, which during the encounter period was very active and displayed to us some eight volcanoes on the surface of the planet. This discovery was of such spectacular interest to the scientific community that it captured almost simultaneously the cover of three noted magazines, with circulation, I guess, in excess of 12 million readers.

Voyager I now continues toward Saturn for a November encounter with its major satellite, its largest satellite, Titan. Voyager II will go past Saturn and on to Uranus in 1986, and, depending on the condition and health of the satellite or the vehicle, perhaps on to Neptune in 1989.

My last picture is one of Saturn taken by Pioneer II, and I think it's truly outstanding. The best detail of this planet that has ever been achieved, and achieved by a satellite, an interplanetary vehi-

cle, if you will, that was launched 6 years ago and has traveled close to 2 billion miles.

I would be, I think, remiss if I didn't close my remarks by pointing out a few of the spinoffs of the space technology, and I would like to do that by exemplifying two items.

We spoke to you last year about a power factor controller that had been developed by Mr. Nola of the Marshall Space Flight Center, on which he holds the patent and, in fact, has received a number of awards this past year. It's been commercialized, and this is an example of it. It's capable of saving up to 30 percent of the energy used by alternating current induction motors. This particular device is built for motors up to one-half horsepower.

The second area is one that is very much in its early stages of development. A problem that was called to our attention and an idea that, in fact, was developed by the director of research at the Helen Keller National Center for Deaf-Blind Youths and Adults, is the problem of communicating with people who are both deaf and blind. One has only the tactile sensations, or the sense of touch, to deal with. This device is the first of two prototypes in an experiment that we're conducting with the Stanford Research Institute and with the Institute for the Deaf and Blind. I would like to demonstrate this for you very quickly. It is a device which you can strap on your wrist. It allows the wearer who would be deaf and blind to communicate with a base station, to receive signals, in an otherwise very difficult communication environment.

I'm going to communicate with the base station that Mr. Roberson has on the table over here by punching this button three times, and in a few seconds, as it indexes to my station, No. 1 on his list, he will hear a signal. I will in turn feel a vibration here that says that my signal was received.

I would now like Mr. Roberson to transmit one of the standard signals, which is a fire warning signal, and then I will hand this to you and you may pass it around and feel the receipt of that signal by the person who would be wearing this unit.

The CHAIRMAN. Do you just put this on your hand?

Dr. LOVELACE. You can put it on your wrist if you want to wear it.

That is a prototype, obviously much larger than it has to be. We will be testing this at a couple of the institutes, the Smith-Kettlewell Institute and the National Center for the Deaf and Blind. Based on the results from these tests, we will develop a second generation of prototypes and see if that experiment does not lead us to a new solution to that problem.

The concludes my remarks, Mr. Chairman.

The CHAIRMAN. Thank you, Dr. Lovelace.

Dr. Frosch?

Dr. FROSCH. Mr. Chairman, I can now either highlight the remainder of my statement or, if you prefer, we can offer it for the record and proceed to questions. It's up to the committee, in terms of what your time constraints may be.

The CHAIRMAN. We have another witness, and I'm sure there are questions to be asked. Why don't we place your statement in its entirety, the remainder of it, in the record, and proceed to maybe ask some questions that the members may have?

Dr. FROSCH. That's fine. Thank you, Mr. Chairman.

[The complete prepared statement and answers to questions asked of Robert A. Frosch follow:]

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PRESENTED BY WITNESS

Statement of

JAN 2 9 1980

Robert A. Frosch
Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Committee:

I welcome this opportunity to present the President's budget for NASA in fiscal year 1981. This budget moves us into the 1980's in a strong position, across a broad front of vital activities in space transportation, space science, and in the practical applications of space technology and aeronautics. The budget includes new initiatives that reflect a commitment to maintain United States leadership in space.

In a moment, before discussing the budget in detail, I will ask Dr. Alan M. Lovelace, NASA's Deputy Administrator, to review the highlights of last year--a year marked by exceptional productivity in the quest to understand the planets and far reaches of the universe. First, however, I would like to reflect on where we have been in the past two decades of space and aeronautical research and on what I see as NASA's role in the aeronautics and space world of the 1980's.

The 1960's were marked by the development and rapid expansion of space capabilities, capped, of course, by the first lunar landing in 1969, but extending across a broad spectrum of both manned and unmanned efforts. Major space activity was virtually the exclusive domain of the two superpowers--the U.S. and the U.S.S.R. U.S. launch capability rapidly grew to a reliable family of expendable launch vehicles. We initiated an orderly, sequential program to explore our solar system. The capabilities of space systems to provide earthly benefits were demonstrated early, as weather and communications satellites proved their worth. NASA's aeronautics work continued to be useful although public attention focused more on the new regime of space flight.

On a whole, the 1970's may be viewed as a period of consolidation of these demonstrated strengths. Early in the decade we completed the planned lunar exploration and then conducted the Skylab and Apollo-Soyuz missions. The Shuttle program, initiated in early 1972, was the logical next step in the evolving capabilities of man to use the continuum of air and space on a routine basis. Our extraterrestrial observing capabilities in deep space improved remarkably, culminating in the recent spectacular and rich returns of scientific data from Jupiter and its moons. Our ability to observe our own planet and to monitor mankind's impact on its delicate ecological balance is now sufficiently developed so that operational remote sensing systems for land and water are a logical next step forward.

During the 1970's, the numbers and kinds of operational civil and defense space systems burgeoned, and space budgets of the rest of the Federal Government grew to exceed the NASA budget. A half dozen new members joined the list of spacefaring nations, and many others came to rely on space systems as important parts of their national life. In aeronautics we enhanced the base established by the National Advisory Committee for Aeronautics and maintained during the 1960's, helping to sustain in concert with a vigorous private sector America's unparalleled role as world leader in civil and military aviation. The 1970's brought us painful lessons about our non-renewable energy resources. As this Committee knows, NASA has played a positive role in answering this challenge, exemplified by our developmental work in solar energy and by other activities where the fruits of our efforts in aeronautics and space have generated promising technologies applicable to problems of energy conservation and supply.

Where are we headed in the 1980's?

Every sign points to a decade of vigorous activity in both aeronautics and space. This activity will be international in character, highly sophisticated in its technology and rich in its contribution to scientific knowledge. It will be activity that has an important commercial dimension as the economics of space flight become increasingly attractive. Perhaps most importantly, the 1980's will be a decade when for the first time the life of almost everyone on earth will be made significantly better by our ability to apply our skills in space to problems here on earth.

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- In aeronautics, we expect a continuing strong demand for civil transport aircraft. In this decade, the free world market for new large transport aircraft has been estimated at over 5,000 aircraft representing a total investment approaching $200 billion. International competition is rising sharply, but United States' industry strengthened by NASA-supported research and technology programs should be able to continue to supply a major portion of this demand. Recent events underline the absolute need for the United States and our allies to maintain strong, second-to-none defense capabilities: this need will bring forth requirements for continued advances in space and aeronautics capabilities. We must make certain that NASA contributes, where and as appropriate, to our technological readiness to meet these challenges.

- Satellites have become the basic mode of international telecommunications. By the end of the 1980's, they will carry the major fraction of worldwide domestic as well as international traffic, and by the end of the century total demand is projected to grow tenfold. Demand for satellite manufacture and launch, as well as for ground terminals and redistribution systems will grow apace. Here NASA's R&D can point the way to the new generation of satellites essential for the 1990's.

- Through NOAA, the United States will establish the first operational earth resources remote sensing system building on the technology developed in NASA's Landsat project. This is the third major civil technological system transfer for which NASA has been responsible. The details of NASA's role in support of NOAA's initial system, and in creation of its successors, are being defined now. These developments, and the advent of their foreign analogues, portend another field of explosive growth ahead, both in the technologies of space systems and the techniques of information generation and dissemination.

- The Space Shuttle and Spacelab will make possible the beginnings of true industrial experimentation to expoit applications of materials processing in space for new and improved processes and products. Symbolic of this promise is the fact that in this first month of the 1980's, we have signed our first agreement for a cooperative manufacturing activity with a private company.

- Finally, in space science, words like "astounding" cannot adequately portray what has happened over the past twenty years in the revolutionary growth of the several bodies of knowledge that we group together under this heading. But if HEAO and Voyager amazed us last year, what will the

Space Telescope, Galileo, the Gamma Ray Observatory, Spacelab and other space science initiatives bring in the decade ahead? In my view, none of us can fully comprehend what the data products of these new, incredibly powerful tools will mean to human knowledge and to our societies here on Earth by the end of this century. Thus, I see the 1980's as a period during which our nation and the world will reap valuable scientific returns from the base so carefully built in the 1960's and 1970's, and build new tools for future returns.

- But the greatest rewards, many unforseen today, will be reaped from the seeds which are sown in the latter half of this decade as we begin to exploit fully the unique capabilities of the Space Shuttle. Already the Space Shuttle is fully booked into 1984 for advanced civil, defense, commercial, and international missions. The following years promise a period of exploration and achievement in space, made possible by applied research and technology--fields in which this country has always excelled. In concert with the aerospace community, universities, the commercial sector, and the international space community, NASA initiatives and expertise using the Space Shuttle as a focus will play a significant role. Moreover, by generating and transferring technology, NASA activities will continue to spur positive non-inflationary returns to our economy and to support a strong national defense.

Mr. Chairman, the President has proposed a NASA budget totalling $5.737 billion for FY 1981, and a fiscal year 1980 supplemental appropriation of $300 million for Space Shuttle development. Summary tables of key features of the budget are appended to my prepared statement. This budget, highlighted by major new starts in space science and in space applications, will preserve and build on NASA's basic strengths in a time of serious national economic stress and heightening international tensions. It reflects the Administration's commitment to a strong, multi-faceted space program in the 1980's. It supports the President's space policy goals of maintaining U.S. leadership in space science and applications as well as exploiting fully the capabilities of the Space Shuttle for all national objectives. With Congressional approval, this budget will support:

-- initial test flights of the Space Shuttle, culminating a decade-long, highly sophisticated design, development and test program;

-- a Shuttle orbiter production schedule that will meet critical civil and defense launch requirements;

-- continued emphasis on a broadly-based space science program, featuring:

  - o a new mission, the Gamma Ray Observatory (GRO), that will provide a major increase in our knowledge of the high energy universe, improving our knowledge of the positions of gamma ray sources like black holes by 50 to 100 times;

  - o development effort on the restructured 1984 Galileo mission, to capitalize on the superb performances of Voyagers I and II at Jupiter;

  - o continued work on the U.S. spacecraft for the 1983 U.S./Europe International Solar Polar dual spacecraft mission;

-- important emphasis on space applications, including:

  - o focus of our Landsat effort to support the President's recent decision on implementing a fully operational satellite-based land remote sensing system under Department of Commerce leadership;

  - o initiation of the National Oceanic Satellite System (NOSS), a tri-agency program that will demonstrate operational global sea surface observation capabilities from space. NOSS will bring space remote sensing capabilities to the oceans, complementing similar atmospheric and land capabilities;

  - o expanded communications satellite research and development studies and advanced technology for experimental wideband satellite communications; and,

  - o continuation of our support to the Department of Agriculture in the AgRISTARS effort to improve early warning and crop inventory forecasting;

-- advanced work on more efficient and effective aircraft, featuring:

- o a comprehensive research and technology base program;
- o continued progress in energy efficiency for the next generation of transport aircraft with a new emphasis in advanced turboprop technology;
- o vigorous flight test programs with the Tilt Rotor and Quiet Shorthaul Research Aircraft and the Highly Maneuverable Aircraft Technology Vehicle;
- o important new thrusts in technology for advanced rotorcraft;
- o emphasis on advanced variable cycle engine technology;
- o increased effort on technology to prolong the life of aircraft turbine engines;

-- continued application of NASA expertise to national energy problems.

Finally, the proposed budget for FY 1981 will support:

-- the critical in-house scientific, technical and administrative staffs and facilities necessary to assure successful national programs in aeronautics and space.

We have continued our advanced planning to define the most promising and useful technological paths we could pursue in the future. We are currently increasing our emphasis on long range planning beyond the five year look of recent years. In our planning we have involved not only our own staff members, but also the outside experts available to us through our advisory structure. One notable activity of the advisory structure during the past year was the Innovation Symposium last June. That symposium's success is to be followed up by a similar endeavor, the New Directions Symposium, in June of this year.

Before discussing each program in more detail, I would now like to ask Dr. Lovelace to review the highlights of the past year.

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Space Transportation Systems

We are requesting $300 million in supplemental FY 1980 appropriations, and $1.873 billion in FY 1981 for the Space Shuttle. In order to maintain our present Shuttle development and production schedules, and to stay within our current cost estimates, it is essential that the supplemental funds be available by June 1. Continued technical development problems, primarily in the areas of the Orbiter Thermal Protection System (TPS) and the main liquid-fueled engines, have been the principal contributors to the delay in the first manned orbital flight test (STS-1). The recent successful full duration firing of the three-engine Main Propulsion Test Article gives us increased confidence in the main engine system. As you know, another test is scheduled for tomorrow. We still have a great deal of TPS analysis, test and manufacturing to complete. I do not believe we can complete this work on Columbia until well into the summer. This would mean that launch is not likely to come much before the end of this year. Our budget, with a timely supplemental appropriation, will support first flight as late as the end of the first quarter of calendar year 1981.

As we discussed with the Chairman's Subcommittee last October, a series of reviews of the Shuttle program management has been completed and a number of actions have been implemented to strengthen and augment the program where necessary. As you know, I reviewed the entire program with the President last fall and was gratified to receive his endorsement and commitment to the Shuttle program as the cornerstone national resource for the whole spectrum of U.S. space objectives.

The organizational changes and other actions resulting from the management review of the Shuttle Program which I discussed with the Chairman's Subcommittee last fall are now essentially complete. We are nearing the end of the process of selecting an Associate Administrator for Space Transportation Operations from among a number of highly qualified candidates. The new organization has been established and is functioning under the able interim leadership of Glynn Lunney. We have made a number of organizational changes in the Space Transportation Systems Office and John Yardley had filled several of the resulting openings with strong people from within NASA and from industry. Organizational changes, additional people, and a heightened sensitivity to the need for greater visibility into program problems and outlook will considerably improve our understanding of program status. We have initiated regular, frequent coordination meetings with senior personnel

within the Executive Office and the Department of Defense in order to assure that they remain current with the program. Finally, we are making effective use of the counsel and advice of a considerable number of "outside" technical experts who are participating in a review of the entire flight certification program--one of the precursor activities to our determination that we are ready to fly.

Despite the delays, we have made major progress. All major first flight hardware has now been delivered to the launch site and the solid rocket motor segments have been stacked on the mobile launch platform in the Vehicle Assembly Building. The Orbital Structural Test Article Program has been completed and conversion of the test vehicle to the second flight orbiter, Challenger (OV-099), was begun in November. Main engine test time now exceeds 60,000 seconds and six solid rocket motor firings have been successfully conducted. Design certification review for the first flight has been completed, all launch facilities are in place and operational, and the launch processing system is on schedule to support the first flight.

Although development progress was substantial during 1979, it has not sustained the pace necessary to accomplish the FY 1980 budget plan. Technical problems, necessary program changes, the need for more work than was previously planned--particularly in the TPS for the first orbiter, and increased systems qualification and certification testing across all elements of the program--have contributed to program delays. This delay and additional work coupled with the growth in a number of the prime and subcontractor efforts along with the need to provide for the potential impact of necessary changes and systems modifications have resulted in our requirement for an additional $300 million, which the President has requested as a Supplemental Appropriation for FY 1980.

FY 1981 Design, Development, Test and Evaluation activities will focus on orbital flight testing of the entire system and main engine testing to achieve full power level performance. The budget request provides for completion of external tank and solid rocket booster deliveries to support the orbital flight tests, continued launch preparations, checkout and accomplishment of the orbital flight tests, and for continued engine testing leading to the uprated performance of 109 percent of the rated power level.

In Shuttle production, fabrication efforts on the Challenger orbiter will be nearly completed and work on Discovery (OV-103) and Atlantis (OV-104) will proceed in FY 1981 for delivery to support the Department of Defense and all other users at both Vandenberg Air Force Base and the Kennedy Space Center. Assuming early approval of the FY 1980 supplemental request, delivery schedules for these three orbiters remain as follows: Challenger-June, 1982; Discovery-September, 1983; and Atlantis-December, 1984. Engine fabrication for the production vehicles will continue and flight spares and ground support equipment will be procured. Additional launch processing equipment for the second line at Kennedy Space Center will be in the manufacturing stage during this time period.

This request also includes $10 million for continued studies for Shuttle thrust augmentation to meet planned payload requirements for flights from Vandenberg in the mid-1980's. Late last year the Liquid Boost Module concept was selected as the baseline approach. This approach, which embodies liquid-fueled engines attached to the base of the external tank, offers lower development risk, less severe ascent loading, and greater performance and growth potential.

The Space Flight Operations request of $809.5 million is significantly higher than the FY 1980 program. This reflects the growing activity as preparations continue for the early operational flights. In total, 36 operational flights have been manifested and the system is essentially fully scheduled into 1984. For those early users affected by delay in the Shuttle schedule, the transition plan has been expanded to provide for back-up flights on expendable launch vehicles, as necessary. A total of $55.7 million is included for expendable launch vehicles, a portion of which will be used to uprate the capability of the Delta 3910 launch vehicle, as we recently informed the Committee.

The request of $151.7 million for Spacelab includes $120.5 million in budget authority for the continued procurement of a second set of Spacelab hardware in accordance with our agreement with ESA.

Mr. Chairman, I urge your Committee to continue to give the Shuttle program, so vital to our Nation, your full support. I ask that you act as promptly as possible on the request for the FY 1980 supplemental appropriations, which are essential to maintain our production schedules and to minimize total program costs.

Space Science

A total of $668 million is requested for FY 1981 Space Science programs. This request includes funds for a proposed new start--the Gamma Ray Observatory (GRO)--and provides the necessary support for continued development of the Space Telescope, three Explorer missions, Galileo, the International Solar Polar Mission and experiments to be conducted on Spacelab. It will also continue mission operation and data analysis on current missions, such as the High Energy Astronomy Observatories, the International Sun-Earth Explorer, the International Ultraviolet Explorer, the Solar Maximum Mission, Pioneer Venus, Voyager and Viking.

The GRO mission is a giant step for astronomy. Gamma rays are produced by the explosive, high energy processes that power the universe. They are the most energetic form of electromagnetic radiation. The creation of the elements, the acceleration of electrons and protons in enormous magnetic fields, the collision of cosmic rays with light waves and dust particles, and the annihilation of matter and anti-matter are all processes that reveal their presence by emitting gamma rays. The sites and times of gamma ray production range from the chaos of the big bang beginning of our universe to the flares on our own sun. They are produced by exploding galaxies, quasars (the most distant known objects in the universe), supernovas, exploding stars in our own and in other galaxies; pulsars, black holes and the sources responsible for mysterious gamma ray bursts. The Gamma Ray Observatory's five large instruments will help us to understand these high energy processes through the first full-sky survey of gamma ray sources.

In visible light astronomy, the keystone of the next decade will be the Space Telescope for which we are requesting a total of $119.3 million in FY 1981. With a 1983 Shuttle launch planned, FY 1980 will be the year of peak design activity. Hardware fabrication, mission operations design, scientific instrument assembly and the beginning of qualification testing will occur in FY 1981.

As the Committee knows, we are planning to establish a Space Telescope Science Institute to manage operation of this permanent observatory in space. This institute will be a national facility for the receipt and evaluation of data from the Space Telescope. We have released a Request for Proposals and we expect to award a contract late this year.

Development activities will also continue in FY 1981 on three Explorer missions: the Solar Mesosphere Explorer (SME), the Dynamics Explorer (DE), and the Infrared Astronomical Satellite (IRAS). There are no major problems on the SME or the DE, and both are progressing well on a schedule leading to launches in 1981.

The IRAS has had to overcome a number of difficult technical problems related to the operation of the telescope system and its associated electronics at temperatures near absolute zero. Since IRAS, a mission with great scientific potential, continues to be a challenging project, we will maintain extremely close monitoring of its progress as we enter the system integration and test phase.

We are requesting $82.6 million in FY 1981 for continued development of the International Solar Polar Mission. This Mission is a joint project with the European Space Agency, and will provide a first look at the Sun's heliosphere from out of the ecliptic plane. The two ISPM spacecraft will be launched in 1983 and will simultaneously travel over opposite poles of the Sun, having first journeyed to Jupiter to use that giant planet's gravitational force to swing out from the ecliptic plane. Launch is scheduled for 1983.

Solar flares and related events will be the focus of the Solar Maximum Mission, which will be launched next month. The focus of this mission is the investigation of solar flares and related events, including the way in which solar flare particles impact our magnetosphere.

With flight crews and mission specialists soon to be in space, the Life Sciences Program looks forward to a continued focus on biomedical research, operational medicine, and advanced life support systems studies in FY 1981. Progress on Spacelab experiments is of major importance, and investigations have recently been selected for the first two Life Sciences missions.

As the Committee knows, the Galileo mission to Jupiter has been restructured. Instead of a single Shuttle launch in 1982, we will use the Shuttle Inertial Upper Stage for separate 1984 launches of the orbiter and probe. Concern over early Shuttle capability necessitated this change. This mission is a particularly important one to NASA's phased plan to explore our solar system, and we appreciate the strong support which Galileo has enjoyed from this Committee.

Scientific studies of the Jovian atmosphere dynamics, satellites, and magnetosphere are unchanged from the original Galileo mission plan. The orbiter should achieve eleven encounters with the Galilean satellites, mapping their surfaces far more completely than was possible with Voyager. In addition, during its twenty-month orbital tour, the orbiter will map the magnetosphere of Jupiter and obtain data on the dynamics of the Jovian atmosphere as originally planned.

The two Voyager spacecraft, which returned extraordinary images of Jupiter and the Galilean satellites in the spring and summer of 1979, are in good health as they travel on to Saturn for November 1980 and August 1981 encounters.

The Pioneer Venus spacecraft that has been in orbit around Venus for fourteen months also continues to return large quantities of excellent data.

Also operating beyond their design lifetimes are the two Viking landers and one orbiter. These spacecraft continue to send information from Mars, providing considerable insight into the seasonal changes and climate of that planet. A small team of scientists and engineers control the spacecraft, making the cost associated with this scientifically productive mission very modest.

In sum, the decade closed on an exhilerating period of rich scientific return from planetary missions which will be completed in the early eighties with two Voyager encounters with Saturn. Since it can take between five and ten years from the start of a project to the return of data, now is the time to be thoughtful and precise about future mission planning. An exciting and vigorous program can still be sustained, by capitalizing on our investment to date. If we affirm our strategy of exploration--that is, progressing systematically from a level of reconnaissance, through exploration, to detailed study of the bodies in our solar system, clear goals emerge. We look forward to this decade, with its rich potential. We continue to plan for future planetary exploration and for the enabling technology.

Space and Terrestrial Applications

A total of $394.8 million is requested in FY 1981 for Space and Terrestrial Applications programs. The increases over the FY 1980 budget level reflect provision for initial

steps toward an operational land observing system, important new thrusts in communications technology and materials processing research; and a major new initiative, the National Oceanic Satellite System.

Of the total request, $162.3 million will be applied to Resource Observations Programs, with emphasis on agricultural research and exploitation of Landsat capabilities.

Last November, in a key policy decision resulting from Administration review of civilian space policy begun in 1978, the President announced the designation of the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) to manage all operational civilian remote sensing activities from space. This decision reflects a confirmation of this Nation's commitment to continuity of remote sensing data through the 1980's, and this year constitutes a hallmark in the progress of remote sensing technology from NASA's role in research and development to NOAA's role as operator of an ongoing system. In accordance with the President's decision, an Interim Policy Group chaired by NOAA has been formed with representatives from NASA, the Departments of Defense, Interior, Agriculture, State, Transportation and Energy, the Central Intelligence Agency, the Agency for International Development (AID), the Environmental Protection Agency, OMB and the Office of Science and Technology Policy. This Interim Policy Group will provide the Federal coordination required for the formulation of an implementation plan for the operational system, which will be presented to OMB this June. The plan will establish what services will be provided, will outline a time-phased transition for a fully operational system, and will establish a Program Board for continued coordination, chaired by the Department of Commerce, with representatives from the Interim Policy Group. Participation by private sector and state government interests will be solicited as applicable.

Initially, operational remote sensing efforts will be based on experience gained over the years from the Landsat program begun by NASA in 1972. NOAA will make the final determination of the characteristics of the operational system. The Interim Policy Group is currently addressing steps which may be necessary to insure Landsat data continuity into the 1980's, and any required FY 1981 budget adjustments for the transition to operational capability.

Among the ongoing systems development and operations activities planned for Resource Observations programs, the Multispectral Scanner (MSS) and Thematic Mapper (TM) for Landsat D are scheduled to be completed during FY 1981.

Major integration activities associated with Landsat D will be accomplished, as well as completion and checkout of the total ground system, leading to a launch of Landsat D in FY 1982.

The Agricultural and Resource Inventory Survey Through Aerospace Remote Sensing (AgRISTARS) initiative, begun last year, is progressing well. This joint effort, with participation by the Departments of Agriculture, Commerce and Interior, and NASA, utilizes remote sensing data, together with other data sources, to improve timeliness and objectivity of information on world crop conditions and anticipated production. AgRISTARS will also provide a research base allowing for integration of improved remote sensing technology into existing or future information systems. FY 1981 NASA funding for AgRISTARS will be directed primarily toward commodity production forecasting and supporting research, addressing high priority requirements for Department of Agriculture initiatives.

During FY 1981, Resource Observations funding also will support continued expansion of geodynamics activities, including crustal dynamics measurements of regional deformation in Western North America and extension of measurements to areas of the Carribbean. Cooperative agreements with the U.S. Geological Survey, National Science Foundation, and the National Geodetic Survey, are nearing confirmation, leading to joint efforts in monitoring motion and internal stability of several major tectonic plates, determination of crustal deformation in seismically active areas, and improved modeling techniques.

In the area of Environmental Observations, a total of $137.6 million is requested. The major new initiative is the National Oceanic Satellite System (NOSS), jointly funded with NOAA and DOD. NOSS will provide an operational demonstration of global sea surface observation through a two-satellite system, launched and retrievable by Shuttle. The NOSS demonstration will be driven by the criticality of the ground segment, so that data may be provided from space to users in near real time and under varying weather conditions. Parameters measured will include surface wind and direction, ocean surface temperature, wave characteristics, ice dynamics and speed and direction of surface currents. NOAA and DOD will utilize this data, processed through a single ground distribution center, to provide forecast and ocean state information to civilian and military end users. While NASA will be responsible for overall development of the NOSS system, NOAA and DOD will be responsible for operations, and have included funding in their FY 1981 budgets for spacecraft development and ground systems operations.

Climate research, emphasizing applications of space observations of environmental variables to improve understanding of climate influence and trends, will continue in FY 1981. Notably, development will proceed on the Earth Radiation Budget Experiment (ERBE). ERBE, with the first of three spacecraft to be launched in 1983, will develop a global system for measuring incoming solar radiation, as well as outgoing reflected and emitted radiation, aiming toward improved understanding of climate change.

Consistent with the President's space policy, articulated in October 1978, and last year's initial re-entry into selected areas of communications research and development, our FY 1981 request includes $10 million for advanced technology development and definition studies addressing long-term, high-risk initiatives in multi-beam antennas, onboard switching systems, and components. Such definition studies may lead to an experimental wideband communications satellite to operate at the 30/20 GHz spectrum. These advanced state-of-the-art efforts are vital if the U.S. is to maintain, during the 1990's the technology leadership we enjoy today in world space communications research and development.

In Materials Processing, work will continue during FY 1981 in Shuttle/Spacelab payload development, as will research and technology development activities, definition studies, and efforts toward commercialization. As you are aware from previous testimony before this Committee, NASA has instituted a new and innovative program effort to stimulate commercialization of materials processing in space through joint endeavors with private industry. As I mentioned earlier, we have just concluded our first agreement for a joint endeavor--with the McDonnell Douglas Company--a significant step in pioneering new techniques for utilization of government and industry resources to commercialize processes or products that might not otherwise be introduced to the marketplace. In this joint endeavor, McDonnell Douglas will develop electrophoretic separation systems to process biological materials in space, while NASA will furnish flight time and related services on Shuttle missions. We are currently negotiating two other joint endeavors.

In the area of Technology Utilization, a total of $13.1 million is requested, a slight increase over the FY 1980 budget level. Development of bioengineering applications for internal and external medicine is a notable highlight of this year's planning. One example is the improved use of ultrasound, derived from SEASAT's high-speed digital recording and synthetic aperture radar, which is projected as a source for more accurate diagnosis of eye afflictions, including retinal abnormalities and both malignant and benign eye tumors. Such improved diagnostic techniques could benefit thousands of patients annually by eliminating surgery or suggesting more meaningful medical treatment.

Aeronautics and Space Technology

In Aeronautics, our FY 1981 budget request is $290.3 million. Overall, this represents a reduction from the FY 1980 level, reflecting our progress past the peak funding requirement in the Aircraft Energy Efficiency (ACEE) program and a gradual buildup in subsequent new activities. Our primary emphasis will be on strengthening the technology base, continuing the ACEE program and related energy-efficiency research, and expanding our technology efforts related to recognized needs in the major vehicle classes.

Flight research vehicles which recently became operational will be vigorously utilized to explore their unique technology features. The Quiet Short-Haul Research Aircraft will be flown to provide design and airworthiness criteria data. Proof-of-concept flight testing and documentation of the Tilt Rotor Research Aircraft and the Highly Maneuverable Aircraft Technology (HiMAT) remotely-piloted vehicle will be aggressively pursued.

A strong generic research and technology base has been the foundation of this country's leadership in aviation. In order to maintain military preparedness and to meet the ever-increasing challenge of civil competition from abroad, we must invest in the disciplinary areas of materials, structures, propulsion, avionics, and aerodynamics, upon which advanced aircraft will be developed. Our FY 1981 request includes a ten percent increase in the aeronautics R&T base budget.

The ACEE program, which is still our largest single effort, is progressing very satisfactorily toward its goals of major reductions in fuel requirements for transport aircraft.

New transports now in development already feature innovations based on early ACEE technology, and research on more ambitious advances is producing promising results. In FY 1981 highlights will include full-scale testing of energy efficient engine components, flight testing on nacelle loads, DC-10 winglets, and medium-sized composite primary structures, and final preparation for laminar-flow-control flight research.

Two important enhancements are proposed which build upon augmentations by Congress in the FY 1980 budget--variable cycle engine and rotorcraft technologies. Variable cycle effort will focus on variable-flow component and exhaust nozzle system technology for improved efficiency and reduced noise. Rotorcraft emphasis areas will include systematic small and large-scale advanced rotor research, all-weather guidance and navigation, and airframe dynamic modeling.

Two additional significant enhancements include a second phase of advanced turboprop systems, to evaluate at large scale the structural characteristics of an advanced high-speed propeller concept, and new research on the hot sections of aircraft turbine engines.

The FY 1981 budget request for Space Research and Technology is $113 million. This essentially level budget will continue to provide the funding for advanced research and development to enhance planned missions and enable identification of candidate mission concepts. This critical investment in technology provides a basis for options in future planning of beneficial, cost-effective space missions. The planned program includes funds for the disciplinary technologies of structures, materials, propulsion, power, and electronics as well as interdisciplinary systems technologies for spacecraft, information and transportation. Emphasis will continue on communications and data management technologies to enable more efficient transmission and conversion of space-derived data into useful information. Technology for future large space structures will be emphasized to serve the expected growth of multi-function, space-based systems. The first flight of the Shuttle will provide the mechanism for a rapid expansion of our knowledge in hypersonic aerodynamics and flight mechanics using special instrumentation developed in our space technology program; this knowledge will have implications not only for the design of future launch and entry vehicles but also for the current Shuttle system.

For FY 1981, $4 million, an increase of $1 million over last year's budget is proposed to support the identification of technology developed in our space and aeronautics programs that has application to national energy problems. This technology identification activity leads directly to research and development projects that become important elements of the programs of the Department of Energy (DOE). As a result NASA is managing this year over $250 million in energy projects for DOE and other agencies. Alternative energy technologies for such diverse applications as wind turbines, photovoltaics, automobile engines, energy storage, and coal mining, cleaning, combustion and conversion are being developed successfully. In addition, we are proceeding on schedule with DOE to provide recommendations this summer on the future course of Satellite Power Systems (SPS) activities.

Space Tracking and Data Systems

A total of $359 million is requested for continuation of tracking and data acquisition support for earth-orbital spacecraft, planetary missions, sounding rockets, and research aircraft. An average of about 40 earth-orbital applications and scientific spacecraft will be supported during this period. The Deep Space Network efforts will be highlighted during the encounters of Voyager 1 and 2 with Saturn, both occurring in FY 1981.

Contractor development of the Tracking and Data Relay Satellite System (TDRSS) continues on a schedule consistent with launch of the first satellite onboard the first operational flight of the Shuttle.

Late last year we announced our plans to consolidate our tracking networks once TDRSS is fully operational in 1982. Consistent with our prior planning and the greatly expanded coverage available through TDRSS, we will close stations in Hawaii; Guam; Quito, Equador; Santiago, Chile; and on Ascension Island. The Rosman, NC, facility which had been supporting the Applications Technology Satellite-6, will be closed in January, 1981. We will also terminate our operations at the Winkfield, England station during the current year.

Since the Spaceflight Tracking and Data Network capabilities needed at Goldstone, Australia, and Spain are similar to those required for the Deep Space Network stations at the same locations, we will be combining the capabilities at each station to achieve more efficient use of the facilities, and to save operations costs. The facilities at Goldstone,

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Australia and Spain will be consolidated into a single network under the management of NASA's Jet Propulsion Laboratory.

The third General World Administrative Radio Conference (GWARC) took place last fall. The long range impact of decisions made at the GWARC is significant to the space program, and several years of preparation were involved in the effort to develop U.S. position papers, negotiation strategies, and proposals. From the standpoint of major NASA interests--space research, earth exploration, and applications frequencies--the conference was highly successful.

International Activities

In the International area, the 1980's offer the promise of additional opportunities for beneficial space cooperation with other countries. Many of the countries which entered space activities in the 1960's and 1970's have maturing capabilities and interests which continue to make them attractive potential partners on major projects--such as in planetary exploration--projects which might not otherwise be possible for NASA to fund. Moreover, developing countries which took limited notice of space a decade ago are increasingly interested and are seeking opportunities to participate in and share the benefits of space activity.

There is significant international involvement in a number of the major projects I have mentioned. The European Space Agency is an active partner in or contributor to the Space Transportation System with Spacelab, the International Solar-Polar Mission, Space Telescope and the International Ultraviolet Explorer. The German Federal Republic is providing an important element of the Galileo orbiter and the Netherlands and UK are contributing the spacecraft and ground support system respectively to the Infrared Astronomical Satellite (IRAS). International interest in the proposed Gamma Ray Observatory is high and I would expect that prospects for fruitful cooperation will emerge here as well.

Many countries are now involved in satellite remote sensing activities. During the past decade, nine Landsat receiving stations have been established in eight foreign countries. A number of other countries are currently planning their own Landsat stations, I have just returned from China where we concluded a Landsat Memorandum of Understanding; the Chinese are to begin procurement of a Landsat D ground station from U.S. industry in the near future.

By the mid-1980's, more than 15 foreign funded ground stations may be receiving and distributing Landsat data around the world. In addition, users in more than 100 countries have purchased and used Landsat data for research and assistance in development planning. On the space segment side, France is building a Landsat-type satellite scheduled to fly in 1984 and Japan, ESA and India are in various stages of planning for the development of remote sensing satellites. The U.S. is currently undertaking bilateral discussions with these countries in an attempt to determine the possibilities for compatibility and complementarity among nationally operated satellite systems. Selective cooperative activities in the remote sensing area will continue to be considered where there appear to be equitable gains for the U.S. as well as the cooperating partners.

It is clear that we are seeing steady growth in foreign government investment in space activities and there is every reason to expect this trend will continue through the 1980's. In some instances this will result in increased competition. For example, last month ESA successfully tested the Ariane vehicle (Atlas-Centaur class), Japan is developing advanced versions of the N Vehicle (Delta class) and India last Summer fired with partial success its initial SLV-3 (Scout class). I believe such competitive challenges to U.S. leadership are predictable and natural outcomes of the growing experience and interest with space around the world. They are a reminder that to stay ahead we need to maintain a vigorous program.

Construction of Facilities

For Construction of Facilities we are requesting a total of $120 million, a decrease of some $37.6 million from the amount requested in FY 1980. No single project is predominant in this request which is comprised of a number of smaller though vitally necessary efforts. Slightly over $10 million is requested for Shuttle-unique projects at various locations including continued modification of facilities at the Michoud Assembly Facility in New Orleans for external tank production and modifications to the solid rocket motor manufacturing facilities at the contractor's plant in Brigham City, Utah. Also included is $15 million for "Repair of Facilities" not in excess of $500 thousand per project. This category, new last year, is for projects to prolong the life of existing facilities and return them to their original capacity and design purpose.

Funding for the National Transonic Facility at the Langley Research Center and the modifications to the 40 x 80 foot Subsonic Wind Tunnel at the Ames Research Center were completed in FY 1980. I am pleased to report that both projects, which will become invaluable national aeronautical test facilities, are within cost and on schedule for operational capability in FY 1982.

Research and Program Management

Over the years, Mr. Chairman, your Committee has steadfastly supported our request for Research and Program Management (R&PM) funds. The performance of research, technology and test activities at NASA Centers, and the planning, management and support of contractor research and development activities necessary to meet the Nation's objectives in space and aeronautics research are covered by these funds.

The civil service personnel funded by this line item represent NASA's most important resources and are the strength on which our world leadership in space and aeronautics depends. Three-fourths of this appropriation is required for their salaries and related costs. About two percent is for travel which is vital to the management of our R&D programs. The balance is for facility support and related goods and services. Our request for FY 1981 is $1,047.2 million.

The FY 1981 R&PM budget request is austere and represents the funding to provide adequately for the necessary costs of our centers and people. There is one area, however, where the funding availability is a source of continuing problems. That area is travel. Our request last year was tight, and the government-wide reduction in travel, which for NASA amounts to an eight percent reduction in the current fiscal year, is causing us difficulties in maintaining adequate levels of support to the NASA R&D programs which are carried out at NASA centers across the country. The FY 1981 request for travel is not significantly above what we requested a year ago and represents the bare minimum necessary to oversee our obligations.

On a more positive note, FY 1981 represents the first time in over ten years where we are projecting requirements for an increase in civil service staff. The budget is based on a planned increase of 150 people above the level we presented a year ago. Fifty positions will be added in 1980 and another hundred in 1981. The bulk of the positions, 125, are in direct support of the Space Shuttle at the Kennedy and Johnson Space Centers and at Headquarters. They will be

used to augment the program control and management function, and to provide key technical augmentations in a number of critical areas. The other 25 positions are for the Office of the NASA Inspector General and will, along with positions reassigned from other functions, bring the Office to a staffing level adequate to do the job envisioned in the Inspector General Act of 1978.

During FY 1979 NASA continued to make equal opportunity progress in the hiring and promotion of minorities and women in most occupational groups and grade levels. Despite a declining workforce, minorities in our workforce increased to 2,187 (9.7%), and women to 4,438 (19.6%). The small resource pool of minority and female engineers and scientists, as well as the more attractive salaries offered by industry, continue to be the major barriers to more rapid progress. Nevertheless NASA has set aggressive goals for itself, and the agency is involved in numerous outreach efforts to encourage young women and minorities to choose careers in science and engineering.

Summary

In conclusion, Mr. Chairman, this budget request taken with the request for Shuttle supplemental funding in FY 1980 represents a continuing strong Administration commitment to completion of the Shuttle development program and timely delivery of production orbiters to meet critical civil and military needs. It provides for vital new starts in Space Science and Applications while continuing ambitious ongoing programs in physics and astronomy, planetary exploration, resource and environmental observations, and aeronautics and space technology. Finally, it provides for the NASA in-house expertise and facilities necessary to conduct these programs.

While I have touched upon only the highlights of the President's request, I would be happy to attempt to answer any questions the Committee may have.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

BUDGET PLAN	FY 1979	FY 1980	FY 1981
Research and development.....	3,477,200	4,107,500[a/]	4,569,500
Construction of facilities...	147,500	156,100	120,000
Research and program management.....	933,808	1,006,186[b/]	1,047,154
TOTAL BUDGET PLAN.....	4,558,508	5,269,786	5,736,654
OUTLAYS.....	4,196,472	5,012,600	5,439,700

a/ Includes proposed supplemental of $300,000,000 for the Space Shuttle.

b/ Includes proposed supplemental of $46,286,000 to cover revised salary rates implemented in October 1979.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT PROGRAMS

BUDGET PLAN
(Thousands of Dollars)

Cognizant Office and Program	FY 1979	FY 1980	FY 1981
SPACE TRANSPORTATION SYSTEMS	2,011,600	2,403,300	2,738,200
Space Shuttle	1,638,300	1,886,000[a/]	1,873,000
Space flight operations	299,700	446,600	809,500
Expendable launch vehicles	73,600	70,700	55,700
SPACE SCIENCE	505,400	600,800	668,000
Physics and astronomy	282,900	337,100	438,700
Planetary exploration	182,400	219,900	179,600
Life sciences	40,100	43,800	49,700
SPACE AND TERRESTRIAL APPLICATIONS	283,900	343,900	394,800
Space applications	274,800	331,800	381,700
Technology utilization	9,100	12,100	13,100
AERONAUTICS AND SPACE TECHNOLOGY	376,400	427,100	409,500
Aeronautical research and technology	264,100	308,300	290,300
Space research and technology	107,300	115,800	115,200
Energy technology	5,000	3,000	4,000
SPACE TRACKING AND DATA SYSTEMS	2[illegible],900	332,400	359,000
TOTAL	3,477,200	4,107,500	4,569,500

a/ Includes proposed supplemental of $300,000,000 for the Space Shuttle.

RESPONSES TO GENERAL QUESTIONS SUBMITTED BY THE MAJORITY DURING THE JANUARY 29, 1980, POSTURE HEARING BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY TO DR. FROSCH.

QUESTION A-1:

Dr. Frosch, does the NASA FY 1981 budget request fully support the President's stated policy of maintaining this Nation's leadership in space activities.

ANSWER A-1:

The FY 1981 budget request for NASA supports the President's policy of maintaining the Nation's leadership in space activities. The FY 1981 budget request together with the requested FY 1980 supplemental appropriation strongly supports completion of development and flight testing of the Space Shuttle and production of follow-on orbiter vehicles on a schedule consistent with both civil and national security needs. At the same time, the budget request supports objectives of leadership in space science and exploration of the solar system and in practical applications of space capabilities.

In space science and exploration, most of the funds are requested for ongoing projects that will make major contributions to this Nation's leadership in space. For example: the Galileo mission to Jupiter planned for launch in 1984 will result in data on the dynamics of the Jovian atmosphere, satellites, and magnetosphere that are now unobtainable; the Space Telescope will provide a capability in astronomy far superior to any that now exists; and the International Solar Polar Mission will investigate previously unobserved regions of the Sun. The budget request also includes initial funding for a new mission, the Gamma Ray Observatory, which will provide a major increase in our knowledge of the high energy universe.

In space applications, the previously approved flight projects to provide and demonstrate new and expanded capabilities in land and atmospheric observations, in materials processing and search and rescue will be continued and important new efforts will be undertaken. The budget request includes funding for continuation of Landsat D development and for initial steps toward an operational land sensing satellite system to be operated by the National Oceanic and Atmospheric Administration. The budget provides an important new thrust in communications technology for future wideband communications satellites to operate in the newly allocated portion of the spectrum. A major initiative is the National Oceanic Satellite System to be undertaken jointly with the National Oceanic and Atmospheric Administration and Department of Defense to demonstrate an operational satellite system for ocean observations.

The FY 1981 budget request also provides for the basic and applied research activities essential to future capabilities and leadership in space.

In summary, this budget request reflects a commitment to a strong, multi-faceted pro-ram which fully supports the maintenance of United States leadership in space activities.

QUESTION A-2:

Dr. Frosch, for the first time since 1964 and beginning in 1982, we will have a gap of several years during which no images will be returned from planetary spacecraft. Are you concerned with maintaining a viable planetary exploration technology base under these circumstances?

ANSWER A-2:

Yes, there is a serious concern with maintaining a viable planetary exploration program; and we, therefore, consider that a new start for a planetary mission and also for the development of the Solar Electric Propulsion System (SEPS) must be given high priority in our next budget submission. Galileo, which was approved by Congress as a FY 1978 new start, is the only planetary mission presently under development. High priority candidate new start planetary missions are the Venus Orbiting Imaging Radar (VOIR) mission and a Comet mission. A new start for a planetary mission in FY 1982 will allow us to maintain the remarkable technology base which has been built up so successfully and so painstakingly over the last two decades. A new start for SEPS in the near future will provide the technology base for a viable planetary exploration program until the end of the century.

The Solar Electric Propulsion System will provide transportation to geosynchronous orbit, make possible rendezvous missions to comets and asteroids and enable orbital missions to the planets beyond Jupiter. Moreover, the availability of SEPS will provide a large measure of independence from the launch year constraints that have tended in the past to "drive" the order in which we have undertaken planetary missions.

QUESTION A-3:

Your statement appears to indicate that the first flight of the Space Shuttle is not likely to occur until sometime in FY 1981. Are you confident that the FY 1980 supplemental request contains adequate reserves to accomplish the first flight, and to maintain the production orbiter delivery schedule?

ANSWER A-3:

The FY 1980 supplemental and the FY 1981 budget requests are predicated on achieving the first launch of the Space Shuttle before the end of the first quarter of FY 1981. We are confident that there are adequate reserves, barring major unforeseen problems, to accomplish this schedule, and at the same time maintain the production orbiter delivery schedule.

QUESTION A-4:

When does NASA need approval of the FY 1980 Supplemental request?

ANSWER A-4:

In order to hold current schedules, the Space Shuttle program is proceeding as if the FY 1980 Supplemental were available. To support the schedules, the supplemental funding is urgently required by June 1, 1980. The FY 1981 Budget request is also based on receiving these funds in a timely manner.

QUESTION A-5:

What are NASA's contingency plans if approval of the supplemental is delayed beyond June 1, 1980?

If you reallocate production funds will this result in a slip of the Production Orbiter schedules?

ANSWER A-5:

The Shuttle DDT&E and production activities are currently proceeding at a pace which assumes timely availability of the requested supplemental funding. This pace of activity is directed toward achieving the development, test and follow-on orbiter production schedules outlined in the FY 1981 budget request. Approval of the supplemental funding is required by June 1, 1980, to sustain this pace of activity. In the absence of approval of the supplemental funds by June 1, it would be necessary to begin a severe curtailment of both the DDT&E and production activities. The most prudent approach would be to follow as nearly as possible the planned development activities leading toward first orbital flight, even though this action would result in a more severe impact on production activities. The degree of the cut back and disruption of the program activities would depend on the extent of the delay in approval of the supplemental funding. Any appreciable delay would force major adjustments in development and test activities as well as production. If the supplemental were delayed until near the end of FY 1980 there would be significant delays in the first orbital flight and follow-on orbiter deliveries, and reductions in employment on the Shuttle program would exceed 20,000.

QUESTION A-6:

Dr. Frosch, could you list the new start candidates which NASA requested from OMB and elaborate on the rationale for establishing the priority among these candidate new starts?

ANSWER A-6:

Priorities are developed for new starts through a series of judgments on the required timing and the potential contribution of each proposed initiative to the objectives of the national aeronautics and space programs. Specific new start proposals need to be considered enhancements of currently approved programs. Key considerations in this process include:

- related activities in progress or proposed in the program area involved;
- specific objectives and requirements for the proposed new initiative;
- the potential benefits of the new initiative;
- the estimated cost of the new initiative;
- the technical readiness of the new initiative and the confidence with which it can be undertaken.

In the final analysis, judgments have to be made and a priority list established. A list of the new start flight projects included in the NASA recommendation to OMB in priority order follows:

Gamma Ray Observatory (GRO) to conduct a comprehensive all-sky survey in low, medium and high energy gamma rays; to locate and study gamma ray burst sources; to measure the spectrum and anisotrophy of the diffuse galactic and extragalactic radiation in the gamma ray energy range; to search for direct evidence for the synthesis of the chemical elements in astrophysical environments; and to study the high energy astrophysical processes occurring in objects such as black holes, neutron stars, and supernovae.

Solar Electric Propulsion System (SEPS) to provide a new propulsion capability for solar system exploration, geosynchronous orbit missions and other high energy missions. The SEPS is a highly flexible system capable of performing missions that require high energy and/or extended operations. The SEPS would provide propulsion and performance to meet future missions needs beyond the capability of present systems.

National Oceanic Satellite System (NOSS) a joint program with Departments of Defense and Commerce, to

demonstrate an operational ocean monitoring satellite system capability which would meet the needs of both the military and civil sectors. The availability of global ocean conditions data on a timely basis would improve the efficiency, safety and cost of ship operations, transportation, off-shore oil and gas exploration and drilling, marine construction, commercial fishing, pollution monitoring, ice monitoring, and marine search and rescue.

Upper Atmospheric Research Satellites (UARS) to provide global data on the upper atmosphere and its response to perturbations. UARS would provide the first simultaneous, comprehensive investigations of the global energetics, chemical composition, and dynamics of the Earth's stratosphere, mesosphere, and lower thermosphere. Only such simultaneous measurements can give insight into the many processes important in the maintenance/destruction of the stratospheric ozone shield; the internal heating and cooling within the upper atmosphere; and the mechanisms for coupling of solar radiation, photochemistry and dynamics.

Power Extension Package (PEP) to provide longer duration and high power capability to sortie mission support for the space transportation system. The PEP would more than double both the power available and the mission duration capability for users of the Space Shuttle throughout the full range of operational inclinations. The STS payload manifesting would be substantially improved by the combinations of power and duration afforded by the PEP.

Venus Orbiting Imaging Radar (VOIR) to provide the global characteristics of the planet Venus, including a determination as to the existence of such phenomena as volcanoes, mountains, and plate tectonics. This information is available for all the terrestrial planets except Venus. For each major planet, studies to date show radically different surface characteristics. Venus would complete the data set on the inner planets.

QUESTION A-7:

Reports in the press indicate that NASA appealed to the President, the decision to eliminate funds for development of the Solar Electric Propulsion System. I further understand that this upper stage would be required to perform a Halley flyby/Tempel 2 rendezvous mission in 1985.

a) Are we now in a position that we must forego the Halley comet mission ?

b) What are the benefits of a combined Halley/Tempel 2 mission when compared with separate missions for each?

c) In addition to the comet missions, what are the other mission requirements, if any, for the Solar Electric

Propulsion System?

ANSWER A-7:

a) A Halley Intercept Mission can be effected ballistically. Solar electric propulsion is not required for this ballistic intercept. The mission proposed by NASA involving a Halley Flyby followed by a Tempel 2 rendezvous, with the same spacecraft, however, is foreclosed without the Solar Electric Propulsion System.

b) The Halley Flyby/Tempel 2 rendezvous mission originally proposed was the lowest cost mission to achieve a rendezvous with a short-period comet, as well as to compare two comets in different evolutionary states. The rendezvous can be performed at a later date with a separate launch, but at an increased cost. Aside from this issue, the objectives of the Halley Flyby/Tempel 2 rendezvous mission can be achieved by separate missions to Halley and to a short-period comet.

c) Solar electric propulsion is mandatory for the exploration of asteroids, as well as for the comet rendezvous. Solar electric propulsion provides the ability to visit the outer planets at each launch opportunity with adequate payload margins and with reasonable trip times. However, in addition to the capability of SEPS to fulfill planetary exploration requirements, solar electric propulsion has the capability to deliver extremely large payloads to geosynchronous altitude due to the unique characteristics of low-thrust propulsion in the ability to trade payload delivery capability with trip time.

QUESTION A-8:

Have the deliberations at the World Administrative Radio Conference (WARC) changed in any way the focus of the NASA space communications technology program?

ANSWER A-8:

The results of the WARC have served to sharpen the focus and reemphasize the importance of NASA's communications program. From NASA's perspective, the WARC results were very favorable. The additional allocations at C- and Ku-band have given us the added time necessary to bring new technology on line to relieve the impending saturation of the electromagnetic spectrum and geostationary arc. Our earlier projections of the onset of saturation varied between 1987 and 1992, a time that is essentially here, because of the length of time needed to develop, test, and implement new technology. Our assessment of the effect of added allocations obtained at the WARC is the shifting of that onset to the period from 1990 to 1995. Further, prior to the WARC we were very concerned about the lack of a frequency allocation for satellite-aided mobile communications. Such communications have important roles in extending the terrestrial systems out into

rural areas, and in many emergency situations. Through our efforts, an allocation has been made available in the UHF, between 806 and 890 MHz, which now makes these services possible. Our advanced studies program will be investigating such systems in the future.

QUESTION A-9:

Dr. Frosch, when compared to the October testimony your statement alludes to a launch date slippage of several months for the first Shuttle flight. Does this also imply a slippage in the delivery of the Production Orbiters?

ANSWER A-9:

The technical problems that have caused a delay in the schedule for the first Space Shuttle launch from our estimate in the October testimony, have not required any change in the delivery schedule of production orbiters.

QUESTION A-10:

a) Dr. Frosch, when do you now expect resolution of a firm schedule for completion of the TPS tile structural certification activities?

b) Dr. Frosch, could you briefly elaborate on the tile situation and explain where we have been and where we are going?

c) Are we adequately bringing to bear the total resources of the agency (including Ames and Langley) on this problem?

ANSWER A-10;

a) Special management attention has been focused on the structural problems associated with the TPS tile. A new plan should be defined and in effect by the end of February.

b) It should be pointed out that the Thermal Protection System was identified from the outset as one of the most difficult development problems in the Space Shuttle Program. It required the development of a new type of material which would be capable of insulating against extremely high temperatures and withstanding high acoustic loads and large thermal gradients, be reusable for 100 mission cycles, yet be light enough to make the Space Shuttle feasible. We have essentially met the criteria.

To meet the schedule for the Shuttle system, it was necessary to pursue concurrently the engineering analysis with the development, testing and manufacturing of the Thermal Protection System. Installation of tiles was initiated on OV-102 using preliminary

load estimates, knowing that as refined loads data become available from wind tunnel and structural tests, some changes might be required.

After a large fraction of the total number of tiles was installed, a weakness of the insulation system was discovered in laboratory tests. It was found that the nylon felt pad interposed between the tile and the structure to isolate the tile from the airframe strains would not allow the tile to develop its full strength. Under load conditions, stress risers in the felt pad caused local tile strengths to be exceeded thereby initiating failure in the bond joint of the tile and rendering an unknown fraction of the installed tiles to be unsatisfactory for flight.

It was therefore decided to move out on several parallel actions:

1) the installed tiles on OV-102 are being pull-proof tested to 1.25 times the maximum expected flight loads, 2) a concentrated effort was started to develop a method for strengthening the bond surface of those tiles which failed the pull-proof test and those not yet installed, 3) a method was developed to assure a satisfactory safety factor for those tiles which could not be proof tested on the vehicle, 4) an independent group of experts was convened to review the actions taken and to make certain that the failure mode was fully understood. Where refined loads data indicated a need for redesigning tiles to increase the safety factor, we have substituted denser tile material or changed tile shapes.

In addition, a large number of TPS test articles are in preparation or in test as part of the TPS certification to be completed by July 1980. The Palmdale facility has been placed on three shifts to supply necessary tiles for this program. With the engineering now underway, the test program proceeding, and the tiles being proof tested, we are confident that the TPS will be a safe and reliable system.

c) The research centers have been supporting the manned space flight centers in the TPS development since the inception of Phase A studies and supporting technology since 1969. Large arc-jet facilities and wind tunnels have been crucial in this program. Ames has developed coatings for the tiles as well as complete tile systems with superior strength. The Ames and Langley Research Centers are currently participating in an engineering team to assure that everything that can be done is being done to assure adequate margins as well as helping assess alternative approaches for later vehicles.

QUESTION A-11:

a) What is the current status of the development of a new material for the Thermal protection system?

b) Is Ames Research Center fully involved in the evaluation of this new material?

ANSWER A-11:

a) Ames Research Center has developed an improved tile using a blend of fibers used in the existing design and a product of Minnesota Mining and Manufacturing. This product is an alumina-boro-silicate. The boria acts as a flux during firing, resulting in a much stronger material and potentially lighter material. However, testing on the new material shows that it has a higher thermal conductivity than the present material. Until the thermal properties are resolved we will continue to use the present tile material.

   Ames has also developed a flexible material for lower temperature applications, thereby eliminating a large part of the tiles on the lee side of the vehicle. But it must be completely characterized (properties measured) before it can be used on the production vehicles.

b) Yes. Ames is fully involved in the evaluation of this new material and in fact, did the initial development.

QUESTION A-12:

Dr. Frosch, in your statement you mentioned a New Directions Symposium scheduled for June of this year.

a) What are the objectives of this symposium?

b) What do you expect to be the product of this Symposium?

ANSWER A-12:

a) The objectives of this symposium, organized by the NASA Advisory Council, are:

   1) To identify and explore new and provocative ideas for the future space program, with particular emphasis on the Human Role in Space, Life Sciences, Applications, and Solar Physics and Solar Terrestrial Relations, all subjects not treated in a recent similar symposium. The opportunity to introduce other topics will be held open, also.

   2) To do a first-order feasibility analysis of these ideas to determine their merits and prospects, and recommend actions for NASA to take for further examination.

b) The ideas generated at the symposium will be examined by the NASA Advisory Council and forwarded to NASA in the form of recommendations for further study. NASA may decide to do additional research on some of the ideas, set others aside for future consideration, and incorporate some into the next version of the NASA five-year plan, depending upon ultimate promise, technical feasibility, and other factors.

QUESTION A-13:

Dr. Frosch, during the past year we have made considerable progress in establishing institutional mechanisms to manage Landsat and ocean satellites. What progress is being made in other Earth Science areas such as geodynamics?

ANSWER A-13:

We are pleased with the coordination of geodynamics research among the federal agencies, particularly as it relates to the application of space technology and the use of space for geophysical and geodetic measurements. This coordination is actively pursued through interagency boards, special study panels, and informal daily contacts. Last year, a joint federal program for studies of crustal dynamics and earthquake mechanisms was formulated by NASA, the U.S. Geological Survey, the National Geodetic Survey of NOAA, the National Science Foundation, and the Defense Mapping Agency. An interagency agreement has been negotiated for this program and will be signed by the five agencies in th near future. Under this agreement, a Program Review Board and an Interagency Coordinating Committee for Geodynamics are established to plan and assess the progress of the research. An excellent example of this coordination under this interagency arrangement is the joint NASA/USGS monitoring, currently in progress, of unusual crustal movements in southern California.

A Satellite Geodesy Applications Board (SGAB) (formerly the Geodetic Satellite Policy Board) has been in existence since 1964. NOAA, NASA, and DMA are represented on this board. Under the auspices of the SGAB, an interagency panel is coordinating the development of methods for use of the Global Positioning System for geodetic surveying. A similar panel is considering federal agency needs for improved mapping of the earth's gravity field from space.

Also, under the Non-Renewable Resources program, NASA has been working with the Department of Energy in the formulation of a program to support mineral and energy resource assessment on a global basis.

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QUESTION A-14:

From NASA's perspective, how is the National Climate Program progressing?

ANSWER A-14:

While the study of climate is scientifically and technically a most challenging one, our initial endeavors are progressing well, and are providing some interesting insight into the study of climate. NASA's efforts have been recently reviewed by the Climate Research Board of the National Academy of Sciences, which reported that they were pleased with the support in NASA's portion of the Climate Program.

NASA's participation in the National Climate Program is focused on the utilization of remotely sensed information in studies to help determine the predictability of climate. Our major flight activity has been in the development of the Earth Radiation Budget Satellite System (ERBSS) mission designed to study the variability of the Earth radiation budget, and possibly to correlate it with external variables such as cloudiness and aerosols. In this mission, two NOAA sun-synchronous satellites and a NASA satellite will be equipped with instrument packages designed to measure atmospheric solar radiation, obtain stratospheric measurements of aerosols and other gases, and study the vertical composition of key constituents of ozone-chlorine chemistry.

QUESTION A-15:

The Committee is encouraged by the progress made in establishment of a joint endeavors program for Materials Processing activities. Legislation has been introduced to establish a Space Industrialization Corporation to encourage further private sector participation in the important area.

a) Do you consider this legislation and the joint endeavors program to be complementary?

b) It would appear that the joint endeavor concept could be useful in a broad spectrum of areas for encouraging private sector industrial innovation resulting in increased productivity. Have you proposed this concept to other agencies and economic advisers?

ANSWER A-15:

a) The proposed Space Industrialization Corporation would be a satisfactory mechanism for providing funding assistance to fully commercialize activities from NASA's joint endeavor program provided that proper incentives are retained to insure that private capital will not be displaced.

b) Discussions of the NASA joint endeavor concept have been held with the Departments of Energy and Commerce as well as the National Science Foundation. It should be emphasized that the program is being implemented on a case study basis to provide an effective means to understand and appropriately modify those institutional constraints that inhibit private sector involvement in our applications programs.

QUESTION A-16:

Dr. Frosch, what would be the impact of the supplemental request for the Space Shuttle program were not approved?

ANSWER A-16:

In order to hold current schedules, the Space Shuttle program is proceeding as if the FY 1980 Supplemental were available. We are at a high spending rate now, due to the high level of development, qualification, and certification testing, and the checkout of hardware leading to the first launch. We are also beginning a buildup in production to meet the planned deliveries for follow-on orbiters. If the FY 1980 Supplemental request were denied, there would be severe disruptions across the program. Our priorities would be to try to minimize the schedule delay for the first Space Shuttle launch, even though this would result in additional impact on production activities. Our preliminary estimate is that the first launch of the Space Shuttle would be delayed three to four months, the follow-on orbiter deliveries would be delayed approximately nine months, and the cost impact for these schedule delays would be in the range of $600-900 million.

QUESTION A-17:

When does NASA plan to award the contract to establish a Space Telescope Science Institute?

Will this contract be awarded to a university?

ANSWER A-17:

A Request for Proposal for the Institute was released on December 14, 1979. The proposals are due to be submitted to Goddard Space Flight Center by noon, March 3, 1980.

The competition for the ST Science Institute is not restricted to universities or non-profit organizations. Proposals are expected from several university consortia and at least one non-profit organization.

QUESTION A-18:

In your statement, you suggest that clear goals are

emerging from our planetary exploration program.

What are some of these goals and why are they important?

ANSWER A-18:

In light of the knowledge that has been accumulated in accomplishing the reconnaissance of the solar system to as far out as Saturn, we understand what are appropriate goals to set for our program of planetary exploration. These goals, developed with the help of the Space Science Board of the National Academy of Science, address problems of the most fundamental nature:

1) To understand the origin and evolution of the solar system,

2) To provide new understanding of Earth by comparative studies with other planets, and

3) To understand how the appearance of life in the solar system is related to the chemical history of the system.

We have already made much greater progress towards the achievement of these goals than would ever have seemed possible twenty years ago.

Starting with these goals, and working with the Space Science Board, we have adopted an exploration strategy which emphasizes both scientific balance and technological prudence. Balance is sought in the emphasis that is placed on the exploration of the three classes of solar system objects -- small rocky inner planets, giant gaseous outer planets, and primitive comets and asteroids. Prudence is exercised by undertaking a steady progression from the reconnaissance and exploration phases of investigation to the level of detailed study. The reconnaissance of the outermost planets and of comets and asteroids remains to be accomplished. The exploration of Mars, Venus, and Jupiter has begun. The exploration of the moon has alone reached the level of detailed study-- the scientific legacy of Apollo and the returned lunar samples.

QUESTION A-19:

With regard to the AgRISTARS initiative which was begun last year and considering potential schedule delays of Landsat D, what will be the impact on the AgRISTARS program of any gaps in the availability of Landsat data?

ANSWER A-19:

The conduct of supporting research exploratory tests, and

pilot tests can be performed using retrospective data where available. Although these efforts are not predicated on the use of real time data, current data with concurrent ground truth will help to augment our existing data base for the conduct of these efforts. Full crop year data bases are available for retrospective analysis in most countries of AgRISTARS interest with the exception of Australia. Large Scale Application Tests require real time data and are planned for the 1982/1983 time frame using Landsat D.

QUESTION A-20:

What is the current plan with regard to the availability of data from the National Oceanic Satellite System?

Will the data be available to all users including both civilian and military users?

ANSWER A-20:

One of the features of the overall NOSS Program is that there will be an extensive ground system in place prior to launch, which will provide a capability to make data available--in geophysical units--in essentially real time to both DOC/NOAA and DOD, who themselves will be responsible for passing it along to specific civil and military users.

QUESTION A-21:

During the shift to NOAA from NASA of the responsibility to create an operational civiliam satellite remote sensing capability. What has happened or will happen to the development of a Stereosat and a synthetic apeture radar.

ANSWER A-21:

NASA plans to continue an advanced study effort on the Stereosat system during FY 1980 in order to maintain the continuity of the program during the transition to NOAA. The involvement of the private sector in the development and operations of land remote sensing systems is clearly a Department of Commerce (NOAA) responsibility under Presidential Directive/NSC-54. Stereosat appears to be a candidate for early involvement of the private sector in a government-industry partnership. NASA has been conducting a Stereosat study effort over the past three years and is cooperating with NOAA in transferring the information we have developed.

The Synthetic Aperture Radar program is primarily a research and development program. We are scheduled to fly the Shuttle Imaging Radar-A (SIR-A) on the second Shuttle orbiter test flight primarily to investigate its usefulness for geological investigations. We have also formed an Earth Resources Synthetic Aperature Radar

Working Group whose basic objectives are to establish the value of imaging radar for specific earth resources applications and to formulate an active microwave applications research program plan. We plan to invite NOAA to participate in this planning process; however, because of the research and development nature of this program, NASA will continue to take the lead in the development of synthetic aperture radars for observations from space.

QUESTION A-22:

If Stereosat is delayed much further, the US and other world-wide non-renewable resource industry will be able to purchase similar high resolution, digital, multispectral stereo data from France and Japan by 1984-85. Is it in the U.S. national interest to not have our own similar capability such as Stereosat?

ANSWER A-22:

NASA believes it is in the U.S. national interest to have a capability to obtain global stereoscopic imagery even if somewhat similar data may be available for purchase from France and Japan. Stereoscopic imagery is a vital tool in the assessment of the global distribution of mineral and petroleum deposits. It also contributes directly to improvement in the efficiency of exploration surveys, provides needed information for large engineering projects and is needed for research into the composition and structure of the earth's near-surface crust. There is no guarantee that foreign acquisition of stereoscopic imagery would cover these areas of particular interest to the United States government and the private sector non-renewable resources industry nor that such data would be available in a timely fashion. It is expected that the mineral and petroleum industries will purchase high resolution, digital, multispectral stereo data from all sources that offer it for sale.

QUESTION A-23:

Many reviews of the NASA 5 year plan for non-renewable resource R&D consider the plan to be excellent but underfunded by perhaps an order of magnitude.

Why does NASA's 5 year plan reflect non-renewable resource R&D so low relative to the renewable resource R&D?

ANSWER A-23:

The Non-Renewable Resources program at NASA is in an early stage of development. NASA has increased its professional staff in this area in the past year and is increasing its research activities at universities, private

institutions, and appropriate NASA centers. The program has grown modestly from FY 1979 to FY 1981. Recognizing the importance of this research area to the United States, the highest priority of the Resource Observation R&D program will be an orderly expansion of the non-renewable resources Applied Research and Data Analysis program. The availability and allocation of available resources, of course, is dependent on many factors, and the pace of the expansion will also be geared to the rate at which an expanded community of researchers and scientists can be developed.

The Five Year Plan for non-renewable resources does reflect an apparent imbalance with the renewable resources research and development program. The basis for this is the maturity of the renewable resources program. The main driver in the early stages of NASA's remote sensing program came from the agriculture, water resources, and land use planning communities. The spectral bands for Landsat-1 through -3 were chosen for their usefulness in vegetation analysis; and over the past several years, this has contributed to the build-up and quasi-operational nature of this research. Therefore, compared to the renewable resources program at this time, the Non-Renewable Resources program is in an early state of development. NASA, with the assistance of other federal agencies, industry, and the scientific community, is actively developing an aggressive long-range plan for non-renewable resources R&D.

QUESTION A-24:

With regard to Landsat-D, will both the Thematic Mapper data and Multispectral Scanner data be available to foreign users?

ANSWER A-24:

Yes. A capability to transmit both the Thematic Mapper and Multispectral Scanner (MSS) data directly to goreign ground stations is incorporated in the Landsat-D design. It is expected that the satellite will be turned on over foreign ground stations that have agreements with the U.S. in much the same matter that the earlier Landsats have been utilized by foreign ground stations. Also, foreign users will be able to obtain the foreign data the U.S. collects for our use.

QUESTION A-25:

Since the Tracking and Data Relay Satellite system will not be available during initial operations of Landsat-D, how will the data be made available to users, both foreign and domestic?

ANSWER A-25:

If a Tracking and Data Relay Satellite (TDRS) is not operational when Landsat-D is launch, the Multispectral Scanner (MSS) data over the U.S. will be available through the continued operations of the U.S.-located spaceflight tracking and data network (STDN) stations at Greenbelt, Maryland; Goldstone, California; and Fairbanks, Alaska. A

receiving station to be located at Goddard Space Flight Center (GSFC) will be equipped to receive Thematic Mapper data over much of the U.S.

Acquisition of foreign data would only be achieved by the utilization of foreign ground stations and transmittal of the data back to the U.S. by mail.

QUESTION A-26:

During hearings on International Space Activities in September 1979, substantial discussion centered on the importance of considering institutional implications in the process of developing new technology. In particular, space technology involving remote sensing and communications services, as well as, major space scientific facilities can have major impact on institutional arrangements both on a domestic and international scale. (Institutional arrangements include user requirements, financing, ownership, operational responsibilities, lease arrangements, socio-economic and emerging world-wide needs.)

To what extent do you believe NASA has a role in addressing institutional considerations in conjunction with research and development activities?

If not NASA, what agency or agencies have this responsibility? Is new legislation required?

ANSWER A-26:

The very nature of the applications program requires that NASA consider institutional matters as a part of framing the objectives for and carrying out its research and development program. The applications of space technology to national and international needs are well recognized, and even though applications may involve exploratory, high-risk activities, the intent is to produce results which are indeed useful. The ultimate utility of those results can only be measured by their incorporation into an institutional framework that allows them to be exploited. In order for that incorporation to occur, two conditions must be met. First, the program results must have relevance to a problem of genuine and high priority concern to users, whether those users are other Government agencies, private industry, or the individual citizen. Second, the results must be of a character and form that allows the user to employ them. Thus, user needs and the solutions that are suitable for incorporation into the user's institutional framework are vital aspects of the NASA applications program.

The process of understanding user needs necessitates a full examination of the origin of the perceived requirements. Does it stem from a technology deficiency, a lack of application of available technology, or is it the result of institutional, policy, coordination, legislative,

or regulatory conditions? This understanding is obtained through vigorous dialogue between NASA and many other organizations. Each of our programs requires interchanges with a different set of participants. This is epitomized by the NASA - Department of Agriculture relationship in the AgRISTARS program, the NASA - NOAA relationship in meteorological and earth resources satellites, and the joint endeavor program between NASA and industry in materials processing. In all of these areas, highly promising efforts are either well underway or have recently been initiated. In the communications and data systems area, although some encouraging beginning are visible, we feel that a great deal remains to be done, especially in public service communications.

Institutional considerations are an important factor in the decision-making associated with all of these activities. NASA, the users, and the appropriate staff offices of the executive branch share the responsibility for addressing these considerations.

In response to the question of whether new legislation is required, we believe that each of the complex issues mentioned above must be treated separately and carefully studied to determine if legislative remedies are in order.

QUESTION A-27:

The European Space Agency (ESA) has recently launched Ariane, Europe's first launch vehicle. What effect do you expect this new launch system will have on Space Shuttle utilization?

ANSWER A-27:

NASA for some time has been tracking the market for space systems. As part of the normal dialogue between NASA and potential users--domestic and foreign alike--discussions have been conducted concerning the desires and plans for customer utilization of the Space Shuttle and other launch systems, including expendable launch vehicles available in the U.S. (Atlas Centaur and Delta in particular) and the Ariane.

Over the years it has become evident that there is substantial business for all competing launch systems. The passing of time shows a greater world-wide acceptance and planned use of space for domestic and international purposes. We believe there has been established a wide acceptance of and demand for NASA launch vehicles because of our favorable record of performance. In addition, the user community is aware of the continuing commitment by the Congress to maintain a viable space flight capability in the U.S. Use of NASA launch vehicles is also encouraged by our established policy for providing orderly transition from ELV's to the STS, which involves building payloads which are dually compatible (ELV and STS).

NASA expects the European users to favor launches on Ariane so long as Ariane remains generally competitive in price with the Shuttle. Likewise, there is strong evidence that U.S. and other international civil customers will favor launches on the Space Shuttle so long as price and performance are attractive. Sixteen foreign users, including a number of Europeans notified NASA of their intentions to use the Space Shuttle/Spacelab to support their activities in space.

QUESTION A-28:

a. What action has NASA taken with respect to considering the use of Centaur or other liquid upper stages with the Space Shuttle?

b. Are you satisfied with the progress and cost effectiveness of the Inertial Upper Stage (IUS) and the availability and capability of IUS to meet NASA mission requirements?

ANSWER A-28:

a. In response to expressed Congressional interest, we are reexamining existing and future upper stages for use with the Space Shuttle in the mid-1980's and beyond. The viability of our decision to redirect the 1982 Galileo mission to a dual-flight mission on the Space Shuttle/IUS 3-stage in 1984 was confirmed based on our reassessment of the technical, schedule and cost factors, and the Air Force study of IUS alternatives. Therefore, we do not plan to prepare the Shuttle to fly any new upper stages before 1985. We are continuing our review of future upper stage requirements and candidate stages. These candidates include the Centaur and IUS as well as other concepts designed to meet orbital transfer vehicle requirements.

b. The projected development schedules and delivery dates for both the two-stage and planetary configurations of the IUS are consistent with NASA mission requirements and in our judgment are progressing satisfactorily. The performance currently predicted for both configurations shows a slightly positive margin for the NASA missions. However, there is design reserve remaining in both configurations and design changes that can be made to enhance performance.

We are monitoring both the schedule and performance closely and if necessary will take action with the DOD to insure that our requirements are met. Both NASA and the DOD have recently again examined the advisability of using alternative upper stages in lieu of the IUS. It was concluded that at the present time the IUS is the only viable choice from both cost and schedule considerations.

QUESTION A-29:

Dr. Frosch, the Shuttle manifest is filled through the 1984 time span, which means other potential users will have to use other launch capability such as the Delta or Atlas/Centaur vehicles.

a. Is it the agency's intent to encourage the use of these launch vehicles versus the European-built Ariane vehicle?

b. From a U.S. Government standpoint does it not make more sense for NASA to encourage the continued use of the U.S. launch vehicle first?

ANSWER A-29:

NASA believes that in general the best interests of the U.S. Government would be served if potential users who may overflow from the Shuttle were to use U.S. expendable launch vehicles. Evidence of this belief is demonstrated by the alteration of the Delta and Atlas/Centaur backup transition policies as the Shuttle operational date has been delayed.

The NASA policy regarding the use of U.S. expendable launch vehicles has extended the time that Delta backup launch vehicles will be available to customers by two additional years and has increased the number of customers covered. We are currently evaluating the need to extend the Atlas/Centaur capability in response to user requests. Extension of these capabilities will be on a reimbursable basis. In this manner, it is believed that the concept of dual compatible payloads (compatible with either the U.S. expendable launch vehicles or the Shuttle) will, in the long term, be more beneficial to the users by providing the ability to switch to U.S. expendable launch systems with minimum perturbation to their spacecraft designs which would not be the case if they were to switch to a launch on Ariane.

QUESTION A-30:

In your prepared text on page 3, third paragraph, you talk about the Earth Resources Operational System being the third major civil technological system transfer for which NASA has been responsible. Could you elaborate on the past two transfers?

ANSWER A-30:

The first area was communications satellites. The basic technology for the first years of satellite communication systems was developed and successfully demonstrated in the NASA programs involving SYNCOM and the Applications Technology Satellite (ATS) series. The Interim Defense Communications Satellite Program also made important contributions, as did AT&T's TELSTAR. Because of the level of investment risk had thus been explored and demonstrated

to be acceptable, commercial exploitation readily followed, and in 1963 the U.S. Congress established the Communications Satellite Corporation (COMSAT) to foster a rapid growth of commercial international satellite communications. The intervening years have seen a rapid increase in the use of communications satellites in nearly every country, and a large decrease in the cost of communications service via satellite. As we look to the future to the advances necessary to continue this growth, we now see it is appropriate for the federal government to again enter satellite communications R&D and infuse it with the new technology that will open new frequency bands and permit the more efficient use of presently used bands. Even this reentry, however, will be made via the sophisticated industry which resulted from NASA and DOD's earlier efforts.

The second area was the climate/meteorology program. The basic technology was started by NASA as a research program in 1958, with the first Tiros R&D series satellites flown in April 1960 for climate monitoring. The National Environmental Satellite Service (NESS) worked with NASA in doing research using the data from the satellites. In the 1962-1963 time period, the second series (Nimbus) of research polar orbiting meteorology satellites was started. The first Tiros "wheel" operational satellite was launched in February 1966. This was followed by the ITOS satellites which provided night-time coverage. The third generation of operational satellites is the current Tiros/NOAA series. These satellites have the ability to acquire large volumes of data for NOAA/NESS's use.

At the same time that the polar orbiting satellites were being developed, NASA extended their research to geostationary satellites for monitoring meteorological conditions. As a result of the ATS R&D work, the Synchronous Meteorological Satellite (SMS) series of geostationary satellites was started as operational entities. These were followed by the GOES series which is currently being operated by NOAA as a monitoring system for meteorology purposes. NASA continues to develop R&D instruments to better accomplish the monitoring of weather and climate, and the current Earth Radiation Budget Experiment program is the next R&D effort in which we will investigate the radiation impact on climate and climate prediction.

QUESTION A-31:

The Aeronautics request has been reduced this time from $300 million (raised to $308 million by Congress) to $290 million.

a. Do you feel this is wise considering the concerns about national security this year?

b. Isn't this action inconsistent with the intent of Congress as expressed last year when we raised your request?

c. What actions did you personally take with the Administration to prevent this reduction?

ANSWER A-31:

a. A significant portion of the NASA aeronautics program is applicable to military technology needs and these portions of the program are continuing as planned. The FY 1981 budget provides for a modest increase in effort identified as relevant to military technology needs. The reduction in funding for the NASA aeronautics program from FY 1980 to FY 1981 will not affect the NASA military support activities.

b. The reduction in the NASA aeronautics program from FY 1980 to FY 1981 is primarily the result of the planned phasing of the Aircraft Energy Efficiency (ACEE) program which required peak funding in FY 1980. The R&T Base, which is the fundamental discipline oriented part of the program which provides for broad technical advances, increases 10 percent from FY 1980 to FY 1981. Systems technology other than ACEE continues slightly above the FY 1980 level. Four program enhancements are included in the systems technology area. The $8 million added by Congress in FY 1980 provided early starts in two of these enhancements; namely, Advanced Rotorcraft Technology and Variable Cycle Engine Technology.

c. The NASA aeronautics R&T program proposed to OMB contained a number of enhancements in addition to those contained in the current budget request. These enhancements were vigorously advocated through the budget formulation process.

RESPONSE TO GENERAL QUESTIONS SUBMITTED BY THE MINORITY DURING THE JANUARY 29, 1980, POSTURE HEARING BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY TO DR. FROSCH.

QUESTION A-1:

Could you briefly describe the management changes that have been made in the Shuttle program during the past year?

ANSWER A-1:

a. Duties of the Administrator and Deputy Administrator were realigned to permit Dr. Lovelace to spend a major portion of his time on the Shuttle.

b. Separate management organizations were formed to handle Shuttle Development and Space Transportation System Operations.

c. Approximately 100 people have been added to these two organizations and the Centers with major Shuttle responsibilities to provide strength where needed, particularly in the financial and program management functions.

d. Rockwell, the prime Orbiter contractor, has made organizational and top personnel changes to strengthen their management.

e. The NASA Plant Representative Office at Rockwell is being strengthened by additional personnel and responsibility.

f. The Information Management System is being revised at all levels within the program.

g. The Comptroller, Director of Procurement and the Chief Engineer have been given broad overview responsibilities, reporting to Dr. Lovelace.

h. A detailed audit of the flight certification program is now taking place under the direction of the Chief Engineer.

i. Frequent coordination meetings are being held with DOD and OMB, chaired by Dr. Lovelace.

QUESTION A-2:

Which of these changes do you feel are most important?

ANSWER A-2:

It is not possible to say that any one action is more important than any of the others. These are all parts of an

overall strengthening of program management. Obviously we feel that they are all important.

QUESTION A-3:

Has your role in Shuttle program changed substantially in the past year?

ANSWER A-3:

Although I have given a broad responsibility to Al Lovelace, I have obviously also become more involved. It is a little hard to say that my greater involvement is a result of our management review or because of the status of the program and the approaching operational commitments in which I will play a significant role. In any event, I have become considerably more involved during the past year.

QUESTION A-4:

Previous studies by the Committee have pointed out that the funding requirements for several of the past years have been underestimated. How do you feel about the FY 81 budget? Do you feel comfortable or do you think there is a strong possibility of exceeding that budget?

ANSWER A-4:

During the formulation of the FY 81 budget request for the Space Shuttle, we recognized the importance of providing adequate funding in FY 80 and 81 for Shuttle development (DDT&E) activities to help insure against the need to reallocate funds from the follow-on orbiter production efforts. In doing so, we developed a Shuttle budget, based on currently identified or known requirements, which provides funding for a first orbital flight to occur as late as March 1981, even though the program is working to an internal target date three to four months earlier. Also for the first time, a specific reserve for unknown changes and systems modifications to the Shuttle, in addition to normal reserve allowances within the project estimates, has been identified and included in the total program estimate. A similar provision has been identified in FY 80 and represents a portion of the requested FY 80 supplemental appropriation.

As to the possibility of a need for DDT&E funding in excess of the FY 81 estimate, we feel that this in unlikely, however it is always possible in a development project such a as the Shuttle. Should the program experience major unknown problems which would result in a delay of the first

flight beyond March 1981, we would then assess the total STS planning for the purpose of reallocating some operations funding that might be made available due to a further launch delay.

QUESTION A-5:

How has the delay in Shuttle influenced the policy for phasing out the expendable launch vehicles?

ANSWER A-5:

The delay in implementing Shuttle operations has resulted in NASA's continuation of the Delta and Atlas/Centaur production beyond the previous target dates.

As the Shuttle dates become more definite, NASA will review the policy for expendable launch vehicle backups and will establish appropriate phase-out date.

QUESTION A-6:

The projected cost per flight of Space Shuttle has grown. Would you compare the current cost per flight for expendable and space shuttle launches?

ANSWER A-6:

The current estimate of cost per flight of a dedicated Space Shuttle launch is $24 million in FY 75$, plus a use fee of $5 million. This represents an increase over the cost per flight used as the basis for prices currently in effect, i.e. $18 million in FY 75$, and a use fee of $4.3 million.

The prices currently estimated for comparable launches to geosynchronous orbit using Space Transportation System and expendable launch vehicles in real year dollars based on a 1981 launch date are approximately as follows:

Payload Class	STS Price (in millions)	ELV Price (in millions)
Delta Class	10.9	27.3
Atlas Centaur Class	26.3	38.0
Atlas Centaur Class if Optimized for STS Launch	(11.8)	N/A
Titan/IUS Class	50.3	75.1

QUESTION A-7:

What is the difference between the "advanced program" line item in Space Flight Operations and the "changes/system upgrading" in the Space Shuttle line item?

ANSWER A-7:

The Advanced Programs line item under Space Flight Operations encompasses studies and engineering investigations which will utilize the unique capabilities of the Space Transportation System starting in the mid-80's, as well as the technical and programmatic data for the definition and evaluation of potential future space programs and systems.

The changes/systems upgrading line item under Space Shuttle is to provide an adequate allowance for changes and systems modifications anticipated from the flight test activity. As these requirements develop and are approved they will impact the funding estimates for either development or production and the funding will be applied accordingly.

QUESTION A-8:

What is the cost of the second Spacelab?

ANSWER A-8:

The contract price for the second Spacelab is $184 million in FY 79 dollars. This excludes the second Instrument Pointing System and spares which are not yet under contract.

QUESTION A-9:

The President recently approved the establishment of an operational land observing system within NOAA. What effect will this have on the current Resource Observation program at NASA?

ANSWER A-9:

We are working very closely with NOAA to assist them in the development of the implementation plan for the operational system and to define the continuing role of NASA. We anticipate no substantial changes in the current NASA Resource Observation program. NASA expects to continue to perform the research basic to the application of remote sensing and space techniques to the study of the earth's resources and will continue to develop the technology needed for improved space sensors and space and ground systems.

QUESTION A-10:

This year's budget includes a line item for the establishment of the operational land observing system. What will NASA's role be in this transition? i.e., Why is the money required for NASA if NOAA has the charter to establish the institution?

ANSWER A-10:

We are working very closely with NOAA, USDI, and USDA via an ad hoc planning group to identify the tasks to be undertaken as we move forward to a fully operational remote sensing system. The specific institutional responsibilities in the operational era have not been defined. However, NASA will continue to be responsible for space and related ground systems R&D activities and will act as NOAA's agent for the procurement of subsequent space operational elements; NOAA will budget for and manage the operational system.

During the development of the FY 81 budget, at NOAA's request, we included a request for $16 million to partially upgrade the Landsat-D ground system and to initiate procurement of long-lead-time hardware for Landsat-type missions to ensure data continuity until the Operational Land Observing System is functioning. It is anticipated that any additional funds for the operational system will be requested by NOAA.

QUESTION A-11:

What is the effect of going to the operational land observing system on NASA sponsored university research in this area? i.e., Will this effort shift to NOAA?

ANSWER A-11:

There are two areas of NASA-sponsored university research in remote sensing of earth resources--fundamental research basic to the application of remote sensing and space techniques to earth resources problems; and development of university capabilities to demonstrate the practical benefits of remote sensing techniques to state/local government and private industry.

NASA will continue to sponsor fundamental research at universities basic to developing an understanding of remote sensing phenomena and the application of these techniques to earth resources problems.

Similarly, no change is anticipated in the case of develop-

ing university capabilities to demonstrate remote sensing techniques to public and private sector users.

QUESTION A-12:

Last year the President made a policy statement that he was strongly supportative of basic research. However, there were no new starts in the space science program. The policy has not changed; however, we do have a new start called Gamma Ray Observatory. What has changed? Why was this program approved this year? Is it of higher priority or are the budget constraints less severe?

ANSWER A-12:

Our budget for Space Science continues to be austere. The increase in the FY 81 budget--including the new start of the Gamma Ray Observatory (GRO)--over the approved FY 80 budget is smaller than the increase of the FY 80 budget, which included no new starts. However, the FY 80 budget was especially constrained due to the "peaking" of funding requirements for major approved development programs such as the Space Telescope and Galileo. As these projects start to level off, we are able to accommodate a new start in our program at a modest level of funding without greatly increasing our budget.

The lack of a new start in FY 80 was undesirable, but we were still able to pursue a viable Space Science program. Another year without a new start would, however, have serious effects on the viability of our Space Science program. Progress in the interrelated areas of research sponsored by NASA ultimately requires answers which cannot be provided by existing tools or techniques, but which must be provided through new starts. For this reason, a new start in Space Science is of very high priority in FY 81.

In formulating our FY 81 budget, GRO was the highest Space Science priority. Its instrument technology is proven, and its spacecraft requirements are well within the state-of-the-art. Most importantly, its scientific foundations are well established. GRO represents the next significant logical step in pursuing high energy astronomical investigations.

The CHAIRMAN. In your statement, Dr. Frosch, it indicates that probably the first flight of the Shuttle is not likely to occur until sometime in fiscal year 1981. With regard to fiscal year 1980 supplemental request, does it contain adequate reserves to accomplish the first flight and to maintain the production orbiter delivery schedule?

Dr. FROSCH. Mr. Chairman, we have designed the supplemental request and the fiscal year 1981 budget to do that. The fiscal year 1980 supplemental request carries D.D.T. & E. through the end of fiscal year 1980. So that it assumes a first flight not before the end of that fiscal year.

We have calculated the fiscal year 1981 budget assuming that we might need to have sufficient funds in the budget if the first flight did not occur until as late as the end of the first quarter of calendar 1981, that is, half way through the fiscal year.

So we believe that we are covered in terms of that requirement and that we have also covered the continuation of the production program on the schedule that we gave to you previously.

I would like to add the comment that we recognize that asking for additional Shuttle funds places this committee and its members in a difficult position, and that is indeed hard for us because the committee has been among our strongest supporters. Your confidence and willingness to continue to support the program, as it has had some problems, has been a primary reason why we have been able to make progress. I think we are making continued progress, as you can see from Dr. Lovelace's presentation. The pieces of the system are coming together. We've made real progress in demonstrating that the engines will be satisfactory. We have some additional problems still before us in the thermal protection system. We are confident that these delays and difficulties will be overcome in the course of this year and that, while the flight will be delayed, it is going to be a safe flight.

I just wanted to state that we appreciate the support the committee has given us, and hope that we may look for it to continue.

The CHAIRMAN. Last year about this time you sat in that same position, and the question was asked if the $185 million that you were requesting at that time was going to be enough to get the Shuttle through. You stated that you were reasonably sure that that was going to be enough. A few months after that we determined that that was not the case and then you're coming in now for another supplemental $300 million.

Are we to believe that this is going to be the last time or will that happen again in May or June of this year, that we determine that conditions and such have changed, that there will be a need for an additional supplemental?

Dr. FROSCH. We do not expect it to happen again. The best I can say is that, of course, we are considerably closer to having solved our problems than we were last year. At that point we had not had any successful testing of the main propulsion test article which includes a cluster of three engines. We have had some difficulties but we now have had a satisfactory test. We will have another test soon which I hope and expect will be successful. We have demonstrated, through the integrated tests, that the avionic system is coming together well. We have stacked the solid rocket boosters.

We have completed a total of six and have only one more solid motor test to go. We are beginning to see our way through all of the known problems. As I said last year, there may be some major unknown problems, but we don't see where they would be or what they might be. So we feel now that we have a fairly good assurance that we're coming close to the first flight.

I also have to add that after our problems of last year and the year before, and our reexamination of our managerial and budgetary systems, our control has been tighter and more conservative in the direction of trying to be sure we have enough money in the budget to cover us. We have covered the Shuttle program for a first flight as late as the end of March 1981.

In addition, for the first time in the program, I am holding at the administrator's level some reserves beyond the reserves that we calculated as in the normal way to be required for the program at other levels.

The CHAIRMAN. When do you anticipate that the supplemental funds, or when do you think that it's going to be imperative that the supplemental funds be available to you?

Dr. FROSCH. Mr. Chairman, by June 1, 1980.

The CHAIRMAN. By the first of June?

Dr. FROSCH. Yes.

The CHAIRMAN. You're doing some work with the Department of Defense as one of the primary Shuttle users.

What arrangements are made with the Department of Defense for the use of the Shuttle?

Dr. FROSCH. We are working toward the establishment of a formal memorandum of understanding between ourselves and the Department of Defense, and we have been discussing this on several levels, including a number of direct discussions in which Dr. Lovelace and I have participated with the Secretary of the Air Force, who is the designated operating authority for the Secretary of Defense for space purposes. We have arrived at the point where I believe we have agreed upon operating relationships.

Once again, it turns out that the Space Act of 1958 was a remarkably prescient document. It carries with it the necessary legislative authority and the proper guidance which enables us to work together with DOD. We expect we are getting to a very satisfactory arrangement in which we will be able to clarify very definitely the way in which DOD will have control of specified military missions using NASA backup, and NASA having control of civil missions in a way which will be unambiguous and satisfactory to both users.

The CHAIRMAN. Has any problem arisen with the DOD in relation to the priorities that NASA has assigned for DOD missions?

Dr. FROSCH. No. There is no priority problem. We believe that almost all of the priority arrangements will be made in the course of the normal scheduling of the system and that will not be a problem.

We have had to discuss, obviously, what we do in cases of emergency priority, and we have agreed that we can define mechanisms that will enable the assignment of suitable priority in cases of national emergency or defense emergency.

The CHAIRMAN. Since we had the review of the Space Shuttle program by the subcommittee and also by NASA and also by the White House, how would you evaluate the performance of the Shuttle contractors in their performance since that time?

Dr. FROSCH. We have been putting a lot more in-house attention on the detailed performance of the prime contractor and, in fact, will probably increase that further. One of the management problems that we identified was the fact that we did not feel we had enough direct information on what was going on in the plant on a day-to-day basis, and I now believe not enough direct day-to-day guidance and surveillance of the contractor.

In a number of areas the performance of the contractor has been excellent. I would cite the avionics and the general structure and assembly of the orbiter as certainly being that. I think the contractor performance on the engine, in spite of some problems, has been excellent. The contractor who has been doing the solid rocket motor has also done an excellent job.

The area of most concern now—and perhaps it should have been of more concern earlier—has been the area of the thermal protection system. That is going to take additional NASA attention to what the contractor is doing. There, I think, have been some failures of engineering.

The CHAIRMAN. Is that problem with the manufacture of the thermal protection unit, this tile, or the installation of the tile?

Dr. FROSCH. I would characterize the problem as being a thorough engineering understanding of the forces that the tile as a system must be able to withstand and the actual mechanical strength of the system. The manufacturer of the tiles had a good many hiccups in the early manufacturing stages; however, we believe those have been worked out. There is a twofold problem. One problem is understanding and predicting what the forces will be. The difficulty is that the tiles are subjected to a whole collection of forces; forces due to the change in shape of the orbiter from aerodynamic forces, change in shape, and size of the orbiter from thermal heating, vibration effects, and so on.

One would like to be conservative in predicting the forces, but if one isn't careful in being conservative one is much too conservative. That is, one adds up all the forces and gets forces that are so large that it is difficult to make the system work. At the same time, one doesn't want to underestimate them. So that's been part of the problem.

The other part of the problem has been demonstrating exactly what stresses that tile as a system can take. Most of the thermal system can be demonstrated directly by test, essentially by pulling on the tile system to determine its strength and that has been successful. But there are areas on the orbiter where it is not easy or, in some cases, even possible to do a direct full-proof test. What we are doing there is a combination of off-orbiter testing, plus analytical work, plus some on-orbiter testing. I would say that the real problem now is between trying to get a good prediction of the forces and a good understanding of what forces the tile system can take. We're having some problems in going back and reexamining our techniques. That's an area in which I'm not completely satis-

fied with either the contractor's performance or, I must say, with all of the NASA in-house performance either.

The CHAIRMAN. Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman.

I'm glad the Chairman asked that question about the thermal protection system because I have been concerned about the thermal protection system for about 4 to 6 years. We've been briefed by Dr. Frosch and by Dr. Lovelace and by Mr. Yardley, on the subject many times.

It seems to me that at one time we had a meeting and you said that by March of 1980 the tiles would all be under control and the tests would all be run and we would fly in June or July. Now it's my understanding that these tests won't be ready until July and we'll fly in November.

I'm truthfully getting to the stage where I don't know what to believe. I don't know whether we can believe you because I don't think you know. I understand that this is an experimental program so you're guessing. But I think you're getting to be pretty bad guessers.

You mentioned just a minute ago that you weren't satisfied with the NASA in-house nor the contractor on the tiles. It seems to me, when we started this thing, that the design was bad, the materials were bad, and somewhere in there NASA, didn't seem to get deeply involved in the things that you're now concerned about.

This has cost us a bundle of money. We're not ready to go yet. I just wonder if you could tell the committee a little bit about why we should believe that you're going to have the tiles ready to go by July and fly in November. Why should we believe that now?

Dr. FROSCH. Mr. Winn, I'm not sure if we traded places that I would be believing either, given the history that you've cited. From my point of view, looking at what has happened with the tile system, we have gone through a series of what I'll call engineering discoveries about the system. It is experimental. It's extremely complex. The difficulty is that there are 30,000 parts that have all got to be proofed and made to operate correctly.

Two years ago I think it can be said, in terms of what we now understand, that we were looking at that system incorrectly. That is to say, the engineering model was wrong. I think as we began to test it it became very clear what was wrong with that engineering model, and we're beginning, I think, to have a fair understanding of what the problem is now. Understanding is not something that's very easy to demonstrate in a series of testimony, but I think we are getting there.

I will not say that we should not have had a better engineering understanding sooner. I think we should have. I think basically we were treating the materials improperly, and that could have been recognized sooner. I think we now do understand what the fundamental problem is. I am less sure—and I think you're correct there—that our estimates of exactly what it will take and how long it will take to turn that understanding into a satisfactory system are as good as they could be, However, I think we're getting closer all the time, and we're reducing the areas of uncertainty. It is not a problem which is completely coming apart, which is what would really worry me, namely, if every time we turned around things

were much worse. The problems and solutions are beginning to converge and I think we're at the point where we can see our way clear to finishing that part of the system.

A year ago we had to say some things like this, not only about the TPS, but about the engine system. We had not, as I mentioned, run a complete cluster test. We were uncertain about a number of things in putting the orbiter together. We were worried about the softwear systems. Now we're in a position where we have at least demonstrated at least once that that three-engine system can operate as it's supposed to. We have demonstrated that the software in the avionics can operate as it's supposed to. That's a considerable amount of progress. We are most certainly beyond where we were last year. So I think there's good reason to have some confidence that we're a lot closer to understanding when the first flight can come and in a lot better shape for understanding what budgetary requirements there are for that.

Mr. WINN. That proof testing I don't quite understand, and I wish you would try to explain it to me. It looked like some type of a variation of a suction cup. But how do you proof test when they're all different sizes, shapes, forms, angles, and everything else, and weight too, I guess?

Mr. FROSCH. The bulk of the tiles are relatively flat. That is, they have odd shapes, but they're curved shapes that are not heavily reentrant shapes. That is, they're more or less flat against a curved surface. What we are doing is exactly what it looked like. That is, what you're seeing is a spiderlike arrangement with a set of suction cups and a central suction cup. The circle of suction cups pushes against the tiles surrounding the one being tested. The suction cup on the one being tested attaches to it in the normal suction way and pulls against it. It tries to pull the tile off with a stress which is predicted to be the stress that would be applied to that tile under the worst flight conditions times a suitable proof factor of safety, about 1.25, which is a fairly standard factor of safety for these things.

We pull up to that stress, and while we are pulling we listen. We have microphones on the tile that listen to the tile. One of two things happens: Either we pull the tile off before it gets to the critical stress, in which case that's clearly incorrect strength. The other is that we've been able to demonstrate in the laboratory that when you get to the critical stress that breaks the tile—and its is a matter of the tile breaking rather than the glue joint breaking—before you get to the critical stress there is a noise from the tile. That's the only way I can describe it. The tile begins to crackle well before it breaks. So, the beginning of the noise is a warning that you've arrived at a point where you haven't damaged it yet but you're getting to that point. Between either actually pulling it off or getting this acoustic test failed condition, we are able to tell what stress that particular piece of the tile system can accept. If it does not pass, then we have a technique for strengthening the tile, which is called densification. Essentially it means painting the face of the tile that is bonded to the strain insulation pad with an appropriate material which strengthens that part of the tile and brings the system up to full strength. We then rebond that tile and retest it. If the tile is in an area where densification is not suffi-

cient, then we can go to the next higher strength tile, the so-called 22-pound tiles, which we will only do when necessary because it adds some weight to the vehicle.

Now, we can use that proof test technique do that over all that part of the vehicle with black tiles and with the white tiles, which are over flat surfaces. There is a set of tiles most peculiarly shaped, which are the ones that fit over the edges of wings and over the edges of tail and that go into corners where wings meet fuselage and tail meets fuselage, where we cannot test by that technique. There's just no way to grab the tiles. Those we propose to remove, densify, or substitute with the heavier material, and rebond.

There is one other set of tiles which cannot be tested and must be replaced. These are where the stresses are so high that you cannot use the suction cup technique and that has to be simulated in a pressure chamber. There just isn't enough atmospheric pressure in order to enable you to do it. So with this combination of test techniques, we believe we will be able to certify every single tile on the vehicle.

As Dr. Lovelace mentioned, the stresses of first flight will be considerably lower than the stresses of subsequent flights because the vehicle will be very light, and we can fly it in a rather benign trajectory. This will give us an opportunity to have a flight test of this previously certified system with lower stresses, but, importantly enough, it's an opportunity for us to get some real flight data to go with the wind tunnel and the simulation predictions.

I'm afraid that's a rather complex answer, but it is a rather complex problem.

Mr. WINN. No. I appreciate it. I hate to take the time of the committee, but I have thought that I've had a pretty good understanding of the problems there. I've followed it very closely, and I appreciate that explanation.

Mr. Chairman, I have a lot of other questions, but I would like to ask just a couple of basic ones and then submit some questions and you can send them back to me.

One is, I'm not sure whether the Gamma Ray Observatory has a launch window limitation or not.

Dr. FROSCH. It does not have an annual launch window limitation.

Mr. WINN. It doesn't?

Dr. FROSCH. It does not because it's an Earth orbital satellite.

Mr. WINN. In your testimony I wasn't quite sure about what the total program runout cost for the Gamma Ray Observatory was.

Dr. FROSCH. The current planning estimate for development and mission operations and data analysis is $210 million to $270 million. This does not include the launch cost which must be added.

Mr. WINN. And about how much is the launch cost?

Dr. FROSCH. Launch cost would be about $40 million.

Mr. WINN. All right.

I want to know what the manpower level is at NASA. Are there any reductions contemplated?

Dr. FROSCH. No, sir. In the 1981 budget, as compared with the number in the 1980 budget, there is a total increase of 150 civil service positions, of which 50 will be allocated in 1980 and 100 will be allocated in 1981. This allocation is required for two purposes:

One, to augment the Space Shuttle workforce; and to properly staff the office of the Inspector General. Thus, our end-year ceiling for the end of 1981 is 22,713 positions, which is 150 above the end-year ceiling planned in the fiscal 1980 budget report.

Mr. WINN. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Flippo.

Mr. FLIPPO. Thank you, Mr. Chairman.

Dr. Frosch, last year the President appointed a blue ribbon committee to make some recommendations, and I would like to ask to what extent have you implemented those recommendations with regard to in-house planning?

Dr. FROSCH. I think we have implemented, or are in the process of implementing, most of those recommendations. Perhaps the most significant one for the long term was the recommendation that we formally separate the management of the operation of the Space Transportation System from the acquisition of the Space Transportation System. We have taken that organizational step in NASA. It is now in existence, but it is not fully staffed. The Acting Associate Administrator is Mr. Glynn Lunney of JSC, and we are actively recruiting for that senior post and for other necessary posts.

We have in budgeting for the proposed fiscal year 1980 supplemental and for the fiscal year 1981 request, as I've mentioned, taken into account the advice that we should stop trying to run the program with less money than was necessary and to ask for what was required. We believe we have done that.

We are well along in the process of revising the management information structure, with regard to fiscal and performance information. We have put more emphasis on our interface with DOD, as I indicated in my response to the chairman's question, and we are putting much more emphasis on improved and increased NASA in-house manpower working directly with the contractors.

I think those are the principal highlights.

Mr. FLIPPO. Do you feel that the new organization has been in place long enough to get some feel about its effectiveness? Is it going to do the job so we're not likely to have surprises?

Dr. FROSCH. I think it's beginning to pick up the load of the operational planning very well.

Mr. FLIPPO. Dr. Frosch, one of the things that concerns me: Let me ask you, could you give us some idea about the level of reserves that's not allocated to any specific programs that you have, to include yearend 1980 and how much is in the budget for 1981?

Dr. FROSCH. I'm reluctant to give real numbers.

Mr. FLIPPO. I see.

Dr. FROSCH. Because it's been our experience that there's a high evaporation when we do that.

Mr. FLIPPO. OK. Very good.

Dr. FROSCH. But we'd be happy to discuss that with you outside of the hearing room.

Mr. FLIPPO. Fine.

One of the reasons for trying to ascertain that was my concern about your advanced programs area. I think the funds for advanced programs, which I believe you would agree with me, are really the

essence of NASA's future, and that's where the new programs really come from, I suppose. It's essentially a reflection of your future, of the future of the Nation, and of the health and welfare of NASA. But advanced programs funding I believe is only about $10.8 million for fiscal year 1981, which continues the downward trend in this important area. So my concern is why are we not doing more in that area. That has been in a steady decline, I believe, since in the neighborhood of 1972, and, as I look back over the history of the funding for that, in the late sixties and early seventies, in the 1966 era, back in the old days, we had almost $100 million and then in 1972 we had about $75 million. It's been in almost a steady decline until it's beginning to flatten out now, or at least that's the thing that's been indicated by the charts that you've presented to us. They are, of course, inflated 1979 dollars, for comparison purposes.

I guess what I'm asking you is what did you ask OMB for, and could you give us a list of the new start candidates which you requested of OMB and tell us a little something about that?

Dr. FROSCH. I can give you some highlights.

The Gamma Ray Observatory and the National Oceanic Satellite System are both in our fiscal year 1981 budget and request. The Solar Electric Propulsion System and the Upper Atmospheric Research Satellites were both excluded. The power extension package for the Shuttle Orbiter, the Venus Orbiting Imaging Radar, and the numerical aerodynamics simulator were also excluded along with some aeronautical enhancements.

We can furnish you a list of what was submitted to OMB.

[The information to be provided is as follows:]

National Aeronautics and Space Administration

COMPARISION OF OMB BUDGET REQUEST TO CONGRESSIONAL BUDGET REQUEST
(Dollars in Millions)

Research and Development	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	Δ	FY 1981 Budget Request to Congress	Remarks
Space Shuttle	1886.0[1/]	1893.0	-20.0	1873.0	The funding for long-lead procurement of materials and subsystems for a fifth orbiter was deleted
Space Flight Operations	446.6	846.5	-37.0	809.5	Funding to initiate development of Solar Electric Propulsion System and power Extension Package was deleted
Advanced Programs	13.0	47.8	-37.0	10.8	
Other Space Flight Operations Activities	433.6	798.7	---	798.7	
Expendable Launch Vehicles	70.7	55.7	---	55.7	
Physics and Astronomy	337.1	453.9	-15.2	438.7	
Physics and Astronomy Projects Approved	276.1	365.0	---	365.0	
Advanced Technology Dev. for OPEN	---	3.0	-3.0	---	Deletion of funds for studies for Origin of Plasmas in Earth's neighborhood
Research and Analysis	34.1	47.0	-4.2	42.8	Deletion of funds for enhancements in supporting research and technology
Sub-orbital Program	26.9	38.9	-8.0	30.9	Reduction in proposed enhancements for airborne research, balloon program, and sounding rockets

	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	△	FY 1981 Budget Request to Congress	Remarks
Planetary Exploration	219.9	219.9	-40.3	179.6	
Planetary Exploration Projects Approved	174.9	127.9	---	127.9	
Advanced Technological Development Enhancement	---	10.0	-10.0	---	Deletion of funds for advanced planning for future planetary missions
Research and Analysis	45.0	52.0	-.3	51.7	Request was reduced in disciplines of planetary astronomy, atmospheres, and materials
Venus Orbiting Imaging Radar	---	30.0	-30.0	---	Funds requested to initiate VOIR development were deleted
Life Sciences	43.8	50.2	-.5	49.7	Reduction in proposed funding for scientific and technical definition studies
Space Applications	331.8	413.1	-31.4	381.7	
Space Applications Projects Approved	331.8	365.9	---	365.9	
Analytical Float Zone	---	2.9	-2.9	---	Deletion of funds to study the effect of convection flows on crystal growth
National Oceanic Satellite System	---	15.0	-9.2	5.8	NASA funding reduced consistent with revised joint DOD, NASA, NOAA funding plan
Milti-Spectral Sampler ATD	---	7.0	-7.0	---	Deletion of funds for definition studies
Upper Atmospheric Research Satellite	---	10.0	-10.0	---	Deletion of funds for initiation of development
Research and Analysis Enhancement	---	3.3	-3.3	---	Deletion of funds for advanced research and data analysis, and geodynamics

	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	△	FY 1981 Budget Request to Congress	Remarks
Technology Transfer Enhancement	---	1.5	-1.5	---	Funds for increased effort in remote sensing area were denied
Large Antenna Multifrequency Microwave Radiometer	---	2.5	-2.5	---	Deletion of funds for instrument development
Stereosat	---	5.0	-5.0	---	Deletion of funds to conduct a solicitation of private industry in order to determine the extent of use for the project
Landsat-D Ground Data Handling Capability	---	---	+10.0	10.0	Inclusion of funds to augment ground data handling capability for Landsat-D
Technology Utilization	12.1	16.4	-3.3	13.1	
Bioengineering Enhancement	---	1.8	-1.8	---	Deletion of funds for an additional biomedical application team
Technology Applications Enhancement	---	1.5	-1.5	---	Deletion of funds for additional effort to transfer NASA technology to to the private sector
Other Technology Utilization	12.1	13.1	---	13.1	
Aeronautical Research and Technology	308.3	332.3	-42.0	290.3	
Aeronautical Projects Approved	308.3	280.8	---	280.8	
Rotorcraft Design Methods and Criteria	5.0	8.0	-3.0	5.0	Funding adjusted consistent with initiation in FY 1980 as approved by Congress
Variable Flow Propulsion Systems Tech.	3.0	6.5	-2.0	4.5	Funding adjusted consistent with initiation in FY 1980 as approved by Congress
Numerical Aerodynamics Simulator	---	3.0	-3.0	---	Funds for systems design and engineering were deleted

	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	△	FY 1981 Budget Request to Congress	Remarks
Large Composite Primary Structures	---	4.0	-4.0	---	Deletion of funds for systems technology project
Controls and Human Factors Phase I	---	5.0	-5.0	---	Deletion of funds for systems technology project
Aircraft Technology for Future Fuels	---	4.0	-4.0	---	Deletion of funds for systems technology project
Conservation of Scarce Aerospace Metals	---	1.0	-1.0	---	Deletion of funds for identification and evaluation of scarce metal alloys applied to aeronautical vehicles
Rotorcraft Configuration/ Component Technology	---	7.0	-7.0	---	Funds required for project were deleted
Avionics and Flight Management	---	4.0	-4.0	---	Deletion of funds for design and validation technology
General Aviation Propeller Technology	---	1.5	-1.5	---	Funds to establish detailed design characteristics in the regimes of interest were deleted
V/STOL Propulsion Systems	---	2.0	-2.0	---	Deletion of funds for increased effort
High Performance Flight Experiments	---	3.5	-3.5	---	Funds required for the experiments were deleted
Small Transport Aircraft Technology Phase I	---	2.0	-2.0	---	Funds for development and validation activities were deleted

	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	△	FY 1981 Budget Request to Congress	Remarks
Space Research and Technology	115.8	150.0	-34.8	115.2	
Space R&T Base	99.8	111.4	-8.0	103.4	Reduction to minimum level and deletion of proposed enhancement of advanced space engine technology
Systems Studies	2.2	2.4	-.2	2.2	Reduction in level of funds requested
Information Systems Technology	2.6	13.8	-8.7	5.1	Deletion of funds for Phase III of NASA's End-to-End Data System, and for sensor systems technology enhancement
Spacecraft Systems Technology	6.2	14.4	-12.0	2.4	Deletion of funds for enhancement of space platform advanced technology and spacelab payloads
Transportation Systems Technology	---	5.9	-5.9	---	Deletion of advanced technology funds for Composite Structures and Orbital Transfer Vehicle Propulsion
Standards and Practices	5.0	2.1	---	2.1	
Energy Technology	3.0	5.4	-1.4	4.0	Reduction in proposed funding for identification and verification of technology applicable to energy needs
Space Tracking and Data Acquisition	332.4	364.4	-5.4	359.0	
Support for Upper Atmosphere Research Satellite	---	.2	-.2	---	Deleted consistent with proposed mission
Support for Venus Orbiting Imaging Radar	---	1.3	-1.3	---	Deleted consistent with proposed mission
Other Tracking and Data Acquisition	332.4	362.9	-3.9	359.0	Partial deferral of funds for network consolidation
Total Research and Development	4107.5	4800.8	-231.3	4569.5	

	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	△	FY 1981 Budget Request to Congress	Remarks
Construction of Facilities					
Rehab. & Mod., Repair, Minor Const., & Discrete Projects Approved	142.1	110.0	---	110.0	
Construction of Rotorcraft Operations Area - ARC	---	2.5	-2.5	---	Deletion of funds to provide a special flight test area for conducting rotorcraft operations
Construction of Addition to the Technical Processing Facility - GSFC	---	6.8	-6.8	---	Deletion of funds to provide space for data analysis equipment and applications program supporting activities
Construction of Waste Materials Incinerator - KSC	---	.8	-.8	---	Deletion of proposed funding
Construction of Centralized Condenser Water System - JPL	---	2.2	-2.2	---	Deletion of funds for construction of water tower to replace 15 small, dispersed tower
Construction of Large Aircraft Maintenance Dock - DFRC	---	1.8	-1.8	---	Deletion of funds for installation of a large Air Force surplus dock for aircraft mating and operations
Construction of Remote Operation for Deep Space Network Power Plants at Various Locations	---	1.0	-1.0	---	Deletion of funds to provide remote operations for seven manually operated power plants
Modifications to Various Buildings and Systems - Various Locations	---	12.6	-12.6	---	Deletion of funds for modifications to buildings, chiller systems, HVAC systems, and test facilities

	FY 1980 Operating Plan	FY 1981 Budget Request to OMB	△	FY 1981 Budget Request to Congress	Remarks
Facility Planning and Design	14.0	12.0	-2.0	10.0	Reduction in the level of activity for advanced planning and design
Augmentation to Deep Space Network	---	17.5	-17.5	---	Funds for a 40 meter antenna and support were deleted
Small Engine Test Facility	---	8.8	-8.8	---	Funds to provide a capability for small engine component testing were deleted
Engineering Building	---	13.5	-13.5	---	Funds required to construct an engineering building at JPL were deleted
Total Construction of Facilities	156.1	189.5	-69.5	120.0	
Research & Program Management	1006.1[2/]	1053.1	-5.9	1047.2	Reduction in request for travel funds and replacement aircraft
TOTAL NASA	5269.7	6043.4	-306.7	5736.7	

[1/] Includes supplemental request for $300.0 million
[2/] Includes pay raise supplemental of $46.3 million

Mr. FLIPPO. Dr. Frosch, do you think that NASA can adequately define the Nation's future space program with the current level of advanced program funding?

Dr. FROSCH. The advanced program funding area you're describing is the one which is included in space transportation system program. There are advanced planning funds in space science, space applications, tracking and data acquisitions and so on. But just keeping to that area, I think the most important things in priority order are to get the space transportation system going. Then there are certain improvements to that and built around that, including a 25 kW power system and including the program we have been defining in large space structures. Those are the things that clearly need to be done next. Faced with the priority situation, I put my first priority on getting the system operating, and then the improvements.

I think we have, while thin, adequate planning funding for definition and evaluation of potential future space missions and systems. The things that will appear in the next few years' budgets are already pretty well defined, and I think the question is more of budgeting for them in the appropriate years rather than predicting what they'll be.

In the longer run, I think we are going to face some problems in getting things well enough defined.

Mr. FLIPPO. Those latter things that you're talking about, those really reflect the future of NASA, don't they?

Dr. FROSCH. Yes, there are some very interesting new ideas that have emerged, and we are going to work on them. We will not be totally lacking in advanced planning. We just won't do as much as we would with more funding.

Mr. FLIPPO. I thought your comments in regard to seed planning were very appropriate.

Dr. FROSCH. We've started two kinds of exercises in NASA, both aimed at producing new ideas. One is what we've called the innovators' meetings. We had one meeting last June, and another meeting is scheduled for June. We try to get together a group of people, some who have been associated with NASA and some who have not, simply to see whether there are some new ideas that we ought to be taking into account. Out of last year's meeting, we had a number of things that are exciting and interesting and potentially very significant that we're beginning to think about and work on.

We have also put in the hands of each center director an amount of money to be used at the center director's discretion for the early fostering of new ideas that arise in the center or in the technological community the center has contact with. It is specifically money not to be used to solve problems in the existing program. There is no requirement to come to Headquarters. The judgment is to be made after the work has been funded on the basis of whether the whole pattern of what the center director has been choosing to do makes sense in a NASA context. We've had 1 year of experience with this and it has been excellent. Some of the ideas, in fact, have already gone into application in the program and elsewhere, and we've increased, in a modest way, the amount of funding in that activity. We are out looking for ideas.

Mr. FLIPPO. Thank you.

The CHAIRMAN. Mr. Goldwater.

Mr. GOLDWATER. Thank you, Mr. Chairman.

Dr. Frosch, carrying on with the Space Shuttle, one of the problems that NASA's had on this program has been the tiles. The other thing that's caused extensive delay was the Space Shuttle main engine, which has run into a number of problems over a period of time.

I wonder if you could give the committee an update on where that engine is, whether in fact all the bugs have been worked out of it, and do you anticipate further delay because of the engine problems?

Dr. FROSCH. I think we are now at a stage where we have been able to demonstrate that the engine operates at 100 percent power level, for full duration flights, and have demonstrated that the cluster of three engines can be operated for a full duration at 100 percent power level.

I would say that the question now is not whether the engine operates and operates satisfactorily for flight duration, but how much testing is required to give us a sufficient feeling of reliability. That's what we're working on now. Behind that comes the question of how much reusability have we really built into the engine? That is the key to the Shuttle economics. It's clearly a reusable engine, but right now we have not demonstrated to ourselves that it's 55 times reusable. We do have engines that have run a number of times satisfactorily at the rated power level. We're in the certification process now.

When we have completed the preliminary flight certification—and I would expect this to be sometime in the summer of 1980—we'll begin pushing the engine toward the 109 percent power level design. We have enough confidence to believe that we'll be finishing out our 100 percent RPL demonstration on the engine by the middle of this year and then going on to the higher power levels.

Some of our problems have been what I'll call secondary problems. The last problem with the main propulsion test was a good example. The problem in the test was a seal inside the high pressure oxygen pump of one of the engines and the engine system did the right thing, it shut down the test. It was satisfactory for two engines, but the third engine experienced a collapse of the shock wave, which happens in the atmosphere, but wouldn't happen in a real flight in space. There wouldn't be a shock wave because there wouldn't be any atmosphere. The shock wave collapsed as a result of the engine nozzle and vibrations and a liquid hydrogen pipe broke, which starved the engine of fuel resulting in an oxygen-rich mixture which caused extensive engine damage. The break was not due to design problems. It was due to improper weld wire being used in that weld, and good detective work discovered that we had the incorrect welding wire mixed in with correct welding wire in boxes labeled for correct welding wire as it has come from the supplier. We had to analyze over 1,800 welds per engine to insure it was the right material. We now know about the details of how weld wire is manufactured and how one can get into that kind of problem.

We've chased that problem down. It is not an intrinsic engine problem, but it lost us several months. I think the engine is coming

along to a good maturity, and I hope we will see that in the next main propulsion test.

Mr. GOLDWATER. But you're confident that most of those problems that you've encountered have been ironed out and that you don't anticipate any further problems with the engine itself?

Dr. FROSCH. We're confident with the design of the engine. We've had enough running so it would be hard for use to believe that there could be some fundamental problem that has not turned up.

What we're really looking at is making sure that all the parts have the reliability that we need to be ready for flight.

Mr. GOLDWATER. Turning to the aeronautics portion of the budget, there are some bad things and there are some good things. The worst, in my opinion, is the reduction from $308 million to $290 million, which obviously goes against the wishes of this committee as expressed in previous hearings.

The good things that I would point out that I feel are in the budget include the continued work on the advanced variable cycle engine, and, obviously, with the increased concern for fuel efficiency your continued work on the advanced turboprops, and the extreme interest that seems to be generating in the user community for more advanced technology in propellers and turboprops; also your rotorcraft and also your tilt rotor.

The committee pushed hard for the variable cycle engine, as you know, and the turboprops. Both of these, I think, offer and will make a contribution to lower fuel consumption and lower noise levels.

The rotorcraft technology has both civil and military uses. Unfortunately, the latter is growing in importance after recent world events.

One of the questions I have is: Why has your aeronautics budget been reduced?

Dr. FROSCH. I think the overall change in the aeronautics budget comes because the profile of expenditures in the ACEE program, the aircraft energy efficiency program, has begun to decrease. We have passed the peak funding of the ACEE program. As you recall, the ACEE program was intended as a more or less fixed duration program, a push in order to improve technology for fuel efficiency on a rather near term technology basis. We've gotten most of that underway, and that program is beginning to tail off, and since it was a large program it shows pretty much in the total of the budget.

You've mentioned many of the newer things that have been coming along in the past couple of years, and I think it is the case that in fiscal year 1981 aeronautics budget essentially all of the things that the committee has been particularly interested in that we have brought forward as new technology are continued or increased. The total budget is down, but I think the diversity of activity is up. In fact, the portion that we call the research and technology base is the more basic and early engineering work, which is analogous to the type of advanced planning that Mr. Flippo was asking about earlier. But, this part of the aeronautics program is much more in-house and contract laboratory and test work. It has increased by about 10 percent between fiscal year 1980 and fiscal year 1981. What is really down is the runout of previous

programs, and we have not at this point identified and begun to start up on a major new near-term program. I think there is a policy question as to how much of the near to production technology program we should be doing and of what kind.

Mr. GOLDWATER. There are many of us who feel that once you allow these budgets to sink that they are difficult to recover, and I'm wondering if we should be fearful of funding or starting such large programs as the aircraft efficiency program in the future because the thing that bothers me is that obviously you should have foreseen this wind down. Why not use that, available funds, so to speak, for additional starts or emphasizing other programs?

Dr. FROSCH. One thing which will certainly happen is that as we come along in the technology in the advanced rotorcraft, variable flow propulsion, and turboprop systems, those will begin to be somewhat larger. I don't think any of them will be of the size of the whole collection of things in the aircraft energy efficiency program, but those are, in effect, new starts. Two of them were new starts in fiscal year 1980, which are going to grow if they show the technological promise we believe they're likely to. But that remains to be seen.

Mr. GOLDWATER. I just have a few more brief questions I want to pursue.

One which I think is very important is your working relationship with the Federal Aviation Administration. I know there have been efforts made at your level and at Mr. Bond's level to try to obtain the best working relationship. Both of you deal in an area of aviation or aeronautics.

I've been watching you over the years, and I get concerned about duplication of effort. Especially in the area of inflammability and toxicity of materials. You have a big laboratory, I think, down at Langley.

Dr. FROSCH. Yes.

Mr. GOLDWATER. And I think the FAA has been doing some work out in Oklahoma, and I know the Air Force does a lot of work in this area, and a lot of private laboratories and universities do work in this area.

I don't want you to go into a lot of detail, but how would you summarize your relationship with the FAA, and are there problems with this? Is your only agreement at the higher levels or do you actually have some working relationships that would allow the cross-fertilization of expertise and resources in NASA and the FAA, and do you feel that NASA could do more to supplement the FAA's efforts in aviation safety, human factors work, or aerodynamic work, as well as in the electronics area?

Dr. FROSCH. We have a number of mechanisms for being sure that we're coordinated and doing the right things together. They include, as you mentioned, my own contacts with Mr. Bond, and we meet from time to time. There are direct NASA heaquarter's relationships between our aeronautics people and the FAA technical staff. There are areas in which we have colocation of effort, in which there are FAA people at NASA places and from time to time NASA people at FAA places. Some of the programs we do directly to the requirements of the FAA. I think we are pretty well tied together. It's always impossible to say that there aren't some

things that are not tied together, but I think the effort works pretty well.

In an area like fire materials research, aside from the formal mechanisms, the community of people who are engaged in that kind of engineering—I think it's properly described as a community of people—are not a very large population of specialists, and they communicate and keep an eye on each other pretty thoroughly, partly because they have something of a competitive feeling and each of them wants to know what everybody else is doing; also because they are working on the same problems; and they keep a pretty good contact. I don't think that's and area in which we need to worry too much about redundancy of research.

Mr. GOLDWATER. How is your search coming for a replacement for Dr Kramer?

Dr. FROSCH. Al, do you want to comment?

Dr. LOVELACE. We have a search committee that is scheduled in fact to report their findings at the end of this month. We have a number of, I believe, qualified candidates on that list, and I think our problem will not be one of finding, but rather, of selecting from that qualified list. I would be hopeful, although it's difficult to predict in these matters, that by the end of February we would have that selection completed.

Mr. GOLDWATER. Thank you.

Mr. FLIPPO. Mr. Nelson.

Mr. NELSON. Dr. Frosch.

I wanted to ask: You mentioned that OMB had not funded a power boost module for the Orbiter. Is that for a DOD mission?

Dr. FROSCH. That was the power extension package. What this would do is increase the amount of available power to the Orbiter while operating by adding some solar cell arrays to the system. This would give us the possibility of increasing the duration of flight. I would say that it is as much or more something that NASA feels it requires than the DOD.

Mr. NELSON. In fiscal year 1981 you're asking for $1.873 billion. How much is that revised upward from what you were projecting about 1 year ago for fiscal year 1981?

Dr. FROSCH. This is with regard to the total Shuttle?

Mr. NELSON. Right.

Dr. FROSCH. It's about $800 million up from the fiscal year 1981 column of the fiscal year 1980 budget, the original fiscal year 1980 budget.

Mr. NELSON. So we've gone up then $300 million in the supplemental that you're going to ask for 1980 and another $800 million that you're going to ask for fiscal year 1981.

We've talked about this before, but perhaps you could articulate for me what would be the most persuasive language to use in the Budget Committee. Other than what you've stated here can you articulate a statement in an unclassified way on the defense mission that might be persuasive in getting this $300 million supplemental?

Dr. FROSCH. There are several defense missions, but I think DOD should speak to those requirements. They have stated to me that there are defense missions that are crucial to our ability to use space, to know what's going on, and to be able to defend ourselves

in the period of the mideighties. These are missions that are planned for and, in one case, have no alternative but a Shuttle launch. We are calculating our production schedule in terms of the defense requirements as the way in which we set the scheduling of production. That is, we must meet certain delivery dates with the second and third Orbiters in order to carry out the defense missions. We must also meet certain delivery dates in order to launch the tracking and data relay satellite system, which is part of the space transportation system, both for our use and for DOD use. So, we have several Shuttle missions that must take place on time.

This really relates to the essential need for the funding of the production of the Orbiters. However, if we can't do a first development flight then we simply don't know when we will be able to certify those Orbiters to fly. Now, those two are not tightly coupled, but long delays in first development flight would certainly impact the ability to go operational and the ability to do the operational flights.

Should we not get the supplemental, then we would have to look at a stretched out plan. The first cut at those plans suggests that there are two or three possible ways to go about it. One is to balance the stretch both in development and production on a basis that would have a 4- to 7-month slip each, and the effect on production would mean not meeting the defense requirements. It would make no sense to put all of the delay into a development program because that would simply mean that the first flight would come so late that we would not have confidence in the production articles by the time required therefore, it must be split between the two. There would have to be an impact on production, no matter how we shared them, and as soon as there's an impact in production then we miss the defense schedule. It is really, from the point of view of timing, particularly the production, quite tightly tied to the defense requirement.

Mr. NELSON. I thank you.

Thank you, Mr. Chairman.

I might point out that 150 people turned out for the filming of this television show at 7 o'clock in the morning. So that speaks for what our community thinks of you, Dr. Frosch. That's a compliment to you.

Dr. FROSCH. I took that as a response to your television program.

Mr. FLIPPO. Mr. Walker, I understand, is going to yield to Mr. Wydler.

Mr. WYDLER. I would appreciate it.

Mr. WALKER. Mr. Chairman, I would hope that you would come back to me. I'm going to yield my place in line to him, but I would like to ask some questions.

Mr. FLIPPO. We certainly will.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. WYDLER. Thank you, Mr. Chairman.

I'm sorry to come late, and I'm sorry I have to leave early, but unfortunately I'm a member of the conference committee on the synthetic energy bill, and that's a rather pressing matter.

However, I just want to say that I've been one of those who has been critical of the space agency in times when it was flying high and I've been supportive of it in times when it had a lot of critics. I

find myself at this time in a position of trying to help the agency by getting all the facts out before the public, and I think we'd better do that; give them the bad news, and give it to them full blast. I think they can stand it. I don't think they'll fall apart as a result. But I think we're sort of slipping it out bit by bit and it makes it sound worse to me than it does otherwise.

Doctor, can I get a straightforward answer to the question: When do you really think that we'll get the first Space Shuttle flight into the air?

Dr. FROSCH. Not before November.

Mr. WYDLER. I hope not on election day. [Laughter.]

Dr. FROSCH. Certainly not on election day. Not before November, and between November and the end of March.

Mr. WYDLER. All right. So you're thinking in terms of about a year as a realistic figure. Is that what you really are considering over at the agency?

Dr. FROSCH. A year from now?

Mr. WYDLER. Yes; a year from now, more or less in those terms is what you're really considering over at the agency.

Dr. FROSCH. That's about right.

Mr. WYDLER. And is the main problem at this point still the tiles?

Dr. FROSCH. The main problem at this point is assuring ourselves of the mechanical integrity of the tile system; yes, sir.

Mr. WYDLER. What are we doing about getting a substitute for the tiles in the future? I think it's going to be a continuing problem. I'm not a scientist. I'm not even a technical person. But the first time I saw those tiles on the craft I looked at it and I said, "That looks like the inside of my bathroom. I don't think it's going to work." It's a very, very weak system. I mean just looking at it you can see that.

Are we doing something to get a different system built for the future, or are we going to have to go with this tile system for many flights?

Dr. FROSCH. I think we're going to have to go with the tile system for many flights. We are in the laboratory looking at some materials that would be considerably better. The next generation of materials would still be tile materials, but better materials. There is also the possibility of what I would describe as a felt-like material which would be far more like putting a skin on a portion of the Orbiter than like gluing tiles on the orbiter, and that would be a considerable improvement. But I think no one in the laboratory working on it would feel confident that that will be ready to put on an orbiter for several years.

Mr. WYDLER. I was thinking in terms of something which would be sections instead of tiles.

Dr. FROSCH. That's what the felt-like material would do. The difficulty with the tiles in sections, of course, is that it's a brittle material and too large a section would be likely to crack.

Mr. WYDLER. It doesn't look like we've got that under control, and I think it's going to be a continuing problem. I really don't think that hoping for the best in the future is going to help much. I think we really better go on some sort of a crash program, not for

this Orbiter only but for the future ones, because we've had a lot of trouble with that.

Dr. FROSCH. We badly need some flight data on what the forces are that that system really has to be proofed against.

Mr. WYDLER. Assuming that we did the best, which is that we get this up in about a year from now, what is going to be the cost overrun? Are we talking about a billion dollars or more?

Dr. FROSCH. In the D.D.T. & E. we're talking about a growth of 20 percent from the original estimate in 1971 dollars. In 1971 dollars that comes out to be about $1.1 billion. Now, if you inflate that it's quite a different figure, of course.

Mr. WYDLER. I don't exactly understand what you've done fiscally. Are you using 1971 dollars in place of what we're spending now? We're not marking down the dollars we're spending today to 1971 dollars though?

Dr. FROSCH. No; I can mark those down, of course. If you do that then the original total estimate in 1971 dollars for D.D.T. & E. is $5.150 billion, compared to $8.813 billion in 1981 dollars. The biggest part of that increase is straight inflation. That's about the only point.

Mr. WYDLER. You're talking about $1.1 billion, the way you figure it.

Dr. FROSCH. In equivalent 1971 dollars.

Mr. WYDLER. Rather than trying to figure out how you're figuring it, could you give me a one-page summary of how you've come to that number so I can see how you're changing what figures to arrive at the 1.1 billion in terms of real dollars, and so on, whatever you've done, so I can really judge?

Dr. FROSCH. We'll provide that.

[The information to be provided is as follows:]

The current total estimate for Shuttle development, including the proposed fiscal year 1980 supplemental appropriation and the fiscal year 1981 budget estimate, is $8.813 billion in dollars of the fiscal year 1981 budget. The original estimate given in 1972 for Shuttle development was $5.150 billion in 1971 dollars. If the $8.813 billion current estimate is adjusted to eliminate the effects of inflation, the 1971 dollar equivalent of the current estimate is $6.185 billion. Therefore, the growth in the development estimate measured in constant 1971 dollars is $1.035 billion or approximately 20 percent from the original $5.150 estimate.

STS NONRECURRING COST ESTIMATES

[In billions of dollars]

	Fiscal year 1980 budget estimate		Fiscal year 1981 budget estimate	
	1980 budget	1971 equivalent	1981 budget	1971 equivalent
Shuttle nonrecurring costs	11.127	7.613	12.421	8.185
Shuttle development (D.D.T. & E.) [1]	8.386	5.986	8.813	6.185
Initial fleet investment to include the procurement of two orbiters and the modification of two orbiters bought in D.D.T. & E.	2.275	1.327	3.141	1.658
Initial facilities for development, test, manufacturing, production and a launch capability at KSC	.466	.300	.467	.300
Additional investments to fly 581 model	1.500	.799	1.858	.944
Expendable launch vehicle mods for early Shuttle flights [2]	.355	.234	.558	.334
Facilities at Western Test Range [3]	1.145	.565	1.300	.610

STS NONRECURRING COST ESTIMATES—Continued

[In billions of dollars]

	Fiscal year 1980 budget estimate		Fiscal year 1981 budget estimate	
	1980 budget	1971 equivalent	1981 budget	1971 equivalent
Total of above	12.627	8.412	14.279	9.129

[1] Last year's Shuttle development estimate is based on the projected runout of the fiscal year 1980 amended budget.
[2] Represents the projected DOD development of the IUS and NASA involvement in the development of NASA and other non-DOD unique IUS requirements (including GSE) and of the SSUS.
[3] Represents unofficial DOD estimate.

Mr. WYDLER. What will the numbers be that you'll request from Congress in the future in those real terms?

Dr. FROSCH. The fiscal year 1981 budget finishes the development program. We would not expect the fiscal year 1982 budget to have any money in it for development. There would be money in it for production and for operations.

Mr. WYDLER. So there would be nothing beyond 1981?

Dr. FROSCH. Not in development.

Mr. WYDLER. Assuming a March flight, you're not expecting to ask for any further money?

Dr. FROSCH. Not any more for development.

Mr. WYDLER. For the first flight other than what's in the budgets to date, including the 1981 budget?

Dr. FROSCH. That will finish out first flight and the other development flight tests. There would then be in the budget the continuation of manufacturing of the other orbiters, funding for upgrading and changes in the system required by the results of flight tests, and funding for operations.

Mr. WYDLER. All right.

Thank you, Mr. Chairman.

I would just urge you to, as I said a year ago, restore, to the extent you can, the spirit that NASA had, which was they were going to overcome each and every obstacle to do something which was very unique in the world. I realize that was full of problems, but NASA had in the Apollo program the spirit of "can do," and it's something that really has to be restored in NASA now, the "can do" on the Shuttle. Very much of our national prestige is at stake, and I think we're suffering blows right now, but it still can be turned around if the people at NASA do the job they did in the Apollo program.

Dr. FROSCH. I think we have the "can do" spirit. The only thing that can prove it, however, is doing it, and that's going to be the success that we will come to.

Mr. WYDLER. Thank you, Mr. Chairman.

Mr. FLIPPO. Mr. Volkmer.

Mr. VOLKMER. Thank you, Mr. Chairman.

Dr. Frosch, I would like to continue the train of thought of the gentleman from California, Mr. Goldwater, on the aeronautics, and as I look over your request that you made to OMB I find that there are items that were not funded in the budget as it comes to us.

That's correct, isn't it?

Dr. FROSCH. Yes, there are items that went to OMB that are not in the budget, yes.

Mr. VOLKMER. There are items.

Dr. FROSCH. Would you like to know what those items are?

Mr. VOLKMER. No. I have those items. I would like to know why we didn't get them.

Dr. FROSCH. The budget we submit to OMB is a zero based budget. That is, we forward a list of items in priority which, in fact, we estimate to be longer because it requires more money than the President is likely to allocate to NASA for all purposes. So that in a sense we are purposely putting forward a richer menu than will end up in the budget, and we then, in effect, go into discussions and negotitions with OMB and perhaps finally make an appeal to the President for the particular items that have been eliminated.

I think the real answer to the question is that this budget is the result of a long series of discussions, which were pro and con on mny items. What we got was more or less what was in our priority order, with the list sliced at the total that OMB and the President were willing to allocate to NASA.

Mr. VOLKMER. In other words, I think I understand what you're telling me is that you got a lid, you got your priorities, and this is the amount that you can use within those priorities, and the rest of them are lower priorities, the ones that are not funded.

Dr. FROSCH. Yes.

Mr. VOLKMER. And if Congress would fund them you could still use the money for such things as your V/STOL Propulsion System, or Avionics, those types of programs, is that correct?

Dr. FROSCH. Yes. Those are valid programs.

Mr. VOLKMER. All right. Then it would be incumbent upon the Congress to make that determination, this committee to make that determination, as to whether or not our priorities may differ from OMB's.

Dr. FROSCH. That is the responsibility of the committee as I understand it.

Mr. VOLKMER. Thank you very much.

Mr. FLIPPO. Thank you, Mr. Volkmer.

Mr. Walker.

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

You say that you've developed an improved interface with the Pentagon on many of your cooperative programs.

Has there been any discussion with the Pentagon about the usefulness of having more "man-in-space" flight activity in the future?

Dr. FROSCH. The Air Force, who is the appropriate agent for the Defense Department, has done a fairly major study over the past year or so, looking exactly at that question of the use of people in space. I think I could say that their conclusion is that they feel that the usefulness of people in space for many of their missions will be much greater than they had originally thought several years ago. They're thinking in terms of both research and development use, in terms of experiments with regard to various military systems, and, indeed, some operating uses where the work to be done has to be adjusted to the results on the spot and in space.

They are also thinking in terms of having a fair number of military in the astronaut corps.

Mr. WALKER. So in terms of the Pentagon's representations to you, the answer to the question is yes?

Dr. FROSCH. Yes.

Mr. WALKER. They feel as though manned flights or man in space type of activities need to be increased in the future?

Dr. FROSCH. Yes.

Mr. WALKER. Then don't you think, in terms of the budgetary analysis that you've given us here, that it's time to rethink where we're headed in the space program?

I tend to agree with Mr. Flippo. I see very little beyond the Shuttle in this budget that there's any thinking toward the future here as to how we could expand the man in space activities. Sure, we're devoting our resources to the Shuttle. That is the first priority. But I think you have to have some advance planning out there too as to what we could do, particularly now that the national security has received so much emphasis in the President's speech the other evening. If national security considerations are there, don't you think that the budget should begin to reflect the fact that we do in fact need more men in space?

Dr. FROSCH. The budget is going to have to reflect increased experimentation in what people can do in space over the next few years. We have done a good deal of planning. The real funding problems will come when we begin to do the experiments, and I think that's going to be about 1983 and 1984.

To some extent there is money in this budget for that, and some of it is in the spacelab area, which will have the first real sets of experiments in which we have people working in space. Some of it is in the area of structures planning, and that's going to get bigger over the next several years.

Mr. WALKER. If you had more funding couldn't the timetable on some of those things be speeded up?

Dr. FROSCH. Of course.

Mr. WALKER. So if the Pentagon is making the representation that they in fact need more men in space, if more funding could speed up the timetable, then with this budget we are really adversely impacting on the national security options available to us in the mid-eighties by not taking the route of increasing the funding for man in space activities. Isn't that true?

Dr. FROSCH. We're doing less than we could be doing if we had more money.

Mr. WALKER. So if we're really concerned about national security we ought to be doing more in that area.

Dr. FROSCH. I think it would be useful, but I think that has to be planned with the DOD, and we have yet to do the details of that.

Mr. WALKER. Again, should this committee be pushing to see to it that that detail work is done immediately?

Dr. FROSCH. I think it would be useful for the committee to express its views on that matter.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. FLIPPO. Thank you, Mr. Walker.

Mr. Brown.

Mr. BROWN. Mr. Chairman, I would like to ask unanimous consent to insert a paragraph of prepared remarks at the beginning of the hearing, if I may.

Mr. FLIPPO. Without objection, so ordered.

Mr. BROWN. Dr. Frosch, as you know, I have an interest in the applications aspects of the program in the resource sensing and the communications satellite area. There are several aspects of this that we probably won't have time to get into, but I would like to approach them.

It seems to me as you move ahead with the operational resource sensing program which is now under NOAA's jurisdiction and with the NOSS program, and with the additional communications satellite research program that you're going to be faced with an increasing number of problems which we might call institutional in nature, that is, identifying, aggregating user communities, and organizing of the respective roles of the private sector, the public sector, and so on.

My question is whether or not you feel that NASA has a role in the policy planning aspects of this. For example, to be specific, you went through some exercises with the applications technology satellite, and you will be doing this with the communications, what is it, CTS?

Dr. FROSCH. We have done some with the CTS.

Mr. BROWN. The communications technology satellite, in which there are some real institutional problems in how you bring together user organizations, the appropriate role, and so on.

What does NASA do about these? Are you actively involved in the kind of policy planning that this kind of problem requires, or not?

Dr. FROSCH. We have been actively involved in two ways. One, in consultation and working together with the agencies that have operating responsibilities. We have tried to assist them with what we have learned, and, as you know from the history, Mr. Brown, we have learned some things not to do, as well as some things to do. We're trying to make sure that that capability is not passed over. In particular, we're working very closely with NOAA in their planning for the operational remote sensing system, and expect to continue to be involved in it because we will continue to perform the research and development and initial procurement role. So, we will continue to be user oriented in that research and development and would work with NOAA in developing it further.

The same thing is true with regard to NTIA with regard to public broadcast and public service users. In other areas, we have been very active in trying to invent institutional mechanisms. For example, in the matter of space materials processing, we think we are in the process of developing a new way for industry and government to work together on a joint venture basis to do something that properly shares benefits and costs between the public and private sector. It's too early to say whether we've been sucessful, but at least we have in one case been successful in coming up with a legal instrument that shows that we know what we're doing. If that works, I think it will be another institutional mechanism that can be used. We do see ourselves as having some responsibility in that area.

Mr. BROWN. Won't that responsibility become greater as we develop more sophisticated capabilities in both communications and the resource sensing areas?

Mr. FROSCH. Some of it will now be a shared responsibility with the agencies that have the operating responsibility. I don't know whether it becomes greater or less, but it certainly remains there.

Mr. BROWN. Let me ask you specifically about your reentry into the communications satellite research, which we've had some discussion about. I think it's obvious, in the light of proceeding to work in other developments, that this is becoming an increasingly vital area. It seems to me that the projection which you've made of, I think you say, $10 million for a definition study is a rather small reaction to this increasing problem, which not only has vital international aspects in terms of international competition for geostationary orbit and frequency allocation, but which has substantial domestic commercial aspects, it seems to me, in terms of being able to keep ahead of a very rapidly developing technological area.

Can you tell me and tell the committee what you thought would have been the maximum program that the agency should have had in this advanced communications satellite research for next year?

Mr. FROSCH. As I recall, this is the amount that we asked for in communications. The point is that at this stage we are in the ground technology research stage and, while we could, I suppose, sensibly use more money perhaps, 50 percent more, the real expenditure will begin to come when we're successful in the ground technology and are prepared to do demonstrations of technology in space. The communications industry is quite interested in cooperating in such flight tests. There is a potential for a flight start in communications perhaps as early as the fiscal year 1982 budget.

Mr. BROWN. In defining your system, which is a subject of your research area, are you including the transmitting and receiving antennas as well as a part of the overall work that's to be done?

Mr. FROSCH. Yes, new kinds of antenna systems are a key part of this whole technological thrust.

Mr. BROWN. So that the efforts to develop smaller receiving dishes, and so forth, are a part of that?

Mr. FROSCH. Yes, and doing that depends sensitively on the ability to have fancier antennas in space, beam pointing, and so on.

Mr. BROWN. That gives you a very significant interface with private industry in this technology field.

Mr. FROSCH. Yes, very much so, and we have been working this with the communication industry and will continue to do so.

Mr. BROWN. Mr. Chairman, I won't pursue this further because of the time constraints.

Mr. FLIPPO. Thank you, Mr. Brown.

Just one quick question, Dr. Frosch.

Are you satisfied with the progress of the IUS and its availability and capability to meet NASA mission requirements?

Mr. FROSCH. It would be nicer for us if it had progressed a little faster. It appears that it will be available when we require it. We still need to find out what the costs are, but that negotiation is still in progress by the Air Force.

Mr. FLIPPO. Thank you.

We deeply appreciate your coming forward today and your testimony. Thank you very much.

Dr. FROSCH. Thank you, Mr. Chairman.

Mr. FLIPPO. Now we have Mr. Bond, the Administrator of the FAA. Mr. Bond, I think perhaps we'd better try to proceed, so if you would, we will now take the testimony of Mr. Bond at this time. We're pleased to have you with us today, Mr. Bond, and you may proceed at your discretion.

Mr. BOND. Thank you, Mr. Chairman.

I have a prepared statement for the committee. With the permission of the committee I would like to put it in its entirety in the record, and perhaps I could skim through it and summarize the high points of it, and then we could go to questions and answers in light of the lateness of the hour of the morning.

Mr. FLIPPO. I think that would be very appropriate.

[The statement of Langhorne M. Bond follows:]

STATEMENT OF THE HONORABLE LANGHORNE BOND, ADMINISTRATOR, FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE, CONCERNING OVERVIEW OF THE FISCAL YEAR 1981 BUDGET PROGRAM, JANUARY 29, 1980.

Mr. Chairman and Members of the Committee:

It is a pleasure to appear before you to discuss our Engineering and Development Program. While the FAA has not appeared before the full Committee in past years, we have been aware of its high interest in our programs through its deliberations on the reports submitted by the Subcommittee on Transportation, Aviation, and Communications. We appreciate the assistance of the Committee. You have been supportive and have provided sound guidance in several key areas.

We are scheduled to provide Congressman Harkin's Subcommittee on Transportation, Aviation, and Communications with our Semi-Annual Report on our Research and Development Programs in mid-February. Since that report will be in rather fine detail, I will, this morning, provide you with a general overview of the program and dwell for a few moments on several major topics of particular interest.

A measure of any R&D organization is its responsiveness to those who will utilize the products it develops. This

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morning I had the pleasure of opening a two-day conference which will provide FAA's initial response to user and industry views on what our air traffic control system should be to meet the demands for services through the Year 2000. The first step of this process, which we call the New Engineering and Development Initiatives, was to assemble the various segments of the user and industry community and solicit their views on a large number of issues. The user/industry community established five working groups comprised of some of the most talented operational and technical experts to address the issues within their areas of expertise. The Working Groups, operating independently of the FAA, developed an extensive set of recommendations covering the entire spectrum of requirements for the 1990's and beyond. Their recommendations, unedited by FAA, were then provided to the entire community for its review and comment. We have the comments and are now responding to them.

I am extremely pleased that the Working Groups' recommendations and the user community comments are overwhelmingly supportive of our ongoing and planned E&D Programs to meet the requirements of the 1990's and beyond. Our user constituency is too wide and diverse in its

interests to develop a total consensus for each of our programs, but when viewed from an overall standpoint, the recommendations come out strongly in support of our programs. The result reflects the time and effort that have been spent with the users over the years to explain our programs, solicit their input, and apprise them of our progress. We're not perfect but we've made major strides in involving our customers in our E&D programs.

Our programs are, in the main, continuing to progress in accordance with our plans. The Discrete Address Beacon System (DABS) and its companion, Automatic Air Traffic Advisory and Resolution Service, are reaching the end of their development phase, and we are requesting funding in FY 1981 for the procurement of the initial production units in the facilities and equipment appropriation. Our Beacon Collision Avoidance Systems (BCAS) are continuing on schedule; we plan to issue the national standard for the active version of the BCAS in October of this year. Our advanced computer program, which will update our automated facilities, is progressing basically on schedule. This is a huge effort which will involve all of our automated en route centers, and, eventually, our automated terminals. The cost of R&D plus procurement activities will be over $1 billion

over the next ten years. We are currently undertaking the front end system analyses, conceptual studies, requirements documentation, and preliminary specification development.

Our flight service station automation program has now moved into the contractual stage. We have just awarded three design verification contracts, under which the contractors will compete for the eventual production award to automate our busiest flight service stations. This product of our E&D program will, when fully implemented, provide better services to general aviation and accommodate a doubling of the number of services provided, and do it with a specialized work force that is smaller than we have today. Our FY 1981 facilities and equipment request includes the funding to proceed with this long overdue, high productivity program. Other programs, such as Discrete Address Beacon System (DABS), Automated Traffic Advisory and Resolution Service (ATARS), Beacon Collision Avoidance System (BCAS) the Microwave Landing System (MLS) and Airport Surface Detection Equipment are now or will in the next several years be moving from development to implementation. They are key elements in future air traffic control systems. Further products will include the advanced computers I previously mentioned, air and ground data communications,

electronic digital voice and data communications switching equipment, "real-time" display of hazardous weather data on the controllers scopes, higher levels of automation to relieve the controllers of routine tasks -- the list can go on. All of these efforts are directed towards improving safety and productivity, and reducing costs.

That is a very large development program I have just sketched. Obviously, there must be resources available in a timely manner if our goals of improved safety and productivity and reduced costs are to be realized. The Congress currently has before it proposed legislation concerning the updating and renewal of the Airport and Airway Trust Fund (ADAP). Within the proposed legislation is a mechanism through which our E&D programs can be funded, consistent with our plans for the future. The proposed authorization levels for the five year period 1981-1985 will total $500 million.

The aviation industry is a vital part of the U.S. economy, and it's important that our E&D programs assist in its further development. The health of the U.S. aviation industry was a major concern in 1976. High on the list of concerns was a fear that the U.S. airlines would not be able

to raise the necessary capital to purchase new high technology, fuel-efficient aircraft to replace the fleet of older narrow body aircraft.

The events of the last three years have proven these concerns to be unfounded. Concurrent with the overall improvement in the economy and airline economic deregulation, U.S. airlines have experienced three consecutive profitable years. Not only have they ordered increased numbers of current production aircraft, but they have also supported the introduction of a new generation of high-technology aircraft, the B-757 and the B-767. Furthermore, new production models of older jets (particularly the L-1011 and the B-747) are employing new technology to make them more fuel efficient. The newly introduced DC-9-80 employs a variation of the JT8D engine derived directly from the National Aeronautics and Space Administration's (NASA) research on quieter, more fuel-efficient engines.

While it is still true that the foreign manufacturers are making inroads into the U.S. manufacturer's domain with new aircraft sales to foreign airlines, there is no reason to believe that any intervention by the U.S. Government is

warranted. We are already providing partial subsidies to foreign airlines through low cost loans by the Export-Import Bank. Domestically, all but the large U.S. trunk carriers are eligible for up to $100 million in loan guarantees for the purchase of new aircraft. It is interesting to note that most of the eligible certificated carriers have been able to obtain new equipment financing without the Federal loan guarantees.

The U.S. avionics industry is currently in a relatively strong position, but much stronger competition can be anticipated over the next five years, as the other electronics exporting nations continue to adopt our current technologies to sell to our current customers. Our continued leadership in this area will likely be highly dependent upon our development and exploration of technological advances. With the growth in new airframes, and increased demand for services, one can confidently expect U.S. industry operating under the free enterprise system to meet this challenge successfully.

Earlier today, Dr. Frosch, the Administrator of the National Aeronautics and Space Administration (NASA), appeared before you. The FAA and NASA are moving into a stage of

cooperation that is bringing more joint efforts in highly complex areas. An example would be the human factors aspects of providing pilots with air traffic control data in the cockpit.

Mr. Chairman, that concludes my prepared statement. Mr. Al Albrecht, our Associate Administrator for Engineering and Development and I are prepared to answer any questions you may have.

STATEMENT OF LANGHORNE BOND, ADMINISTRATOR, FEDERAL AVIATION ADMINISTRATION, ACCOMPANIED BY ALBERT P. ALBRECHT, ASSOCIATE ADMINISTRATOR FOR ENGINEERING AND DEVELOPMENT, FEDERAL AVIATION ADMINISTRATION

Mr. BOND. I want to acknowledge that we're going to have a hearing before Congressman Tom Harkin's subcommittee later on in February, in which we'll go over the subject in greater detail.

We are now in the middle of conducting a 2-day user conference out at Arlington, with all of the aviation user community: the unions, the general aviation folks, the air carriers, manufacturers, and so on, to discuss the course of our engineering and development program and to receive their recommendations on what we ought to do in the future. We do not operate in a vacuum, if I may turn a phrase, as NASA does sometimes. Whatever NASA decides to do out in space I guess nobody objects to. We are not blessed with that luxury, so we have to get it straight with our user community, and we're doing our best to do that.

The major programs that we have underway: DABS, Automation of the Air Traffic Control System, BCAS, the various types of collision avoidance systems, are on track, as it were, and pretty well on schedule.

We're working on our flight service station automation program, which is primarily a service to the growing general aviation community. That also is coming along in what I believe is a technologically satisfactory way, though I believe its program pace is unsatisfactory. We're trying to get that speeded up. The user community obviously needs such services, and it's not getting them as quickly as expected.

I have a few pages in my testimony that touch on the overall health of the aviation industry in the United States, as apart from our own particular segment of it. I believe that it can be characterized as very good, and I don't take all the credit for it either because somebody else deserves that.

One of the feeders, incidentally, to the aeronautical program—manufacturing technology I mean—is the NASA research program which you gentleman have dealt with earlier this morning. I want to go on record as saying that I am a great supporter and admirer

of that program. I think it has produced good results. The energy efficiency aspect of it has been useful, the work on composites, the work on airfoil design, the work load alleviation that has been done. We're now seeing that in airframes. Noise suppression has been very useful to us. It really is flowing directly into the economy, and my own partisan view is that it's worth more than the space research that goes on, but again I'm talking from the aviation side.

There are some overlaps. I can't help but note that the FAA, which operates the air traffic control towers and the aviation weather notification system is developing an automatic tower to help pilots where we don't have a tower. NASA had also decided to develop one and that did strike me as being a bit more than was necessary. But we have that under control now and for the most part we're pretty well coordinated.

The development of new technology aircraft on the air carrier side is especially encouraging. My statement touches on that also. Boeing is developing the 757 and the 767. They are going to sell well abroad. They are going to be quieter, and they are going to use less fuel, and because they are bigger and are operating at higher load factors, partly as the result of economic deregulation, they will place less burden on our air traffic control system than might otherwise have been the case if we had not moved into that regime. So that's all to the good.

We are clearly facing a challenge from foreign manufacturers abroad in the heavy jet business. The Airbus aircraft is a very competitive aircraft. It has garnered sales that had previously been reserved to American manufacturers, and the possibility is quite real that the Japanese may come on stream with an engine and with a large airframe, or a jet air carrier-type airframe, as well. Our industry must react to that competitively with superior products.

Even, however, in spite of the foreign competition, I will note that our industry today is essentially working at total capacity, flank speed. We are running into limitations on machine tools and engineers that are available for the production, and so on, but still very healthy.

Thank you for your attention. That summarizes my statement.

Mr. FLIPPO. Thank you, Mr. Bond. I appreciate that.

Mr. Brown.

Mr. BROWN. Mr. Bond, I don't have any very sophisticated questions, but you have dealt in your prepared statement with the work that you're doing in upgrading the agency's communications system, or, using a broader term, information system, which this committee is currently taking an interest from the standpoint of a total national information system, and, more specifically I guess, the scientific and technological information, and I'm sort of interested in getting a little better understanding of what you're trying to do there and how it fits in with, say, other information systems. There are very sophisticated systems in NASA for transmitting and processing huge volumes of data from, say, space probes, or meteorological satellites, and so on.

I am wondering to what degree there is an effort of planning and coordination amongst these systems so that what we end up with

represents a total national information system that one can understand and which is compatible to the degree that is necessary, and so on.

As I say, I'm asking this in an unsophisticated way. The efforts we are making at this time are more at understanding what's happening. This is a technological area in which there's tremendous developments taking place. I wonder if you could illuminate on that a little bit.

Mr. BOND. I will. I'm not exactly sure what you mean by information systems, but I take that to mean our computer network that we use for the Air Traffic Control System, with main frames in each of our 20 continental U.S. centers and a similar processing capability in some of the major towers and radar approach control facilities. It is a very sophisticated system, and it works all as one.

We have coordinated with the Defense Department. It interlinks because it is a single Air Traffic Control System. The Congress dictated that, rightly, after the Grand Canyon crash. So that is our principal interdependency. Beyond that, it is for the most part independent of NASA's system and of the General Services' data systems, and so on. It is our own.

We have a special problem, I believe. I've testified on this before other committees. And that is that our system has got to be super reliable. We just cannot tolerate failure rates that would be accepted easily elsewhere because you just can't lose an airplane, or a flight plan, or have conflicts or failures in the program. So I think that has driven us to some independence in our computer network, and I believe it ought to be that way as well.

Incidentally, I might add that our computer system is in the process of design work leading to a complete overhaul of our system. Our main frames are IBM 9020 units. They are far from the best technology that is available today. They are adequate, but they are way behind the power curve in terms of modernization, and we plan to replace them all in the mid to late 1980's.

Mr. BROWN. The pace of technology in this area is so great it defies my ability to understand it, so I don't know how you solve this problem when we apparently are getting new generations in computers every 2 or 3 or 4 years.

Mr. BOND. We fall behind is what happens. We fall behind. But the fact that our computers are technologically obsolete doesn't mean that they're failures. They just are more expensive to operate and their capacity is somewhat limited, and so on. We could do it all much more cheaply, with less personnel, if we were up to the state-of-the-art.

But the problem, again, is that ours is a single integrated system worldwide, literally, and pulling one piece out of it and changing is very difficult, if not impossible to do without a sweeping overhaul. Its interdependence precludes piecemeal replacement, which we will have to do sweepingly in the next decade. That is our dilemma.

Mr. BROWN. What is your communication network? Are you using satellites or ground communication systems?

Mr. BOND. We use all kinds of things. We use microwave relays of our own system. We buy a lot of network services from Telco, the phone company. We have our own hard lines in some cases, and we use satellite relay as well. We have a melange, and we

generally do it where service is best and cost is cheapest. We've picked that solution.

Mr. BROWN. When you use satellites do you buy commercial satellite time, do you use Defense system satellites, or how do you handle that?

Mr. ALBRECHT. Basically, our use of satellites is through the common carriers and their use of satellites in turn. Except for the Defense Department, we're probably Ma Bell's largest customer. So whatever facilities and modernization of their facilities that takes place, then we enjoy the advantage.

In addition, we do have our own data interchange network between computers that will grow in importance in the future, particularly in this era of the advanced computer design to replace what we now have.

Mr. BROWN. Since you have one integrated worldwide system, I presume that means you have one integrated unit that does the planning for this worldwide system. Is that correct?

Mr. ALBRECHT. You sort of have to divide the problem into the functions served by the communications system. Of course, we have a large amount of air-to-ground and ground-to-air communications between controllers and pilots. That's sort of one kind of problem. We also have interchange of data between processors. That's a different kind of problem. Now, the operating services, airways facilities and air traffic people, basically are concerned with the controller-to-pilot interchange, and the planning in terms of their requirements is mostly done by those organizations. In terms of the computer-to-computer communications, which is a different kind of a technical problem, a different kind of planning problem, that's done by the engineering and development group. We work very closely together.

Mr. BROWN. Thank you, Mr. Chairman.

Mr. FLIPPO. Mr. Goldwater.

Mr. GOLDWATER. Mr. Bond, you recently spoke out about the difficulties that FAA is having in hiring and keeping qualified people. I'm wondering if you could discuss briefly the problems which you may be having down there with the civil service system and other problems such as deadwood with respect to the R. & D. function.

Mr. BOND. Let me give you an example of the oddities of the civil service system, and there are plenty of them.

Some years ago the Congress decided that air traffic control was what they called a young person's game. They called it a young man's game. And so we don't hire anybody into our controller ranks who is over the age of 30, and for obvious reasons. The failure rate was higher with folks who are older than that, and we get a full lifetime of work, and so on, out of our controllers. So for all of our controllers, the age is pretty young, and they are very competent people that we are bringing into the system now, excellent, excellent.

On the other hand, the Civil Service Commission has defined the pilots that we hire in a different way. There is a requirement for years of experience, and so on, for our flight inspectors. Those are pilots. And as a result only retired military, for the most part, qualify for that. So we hire all our pilots in their fifties and all our

controllers in their twenties, and the pilots that we get are on a second pension track; they take 2 or 3 years to get up to being a good inspector's level; they don't get there right away. They work perfectly well for a while and then they retire 4 or 5 years later, so we don't get much time out of them, and the turnover is high.

So there's one anomaly the civil service system, and the overlay of statutes, and so on, has created for us. Our average inspector for flight standards is in his fifties and is also male because of the heavy jet experience requirements, neither of which I think is a very good idea. So that's one.

Let me go on.

There are a lot of places that our people would prefer not to go and one of them is southern California because of the high cost there. There is no compensation to civil service employees for moving there, and so everybody wants to go to Atlanta or Fort Worth. It's not that they don't like southern California, but it's more expensive to live there, and the interest rates are out of sight and the housing cost is staggering. So we find that Lockheed and Boeing are able in the free enterprise system to correct for that. If somebody moves from one part of the country to another they can help with the house purchase, or the commission, or the interest rate in some way to keep people. We are not able to do that, and it's a real problem. The same problem exists for Chicago and New York, they are also high cost regions for us. So that's another problem that we have.

I would say also that for our very best people we would like to pay more. Probably the very top engineer at Douglas makes three times or four times what our person does that's dealing at an equal level with them. I think in the middle levels we're probably OK. The salary levels are the same or similar. And at the very beginning levels we're not competitive again. We're maybe $3,000 or $4,000 or $5,000 less than what is being paid now in the private sector, at a very competitive time. Everybody's going for engineers. So that's an example of our difficulties.

Mr. ALBRECHT. Mr. Goldwater, I would like to add something.

In the past few years several hundred of our people have retired. The point is that this has created vacancies in the organization. We find that our ability to rehire is reasonably good for highly qualified people. We've brought in a number of people that we would like to introduce you to who are very exceptional. Now, one reason is because of the nature of the work. We do have a very impressive systems engineering job to do. People recognize this and want to be on this side of the fence.

We do have some problems because of the Ethics in Government Act that makes a person from industry a little reluctant to want to come to work for the Government because he then can't go back out again, and we think this is a restriction, and a somewhat unfair restriction.

But generally speaking, I will challenge you to find any deadwood in the top level of our organization down through the deputy division managers.

Mr. BOND. I'm glad that Al pointed out the Ethics in Government Act. It's a problem for us, particularly in the field of research, where the Defense, FAA, and private sector folks have

traditionally moved around. I don't think it's an enormous obstacle to us in other parts of our operation. Air traffic control is kind of a traditional, unified, somewhat insular discipline. Nobody else does it. So I don't think we're losing much there. Oh, and facilities and equipment also, as well as research. People can't go back and forth, and they're restricted from it by the Ethics Act.

Mr. GOLDWATER. There's some sentiment in Congress, which I don't necessarily concur with, that wants to split the FAA into two functions: along the lines of promoting safety on the one hand, and fostering aviation on the other. How do you feel about that?

Mr. BOND. I think that it's a red herring issue. I think the notion that the promote and foster language in our statute is an obstacle is totally wrong, and the reason I say that is that I don't know, if you split the two apart, who would stand up and leave to go into the "promote and foster" column. I don't think we do very much, if anything, of that. We send an exhibit to the air show in Paris, to Reading, Pa., but it's minuscule. For the most part, ours is an operational and a safety regulatory agency, and if we do something wrong in our technology or our regulatory program then it is simply done because we don't do it right. It's not that we're trying to promote somebody.

So if there's blame to be apportioned it ought to come to us for not doing our job right and not because somebody points to the statute, because I've been in it now nearly 3 years, and I've never seen a single instance where somebody says, "Gee, it will cost us too much, or nobody will fly if we do this." It just hasn't come up as a reason.

Mr. GOLDWATER. Your proposed 5-year request for R. & D. funding, after factoring in inflation, appears to be going downhill.

Mr. BOND. It is going downhill. It's not just a matter of appearance. It's a reality.

Mr. GOLDWATER. Do you concur with that observation?

Mr. BOND. Of course. All you have to do is add. The fact of the matter is that if you were to compare the 1985 number for the research proposal—and it is up in dollars—with what we got in 1976, which would be a 10-year span, you would see that in real purchasing dollars it has fallen from about $67 million to some $44 or $45 million, and that assumes only 10 percent inflation for the next 5 years. If the numbers continue at the higher level that we are now seeing, and I hope that they do not, nonetheless the reduction would be even greater, and so we are seeing a minimum of a third reduction in real purchasing power, and it could be even higher than that. The inflation impact, in short, has been savage upon our program, and we are looking at system requirements which are going up exponentially. There are more and more airplanes in the airspace. There has been greater and greater public demand for safety. And there is a limit to what the FAA can do with numbers of this kind.

Mr. GOLDWATER. Which leads to my question. But obviously, on top of all that, your request is $5 million less than what was originally proposed in your 1981 budget. The question that obviously comes to mind is: How are you going to be able to do the necessary work on this updated ATC computer system that you're

talking about and also complete the R. & D. on all these other systems you're working on? How can you possibly do it?

Mr. BOND. The answer is we can't do it all. We will have to sort out amongst the priorities and pick those that are the best for us to do, the highest priority, and also stretch out and phase out the rest and try to work and meld it all together until we get the best mix for the dollars available, but it won't do it quickly and it won't do it all right now. We have to set priorities.

Mr. ALBRECHT. Let me add a little bit to that, Mr. Goldwater.

If you look backward, most of our engineering development budget has been spent for safety-related items. For advanced development programs it's been small, and then for the large number of upgraded third programs. The upgraded third programs are starting to fall off now. We're implementing them, we're getting them into the field, and the E. & D. requirement to support those programs is decreasing, which helps.

On the other hand, if you look at the systems job Mr. Bond talked about, the computer replacement, the additional automation program, that certainly will expand dramatically, but the major impact on the budget begins to show up around 1983. We are currently reassessing this impact.

Mr. BOND. Let me add to that.

I think that the country is going to have to face up in the very near future to some realities, and the realities are that over the past decade, for a variety of reasons, Vietnam, public pressure, environmental concerns, whatever it has been, the Federal programs that go into the bone, and muscle, and sinew of the United States have been constrained and, in some cases, ours being one of them, have in real terms been cut. No such constraints have been placed upon the social programs of the United States. The pensions, welfare costs, environmental requirements have all been piled on the Government, on the economy, and they are called entitlement programs. Many Members are aware of that, but other people call them uncontrolled spending. They automatically increase themselves and correct themselves automatically for inflation, and what is left over is basic research, and highway construction, waterway construction, the FAA's programs, and investment in research, and so on. They are left under the mechanism that applies to budgeting. They are left constrained. And so they are the ones that are chopped, and I think that when you begin to realize that we must create private sector jobs, that we must export, we must generate technology that will sell in the world market the present system is structured incorrectly and something ought to be done about it.

Mr. GOLDWATER. Mr. Bond, I concur with you. It's something that has plagued this Congress for many years. It doesn't ever seem to get any better; it just gets worse. We keep adding on more and more programs that become locked into the budget.

The other problem that we have is this excessive amount of surplus in the Aviation Trust Fund, which obviously is part of the budget. You and I have gone around and around on this, and I've been critical of your position.

I recognize your constraints. Since you are part of the administration, you have to march to the administration's drum. Neverthe-

less, I'm an advocate of aviation safety. I think the aviation community would like to see a champion of a higher utilization of that trust fund. It becomes almost an embarrassing situation for those of us in Government when we sit here with a surplus of $4 billion, allowing the administration to use that as part of a balancing act in the budgetary process.

It is a disturbing factor when you see that excessive surplus. And yet we look at these declining research dollars and think about the shopping list of needed R. & D. that is three or four times that amount of money in the future. It makes me scratch my head and wonder about the forecast growth of air traffic combined with the decline in the relative sophistication of some of our existing air traffic control systems. These are desperately in need of upgrade to keep pace with the increasing traffic. Then I see this declining R. & D. budget, and it's a very frustrating experience to go through year after year.

Mr. BOND. I share the frustration, Mr. Congressman.

I do want to say that I don't think that the unspent balance in the trust fund is quite the same issue as the question of whether the amount of money that's been given us for research and capital purposes is. I firmly believe that they are separable issues.

I don't mean to be repetitive, but the budget surplus stems from a decision, made almost as soon as the ADAP Act was passed in the 1970's not to spend the balance of income after capital needs were met on operating costs of the air traffice control system. I think that is a fair thing to do, and our proposal recommends that it be done, and I'm sorry that the Congress fell out with the then Republican administration—the Republicans and the Democrats fell out with the administration. It was a bipartisan thing—and stopped spending on operating costs. There should be no balance at all in the trust fund. But in any case, if the Congress fells that not enough is being spent in research or the capital requirements then the Congress ought to put that up, and then spend the rest on controllers' salaries, I think, or operating costs.

Mr. FLIPPO. Gentlemen, we do have a vote on the floor.

Mr. Bond, I do appreciate very much your testimony today, and we would like to submit additional questions in writing. Thank you.

The committee stands adjourned.

[Whereupon, at 12:32 p.m., the committee adjourned.]

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