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AERONAUTICAL RESEARCH AND DEVELOPMENT POLICY

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COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES
UNITED STATES SENATE

JANUARY 31, 1968.—Ordered to be printed

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Glossary

AIA—Aerospace Industries Association of America, Inc.
AOPA—Aircraft Owners and Pilots Association
ATA—Air Transport Association of America
CAB—Civil Aeronautics Board
DOD—Department of Defense
DOT—Department of Transportation
FAA—Federal Aviation Administration
FY—Fiscal Year
ICAO—International Civil Aviation Organization
NACA—National Advisory Committee for Aeronautics
NASA—National Aeronautics and Space Administration
NASC—National Aeronautics and Space Council
R&D—Research and Development
SST—Supersonic Transport
V/STOL—Vertical or short takeoff and landing

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Mr. ANDERSON, from the Committee on Aeronautical and Space Sciences, submitted the following

REPORT

I. INTRODUCTION

Since its inception, the Committee on Aeronautical and Space Sciences has had a great interest in the progress of aeronautical research and development, particularly as related to the National Aeronautics and Space Administration. NASA's predecessor, the NACA, had been engaged in outstanding aeronautical research since its creation in 1915. As NASA grew rapidly after its creation in 1958, leading this nation forward into the space era, many felt that aeronautical research was being ignored or at least relegated to a position of lesser importance. This view was bolstered by the fact that by FY 1964, NASA's line item request for aeronautics was only $16.2 million out of a total request of $5.712 billion, a scant 0.3 percent. However, since the cost of such items as NASA professional personnel working on aeronautics and overlapping space and aeronautics R&D efforts were not included in the Aeronautics program line item total, this committee urged NASA to provide a more realistic estimate of the total level of effort of aeronautics within the agency. Including all items that could be clearly related to aeronautics raised the FY 1964 total to about $82 million—about 1.6 percent of the total amount appropriated. By FY 1966, the line item request for aeronautics had increased to $42 million and NASA was able to identify $108 million as being related to aeronautics. This represented about 2 percent of the total budget request. The total aeronautical effort planned for the current fiscal year, FY 1968, is about $150 million, still only about 3.2 percent of the total NASA appropriation.

While NASA's aeronautics budget lagged other events were taking place, such as President Kennedy's request (June 24, 1963) for funds to start the first phase of development of a commercial supersonic

transport, a growing interest in V/STOL aircraft, and an upsurge in airline traffic.

Closely following these trends, and concerned that insufficient attention was being given to proper planning and coordination, the committee, in the fall of 1965, requested the Science Policy Research Division of the Legislative Reference Service of the Library of Congress in conjunction with the committee's staff to undertake a comprehensive study of aeronautical R&D policy. The result of that study was Senate Document 90, "Policy Planning for Aeronautical Research and Development" (published May 19, 1966). This study contained no recommendations, but it did list a number of important issues and questions for further congressional consideration (see Appendix, p. 25).

This report is the result of the committee's study to date. On January 25, 26 and February 27, 1967, hearings on Aeronautical R&D policy were held before the committee. One hundred and eighty-nine pages of testimony were taken from 12 witnesses (including three statements filed for the record). The views presented by these witnesses have been summarized in Chapter II—Findings. Chapters III and IV contain the conclusions and recommendations of the committee.

No attempt has been made to reach definitive answers to all issues and questions. Indeed, aeronautical R&D policy is a dynamic issue that is constantly changing and evolving and the committee will continue to study the important issues and questions of aeronautical R&D.

II. FINDINGS

THE ADEQUACY OF PRESENT POLICIES

The U.S. aeronautical system—that is, the people, aircraft manufacturers, airlines, airports, airways, government agencies, procedures and regulations that make air transportation possible—is operating satisfactorily. The testimony received by the Committee supports the widely held sentiment that the United States has the most successful air transportation system in the world. Despite an apparent promise for the future, serious operational difficulties have begun to appear and problems are developing faster than government and industry have been able to find solutions. There is an increasing gap between the advanced technology that research indicates is possible and the operating technology of the system. Many viewpoints as to specific areas where technological advancements and policy improvements are needed were presented to the Committee. One idea was prevalent throughout the hearing: in order to improve our aeronautical system, to increase its efficiency and to continue in a position of world leadership in air transportation, a strong aeronautical research and development effort will be required.

SUCCESS CREATES PROBLEMS

Many of the problems which the R&D community must solve have been generated by the success of the present aeronautical system. The health of our system is a testimonial to the value of past research. The rapid rate of growth, however, has outdated our airports, produced noise problems and necessitated many other improvements. These problems have not been overlooked but have proved difficult to solve because of their size and complicated nature.

Witnesses from outside the government tended to agree that currently there is not sufficient aeronautical R&D and that the size and scope of the programs must be expanded. The rationale was as follows: R&D is an increasingly important factor in the growth of the airline industry. Since the United States cannot tolerate a static air transportation system, the government and industry should constantly apply new technology to the air transportation system during the years ahead.

SUPPLY VERSUS DEMAND FOR R&D RESULTS

It is to be expected that the user organizations within the air transportation system would call for more research whereas those agencies charged with providing new technology would defend the adequacy of the current level of effort. The Department of Defense witness felt that the United States has started enough advanced projects and said that he didn't know of any R&D projects in aeronautics that we should have started that we have not.

The relationship between the R&D supplier and the user is of consequence. What is being done can be done better. For example, coordination can be improved and there can be a better exchange of information between government and industry on R&D results. Also, the government should consider new levels of research and development. The view was presented that NASA's approach of supporting mainly basic research in aeronautics was too limited in scope.

In the hardware demonstration phase of aeronautical R&D, the willingness to take risks in order to make new advances is becoming a critical part of the aviation environment. In some cases the amount of risk capital may be so great that only governments, or collective arrangements in the industry, or joint participation of industry and government can finance advanced development. The gains to be achieved will be worth the difficulties created by the budgetary complexity because aviation is becoming more important in the international movement of goods and people.

INTERNATIONAL COMPETITION

The leadership position of the United States in the world-wide aeronautical markets and the importance of the aviation industry to the balance of payments problem are two principal reasons for a strong R&D policy.

The United States has both the resources and the management capability to assert a leadership role in many phases of world aviation and should develop sound aeronautical research and development policies to guide our participation so that we will continue to benefit greatly from our current position in the world markets. Witnesses emphasized that the United States should continue as an international leader in aeronautics because of the importance of our strong aeronautical industry to our economy and because of national defense requirements.

The United States must be prepared to face strong competition in the future. No longer will one nation be able to hold a global monopoly in the aviation market. Already, potential rivals have initiated aeronautical projects ahead of this country, and consequently, the United States has found itself reacting to the developments of others. Even now, France and England are leading the United States in building a supersonic transport because of their earlier decision to proceed with the development of an SST.

THE ROLE OF THE FEDERAL GOVERNMENT IN AERONAUTICAL RESEARCH AND DEVELOPMENT

The Federal Government has a responsibility to the public to see that civil aeronautical research and development is directed to the improvement of the air transportation system. The Government, therefore, must frequently reassess its policy role in this area. Important aspects of this policy include funding, directing, encouraging private innovation, and entering into cooperative programs with industry.

The major role of the Federal Government in aeronautical research and development is to take those steps necessary to insure a sufficient and timely introduction of new technology into the air transportation

system. There is no unanimity of views on how the Government should implement this role.

GOVERNMENT SUPPORT

While there is agreement that the government should do in aeronautics only what the private sector cannot do for itself, the question naturally arises as to how much and what type of support should the government provide; for instance, should the Government support new civil aircraft developments? The answer to this question depends upon the market situation, the purpose to be served, the scale of investment required and the degree to which the development is time critical. In the SST program Federal funds are being injected simply because private industry is not financially capable of carrying the burden alone. Not all programs have received this type of support. In the development of the C–5A military aircraft, after careful study the Federal authorities decided that the modification of the design for commercial use could be undertaken by the manufacturer. In this case the manufacturer considered the aircraft sales potential great enough to plan a commercial version with company funds. Thus, large development projects have been supported by the government on an *ad hoc* basis. The president of the Aerospace Industries Association feels that it is healthier for the air transportation system to have the development phase of civil aircraft R&D accomplished primarily by industry with government participation only when it is in the national interest and when the industry lacks the financial capability to move the program. Clearly, the decision as to what is in the national interest must be made by the President of the United States with the support of the Congress.

In those areas where it has operational responsibilities the Government should sponsor the development activities that contribute to the improvement of our aeronautical systems, both military and civil. Existing agencies including DOD, DOT, FAA, and NASA have the physical resources and the management capability to conduct aeronautical development if properly supported by the executive and congressional branches of the Government.

The question of research support is simpler than that of development. Aeronautical research costs are only a fraction of the development costs, and the results of research are broadly applicable throughout the industry. Therefore, it is reasonable to have a strong federally funded research program.

Although there is considerable government support of aeronautical research and development at the present time, there was some agreement among the witnesses that the level of expenditures will have to be increased. The Secretary of Transportation said that there is not enough research performed in any mode of transportation, including air transportation, and that research should increase for all modes.

If government support for aeronautical research and development does increase, a large number of possible projects will be considered each year by agencies such as NASA and FAA. The policy question then exists, how should these projects be chosen for support with Federal funds? Two different ideas were suggested in the hearings. One suggestion was that in the field of basic research, NASA and its advisory committees should choose and support aeronautical projects,

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but in the field of advanced development, projects should be selected for support only after extensive consultation between agencies, such as DOT, DOD, FAA, and NASA, and the user industries. The other suggestion was that the selection of all projects should be done by decision of a committee in which no one interest—including the Government agencies involved—wields a majority. The committee would be made up of representatives from the various Government agencies and segments of the industry engaged in aeronautical research and development and substantial agreement would have to be reached, perhaps two-thirds or three-fourths, before a project would be chosen for Federal funding.

GOVERNMENT INCENTIVES

The Government cannot permit the nation's industrial capability to lag in meeting aviation opportunities. Thus, one role to consider is providing incentives so that the industry will continue to advance its capability to meet opportunities. Some of the incentives that might be considered are making new technology economically available for incorporation into aircraft, having progressive governmental procurement policies, instituting regulatory measures that require upgrading of aircraft, and giving tax credits. The ATA spokesman stated before the committee, "the 1962 amendment to the Internal Revenue Code establishing a tax credit for capital investment has assisted the nation's air carriers in modernizing their fleets and preparing for the huge equipment purchases . . . required in the next decade." A tax credit for research and development expenditures would assist the airlines in developing market forecasts and systems requirements for passenger and cargo handling facilities.

AERONAUTICS R&D POLICY IN FOREIGN GOVERNMENTS

Much can be learned about aviation policy from the experiences of government and industry in other countries. Comparing the United States with other Western countries, the best system has proved to be competition, within the confines of broad economic and safety regulation by government as contrasted with government ownership of air carriers. The British aerospace industry is a case in point. Over the past few years their industry has been in a state of confusion because of the Government's 3-point policy of trying to decide whether the size of the industry should be expanded or constricted, merging various aspects of the aerospace industries into fewer companies, and injecting a greater element of Government ownership. The Secretary of Transportation believes that this has had some adverse impact on the advance of British technology because of the negative effect on the morale of the operations.

THE EFFECT OF NONGOVERNMENTAL ORGANIZATIONS ON THE ROLE OF THE FEDERAL GOVERNMENT

The purpose of the committee's staff study and the subsequent hearings was to investigate the role of the Federal Government in aeronautical research and development. In keeping with the original purpose the nongovernmental organizations are discussed in this report in reference to their effect on the Federal role.

THE CONTRIBUTION OF INDUSTRY TO AERONAUTICAL RESEARCH AND DEVELOPMENT

The aerospace industry and the airlines have been, and will continue to be, major contributors to the aeronautical R&D process. The Government has provided much of the research and development which the industry has molded into all aspects of aeronautical progress. For the most part the contribution of industry occurs at the advanced development stage. The manufacturer undertakes that part of R&D involved in incorporating a new concept into an existing aircraft or a group of concepts into a new aircraft. This is the proper role for the manufacturer since he is the marketer for the aircraft.

The airlines augment the aircraft companies contribution to technological advancements by the repeated outlay of major sums for new and more modern equipment, and they actively participate in the test and evaluation phase of development. Some airlines even sponsor in-house development work. These are usually modest developments which will directly aid the airline in its operations, but these advances are of value to the welfare of the aeronautical process.

COST SHARING BETWEEN GOVERNMENT AND INDUSTRY

The proper share of R&D costs to be provided by industry is always an area for debate. The AOPA spokesman said, "the aerospace industry of its own volition will contribute very little." The DOD witness countered, "We have been successful in stimulating the companies to invest their own funds." He took the view that the present balance is fair, but it is a dynamic one which has to be watched carefully. The contributions which any one company can make to aeronautical research and development without Government support are a function of their earnings and their policies for making dollars available for independent research and development.

The committee raised the question of how much risk taking in advanced development should be borne by the industry. The position of the representative from the ATA was, "We do not believe it is wise for the public sector to assume the risk of such applied development unless consultation with the ultimate users shows a need exists and justifies the risk." Another idea was that the ratio of participation in risk taking between the public and private sectors should reflect the proportion of interest between those sectors in the particular project. A flexible ratio is better because it leaves room for bargaining as well as providing an alternative decisionmaking process.

THE EFFECT OF THE UNIVERSITIES, NONPROFIT RESEARCH INSTITUTES, AND PROFESSIONAL SOCIETIES

The universities, nonprofit research institutes, and professional societies make contributions to aeronautical R&D mainly in areas of advanced research and technology. Their effect on Federal policy, however, is subordinate to that of industry and defense user demands. The Administrator of the National Aeronautics and Space Administration stated, "At the present, the universities, nonprofit research institutes and the professional societies have very little effect on the aeronautical research and development policy in NASA." The AOPA witness said "the record does not indicate that representatives of

universities, nonprofit foundations and the like bring either the expertise or the impartial and disinterested judgment that is generally claimed to justify their participation."

The main reason these groups have no direct effect on policy is that most refrain from taking a policy position. This does not in any way down-play their role in providing a pool of talent to which government and industry may assign various tasks. These organizations often exercise initiative by bringing to the attention of government and industry those areas where research is needed. Thus, policy is indirectly effected.

THE RELATIONSHIP OF AERONAUTICS TO OTHER MODES OF TRANSPORTATION

BEGINNING OF A NEW AGE

The Federal role in the national transportation system is being studied and defined by the Department of Transportation. In a sense we are at the beginning of a new age in transportation. Advances in technology can be applied to all modes in providing a balanced transportation system fitted in an orderly and economical way to the needs of society. Now that an integrated transportation policy is beginning to receive consideration, the committee is interested in understanding the projected relationship of aviation to the other modes of transportation.

TRANSPORTATION SYSTEM ANALYSIS

Systems analysis is the application of analytical methods to study the relationships of the various elements of a given system. The Department of Defense has used systems analysis extensively, but other agencies concerned with aeronautics have not fully adopted the technique. In this regard it should be noted that many of the major aerospace firms engaged in aeronautical research, development, and production have large staffs skilled in systems technology and use it extensively in their day-to-day planning and decisions.

The Secretary of Transportation said that the systems approach will be the basic approach in the whole area of transportation research. Aviation will be studied along with the other transportation modes, and the forthcoming studies should greatly aid the policy planning process. Systems analysis will be used as a means for determining how to integrate existing transportation modes, for forecasting trends in future requirements and for providing guidelines for aeronautical research and development.

The Administrator of the National Aeronautics and Space Administration said that "NASA expects to rely on DOT for overall system analyses of the Nation's transportation requirements," and that "the forecasts which emerge from this broad analysis will be used by NASA for selecting the most fruitful paths for technological exploration in aeronautics."

There are dangers which must be considered in the use of systems analysis. As the ATA representative pointed out, systems analysts must know the systems they are analyzing. "Too many times in the past the airlines have found that analysts have an insufficient knowledge of the industry."

TRANSPORTATION POLICY

The Department of Transportation came into being on April 1, 1967. In his testimony, the Secretary of Transportation estimated that it would probably be 3 years before the systems approach is working smoothly. By that time, the Department should be able to shed more light on the relationship of air transportation to the other modes. This long wait is unfortunate but apparently unavoidable. In the meantime, some ideas are beginning to take shape.

The ATA president presented the concept to the committee that "no effort should be made to assign roles to the different transport modes because to do so would stifle their growth and slow the application of new technology. . . . Competition between the various modes for their share of the total transportation market is what spurs the use of new equipment and procedures."

In a competitive atmosphere R&D itself is not necessarily in competition. The witness representing the ATA said, "There should be no reason for conflict or competition for research and development resources among the several modes." There is a need to coordinate but not combine R&D on different modes because combining the research and development efforts of several modes dulls the very competitive forces that speed the use of new technologies.

Technology transfer has occurred in the past and will continue to occur. The technological competence of the aviation industry and the Federal groups involved in aeronautics contributes to the development of all the modes of the national transportation system. The high speed rail experiment is an example of the adaptation of aviation to another mode. The Department of Transportation plans to study the total transportation system, and one key area will be the transfer of technology among transportation modes so that the new technology developed by one sector will benefit all modes of transportation. However, no matter how readily available the Government makes R&D information the responsibility for taking full advantage of technological developments must rest with the manufacturers and the user industries.

TOO MUCH OR TOO LITTLE ATTENTION TO AERONAUTICAL R&D

It is very hard to say if aeronautical R&D is receiving too much or too little attention as compared to R&D on other modes of transportation. The view of the ATA witness was that attention to aviation is reasonable. But there is a contrasting view in the general aviation community. The AOPA spokesman said aviation is not receiving enough consideration in view of its expanding role in the economy. The relationship of aviation and the other modes of transportation must be more clearly defined before a reasonable decision on the distribution of annual funding for the various modes can be made by the Government.

THE CURRENT MECHANISM FOR AERONAUTICAL R&D

Although many Federal agencies are involved in some form of aeronautical research and development, no single agency plays the lead role in planning. As a result, the committee found the structure

of aeronautical R&D highly fragmented. This in turn produces a multiplicity of coordinating committees with little overall coordination.

PLANNING FOR AERONAUTICAL R&D

The leading groups which plan or oversee aeronautical research and development are the Department of Defense, Department of Transportation, Federal Aviation Administration, National Aeronautics and Space Administration, National Aeronautics and Space Council, and Office of Science and Technology. The Bureau of the Budget and the Civil Aeronautics Board participate in specialized areas of aeronautical R&D planning.

Witnesses appearing before the committee agreed that no one agency or group dominates planning, nor should this be the case. One felt that the Bureau of the Budget might be considered the dominate, though indirect force, in shaping policy because of their control over the funds for aeronautical research and development. Another view was that it is the President who decides who will participate in planning, and he tends to use the Space Council, the Office of Science and Technology and even special committees to achieve his aims.

COORDINATING THE AERONAUTICAL R&D OF THE AGENCIES

At the present time the three principal organizations involved in aeronautical research and development are DOD, FAA, and NASA. Over twenty other agencies have minor aeronautical programs. Each has prime responsibilities in certain areas. Nevertheless, overlapping interests do exist, and exchanges of information are accomplished through interagency boards or committees.

This fragmented structure has resulted in an inordinate amount of coordination which may be too complex and too entangled to meet the technological needs of a fast moving air transportation system. The complexity of the aeronautical R&D coordination is illustrated by the fact that NASA presently is a member of some 27 coordinating groups involved in various aspects of aeronautics such as all-weather landing, noise abatement, and aircraft fire protection. This not only includes a myriad of governmental agencies but also industry, universities, professional organizations, and international groups such as ICAO.

The desirability of one organization becoming the focal point for coordinating the Nation's aeronautical R&D is not free from divergent views. The Administrator of the National Aeronautics and Space Administration said, "My own view is that it would be very, very difficult for one intelligence to encompass all of this and attempt to do a job of coordination." The Executive Secretary of the National Aeronautics and Space Council said, "It makes good sense for NASA to join with FAA on the civilian side and to join with DOD on the military side," and "it would probably be an inefficient use of FAA's time and DOD's time to have each in on all the examination and discussion of the aeronautical issues of the other." The ATA witness expressed the view that the new Department of Transportation offers a good opportunity for both planning and coordination in civil aeronautical research and development.

There are currently successful coordinating mechanisms in the government which might be used as an organizational model for coordinating aeronautical research and development among all agencies. The Aeronautics and Astronautics Coordinating Board, cochaired by DOD and NASA, is one example. If a new facility is to be requested by NASA, the request is first reviewed by the Board to make sure there are no duplicate facilities in DOD. The panels of the Board deal with each of the major areas of the two agencies and provide for continuing review of the entire aeronautical and astronautical program. The Aeronautics and Astronautics Coordinating Board is one operating mechanism which might be considered as a model for a future Government-wide aeronautical coordinating board.

COORDINATION WITH INDUSTRY AND THE UNIVERSITIES

NASA created a group of research advisory committees several years ago to obtain an exchange of information between industry and Government regarding aeronautical R&D activities and needs. These committees, similar to the committees operating under the old NACA, now report to the Associate Administrator for the Office of Advanced Research and Technology.

Each committee contains members representing industry, the universities, and other Government agencies such as FAA. The chairmanship is rotated every 2 years between industry and the universities. The committees study specific problems in depth, review NASA programs, and help NASA plan its aeronautical research and development program. Presently, there are four committees—Aeronautics, Propulsion, Loads and Structures, and Operating Problems.

ROLE OF THE NATIONAL AERONAUTICS AND SPACE COUNCIL

The Executive Secretary of the National Aeronautics and Space Council stated that the Council is charged by statute to be prepared to advise and assist the President in planning and coordinating in the field of aeronautics. The Council makes recommendations on aeronautics, holds formal sessions on such matters as projections of the civil aviation growth pattern, has staff representation at NASA, FAA, and DOD coordinating boards and assists in the exchange of up-to-date information between agencies. The Council has made it a practice to invite nonmember heads of agencies to Council meetings and has brought together in one forum the top officials of all the agencies which are conducting large amounts of research in the aeronautical field. FAA is not a member; nevertheless, FAA has participated in the deliberations of the Council and in the past has informed the Council of the more urgent problems facing the FAA in aeronautical research and development. The Administrator of NASA, while discussing its presidential advisory role, added "The Council in a way has needled a number of us to do things that were important or has permitted a forum where discussion of a number of things took place."

Many of the witnesses declined to comment on the Council. The AOPA spokesman did say, "We never hear about the National Aeronautics and Space Council although the description on pages 60–61 of the current Government Organization Manual seems to suggest

that we ought to." It appears from the testimony that the present role of the Council is not clearly understood.

ROLE OF THE DEPARTMENT OF TRANSPORTATION

For the purposes of this investigation, the committee was concerned with the role of the Department of Transportation only as it applies to aeronautical research and development. All witnesses agreed that DOT should and will play a large role in aeronautical R&D. The Administrator of FAA said that the Department of Transportation will offer a new mechanism through which aviation and interrelated problems will be considered as a whole fabric. The Secretary of Transportation said that DOT expects to offer leadership in stimulating the direction of aeronautical research and development. The President of the Air Transport Association said that DOT will aid civil aeronautical research and development by (1) analyzing the demands that will be placed upon the nation's transportation system, (2) identifying the deficiencies that stand in the way of meeting these demands, and (3) taking the lead in assuring timely correction of the deficiencies.

Suffice it to say that a more accurate assessment of the role of the Department of Transportation as it applies to aeronautical R&D must await such time as the Department has had the opportunity to implement some of its announced programs.

SHOULD DOT BE REPRESENTED ON THE NASC?

Many witnesses including the Administrator of NASA, and the Secretary of Transportation, agreed that the Department of Transportation should be represented on the National Aeronautics and Space Council. Yet, at present, no plans for placing DOT on NASC have been announced. The Executive Secretary of the National Aeronautics and Space Council said, "I know of no decision one way or the other by the President to request the Congress to amend the National Aeronautics and Space Act to add the Secretary to the Council." Existing procedures would allow DOT to attend Council meetings when invited.

ALTERNATIVES TO THE PRESENT PROCESS OF AERONAUTICAL R&D

In this section some possible improvements in the Government's part of the process are discussed. The designation of a Federal lead agency in aeronautical R&D, and the organization of aeronautics as a separate program in the U.S. budget are suggested as ways to help centralize aeronautical R&D planning. Facilities are viewed not so much from the point of major new construction but rather from the improvements that can be brought into the present facilities. Demonstration of advanced technology without a mission requirement is examined as a possible method to furnish new options for a rapidly changing air transportation system.

DESIGNATION OF A FEDERAL LEAD AGENCY

An alternative to the present process of carrying out aeronautical R&D in the Federal Government is the designation of a lead agency to set the policy, to plan, to fund and to manage aeronautical research and development. NASA has increasingly taken the lead in aeronautical research. The witness from the Department of Defense said, "NASA is the primary Government agency charged with the responsibility of aeronautical research." But the prevalent feeling among the witnesses was that it is unwise to assign the responsibility of all aeronautical research to one agency. The opinion was expressed that there is little need now for a single agency having total responsibility and if the programing-planning-budgeting systems approach functions effectively in this area, the need will be even less.

AERONAUTICAL R&D AS A SEPARATE PROGRAM IN THE UNITED STATES BUDGET

There was agreement among the witnesses that aeronautical research and development *should not be* presented to the Congress as a separate and consolidated program in the U.S. Budget. The ATA representative said, "We do not believe it is desirable to consolidate the aeronautical research and development budgets of agencies such as FAA, NASA, and DOD into a research and development budget that is separate from agency budgets." The NASC witness said that to join together research and development funds for military and civilian purposes might even jeopardize existing priorities for the separate agencies.

The Executive Secretary of the National Aeronautics and Space Council suggested that it would be constructive to have the budget figures for aeronautical research and development for all agencies put into one table so that the overall funding picture could be readily obtained. He submitted such a table to the committee (see p. 155 of the hearing).

IMPROVING AERONAUTICAL TEST FACILITIES

The majority view of the witnesses was that the present facilities are adequate for aeronautical R&D testing. The Department of Defense witness said, "I believe that the facilities in being and planned are generally adequate for the needs of industry and government" and "in most cases Government facilities are available for private industry use."

New facilities for aeronautical R&D should be built only after careful coordination with all possible users in the Government, industry, and general aviation. NASA and DOD do coordinate requests for aeronautical research and development facilities. Other agencies and departments of the Government requesting facilities in the future should be brought into this coordination process. Thought should be given to the coordination of facilities between Government and elements of the aeronautical system in the private sector.

THE DEMONSTRATION OF ADVANCED TECHNOLOGY WITHOUT A MISSION REQUIREMENT

The United States, despite its vast resources, cannot develop all conceivable aeronautical hardware. Approved programs, such as the supersonic transport, are the first priority in advancing the technology for the nation's air transportation system. Major development programs have inherent characteristics of long lead times, high costs, and a necessity to use advanced technology. The latter item is the least understood since technology that appears fruitful in the research and development stage may prove impractical in operation. Thus, it is dangerous to incorporate unproven technology into a new system.

The long lead time between research and prototype development of an aircraft system and the high cost of speeding up development usually force the system designer of transportation systems to use existing technology. Therefore, consideration must be given to a strategy referred to as "capability for contingency" or "readiness capability." This strategy is founded on the philosophy that to produce effective transportation systems the technology must be available when the need arises. Thus, the demonstration of advanced technology without a mission requirement can be justified. This is sometimes called proof-of-concept testing.

Proof-of-concept refers to the development and testing of a technological concept for feasibility. The equipment is usually a subsystem of an aeronautical system. This type of testing normally occurs before a specific requirement for the use of the concept in a system is established.

Limited resources, of course, affect the amount of advanced technology that can be carried forward without a mission requirement. Judgments, therefore, must be made as to which development projects will be started; these in turn will provide the basis for judgments as to where applications of advanced technology will occur. There is no way to determine accurately which developments should be undertaken. But knowledgeable men, carefully considering all factors, can make useful judgments in this regard.

Existing technology should be constantly improved. The demonstration of advanced technology without a mission requirement is simply a mechanism for extending technical developments, and understanding their merits, thereby extending the state of the art before actual commitment to operational development.

AGENCY INVOLVEMENT IN CIVIL AERONAUTICAL PROGRESS

DEPARTMENT OF DEFENSE

Aeronautical developments carried out by the Department of Defense necessarily have an influence upon the course of civil aviation technology. Since the compromises and trade-offs in a military aircraft are different from those in a civil aircraft this influence does not necessarily occur in the direct sense. The direct application of military aircraft technology to the civilian aeronautical system is not as straightforward as it was some years ago before our modern integrated weapons systems.

The Department of Defense spends more money in aeronautics than all other Government agencies combined and the problem is deciding how to make the DOD aeronautics program more useful to civil aviation without compromising military requirements. A Department of Defense technology utilization program, similar to the one at NASA, might serve to make DOD aeronautical R&D results more directly available to civil aviation. For example, DOD might offer its unclassified information to NASA, and NASA through its own technology transfer program could release the information to industry.

The AOPA representative said that Defense aeronautics programs should be coordinated from the outset because there is no valid reason why defense-type aircraft must be extensively modified to meet civil airworthiness standards. The FAA Administrator agreed and said that he believed that if they were in close contact with DOD in the early stages of the development of a system, they would be able to avoid some duplication in systems developments. The ATA spokesman disagreed. It was his opinion that requiring more coordination of defense aeronautics programs with civil aircraft needs at the outset only compromises the military capability of the resulting aircraft without making it suitable for civil use. He did agree that within the limits of national security, civil aviation should be kept fully informed of technological advancements stemming from military R&D.

It was suggested that incremental additions to DOD funding in aeronautical R&D to be paid from civil agency budgets might bring wider civil applicability of military research and development. Although each project would have to be examined for its own merits, some of the witnesses agreed the incremental funding concept could work. Others felt that more attention to resolving some of the impediments to direct application would be more productive.

DEPARTMENT OF TRANSPORTATION

The Department of Transportation will play a large role in developing executive branch policy for aeronautical research and development, undertake comprehensive studies of the entire transportation system of the United States and recommend transportation goals and the means to achieve them. In accomplishing this DOT will look at the consolidated budget activities in aeronautical research and development in an effort to judge the scope and direction of these activities.

The basic approach of the Department to transportation research and development will be systems analysis. Aeronautical R&D will be treated as a major subsystem within the total transportation system. DOT will analyze the needs of the system, identify deficiencies, and take the lead in directing the timely introduction of technology into the system. Once a need or deficiency is identified as requiring research and development, it will be the duty of the Assistant Secretary for Research and Technology to insure accomplishment of the R&D tasks by the most appropriate means. This ability to establish the general and specific responsibilities more clearly than was possible in the past will aid the coordination process.

In the future, DOT will coordinate work with many agencies. This will require special relationships. The link between the Department of Transportation and the Federal Aviation Administration is well defined in the Transportation Act; however, DOT's relationship

with NASA is only beginning to be formulated. The Secretary of the Department of Transportation said, "I think that NASA has a tremendous wealth of resources which should be fully drawn upon," and "I can give you my assurance that I expect within the framework of the Department's jurisdiction to utilize the resources of NASA to the fullest extent."

DOD also is likely to enter the picture in the next few years. The Department of Defense witness said, "I would hope . . . that when the Department of Transportation gets set up that they would take the responsibility for research and development for aircraft for transportation purposes, and that we would work directly with them."

FEDERAL AVIATION ADMINISTRATION

The Administrator of the Federal Aviation Administration stated that "the FAA role is to identify the R&D needs for the system we operate and to do the testing and application research in the development of our system, including our regulatory work, and to identify for NASA the aeronautical areas where we believe more R&D can be profitably undertaken." Another important role FAA fulfills is to identify civil aeronautical requirements which can be built into a developing military system in order to make the system easily adaptable to civil use.

In studying the FAA–NASA relationship it is apparent from the legislation that the two agencies are both authorized to do aeronautical research and development, yet the expertise and facilities are concentrated in NASA. The Administrators of both NASA and FAA expressed satisfaction with this division of resources. The FAA Administrator said, "We believe that the important competence to accompany the responsibility to operate the aeronautical system is the competence to identify the needs of the system, and that competence we have in FAA." The NASA Administrator stressed that coordination and cooperation exist between the two agencies and that NASA has supplied FAA with technical aid. The Administrator of the Federal Aviation Administration further agreed that it is not critically important where the men and facilities are, as long as there is a source available for basic research. One criticism voiced by the ATA representative was that FAA should undertake follow-on applications research after NASA's basic research since there is not now an adequate definition of the respective roles and responsibilities of FAA and NASA.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA's predecessor agency NACA had energetic and influential expertise in the field of aeronautics. In the days of NACA there were many formal and informal contacts in the Government, industry, and the universities. But when NASA replaced NACA this all changed and as one witness said, "Now there is nothing!" . . . "We think there should be." Along this same line the Committee asked what the alternatives were for using the talents and facilities in the sense of the old NACA. The NASA Administrator's answer was, "I am not sure that I understand this" and "I am not sure that I can suggest alternatives."

The witness representing the ATA said that NASA performed exceedingly useful research on many vexing problems of aeronautics and that more of this type of work should be done today by NASA. There may be some occasions, he said, when NASA's talents and facilities might be useful in carrying out development projects, but generally, NASA should perform a basic research function with the development and applications phases left to other agencies and industry. The Administrator of the National Aeronautics and Space Administration said, "with respect to the question of whether NASA should be charged with building flying prototypes of airplanes that are aimed at taking new technology up to a stage that will permit some using agency to procure an operating system, I an unsure." The position of the NASA Administrator is that "we would do it (build advanced prototypes) if it were the policy of the country for us to do it." . . . "I am not asking for an increased role for NASA."

During the hearings the committee attempted to determine what the proper level of aeronautics should be in NASA. Although some witnesses thought that aeronautics should be further upgraded within the agency in terms of people, money, and organizational status, the NASA Administrator felt the present program was adequate. As to whether all aeronautical research and development resources and functions should be withdrawn from NASA and assigned to FAA, the NASA Administrator answered that to remove this research from NASA would be very undesirable at this time. The majority of the witnesses favored strengthening aeronautics within NASA. The full extent of the NASA involvement in "civil-aircraft technology" will become clear only after the Department of Transportation has had the opportunity to examine the many questions of transportation policy. As answers to these questions become clearer NASA anticipates a closer relationship with DOT in evolving the most appropriate program plan and funding for NASA's aeronautics program in civil aircraft technology.

AIR SAFETY

Aviation safety is a matter of vital concern to all participants in aeronautical research and development, and policy should reflect this. But given changes in weather, traffic conditions, procedures, and requirements, plus the need to operate economically, the safety picture is less than absolute. For this reason the committee devoted a substantial part of its consideration to aviation safety.

AIRCRAFT ACCIDENTS

Scheduled air carrier accident statistics show that aviation safety has not improved much over the past 17 years. Accident statistics from the committee's report (S. Doc. No. 90) in the 89th Congress were updated through 1967, and are presented here to emphasize the continuing problem the country faces in aviation safety. Although 1966 saw only four fatal accidents, seven occurred in 1967. The "Fatalities per million departures" and the "Fatal accidents per million departures" for 1967 are about the same as they were during the first five years of this decade.

TABLE 1.—AVIATION SAFETY (UPDATED THROUGH 1967) [1]

Item	Calendar year							
	1960	1961	1962	1963	1964	1965	1966	1967
Departures, domestic (thousands)	3,619	3,532	3,446	3,557	3,692	3,917	4,087	4,662
Departures, international (thousands)	212	198	201	214	239	257	286	306
Total	3,831	3,730	3,647	3,771	3,931	4,174	4,373	4,968
Fatal accidents	12	5	5	5	9	7	4	7
Fatal accidents per million departures	3.1	1.6	1.7	1.6	2.0	1.7	0.9	1.4
Fatalities (total)	378	135	183	145	226	257	72	250
Fatalities/million departures	99	36	50	39	57	60	16	50

[1] Table 1 was extracted from table 28, p. 92 of "Policy Planning for Aeronautical Research and Development," S. Doc. 90, 89th Cong., second sess., May 19, 1966, and updated with information from the CAB and the National Transportation Safety Board. Data for 1967 are preliminary and estimated.

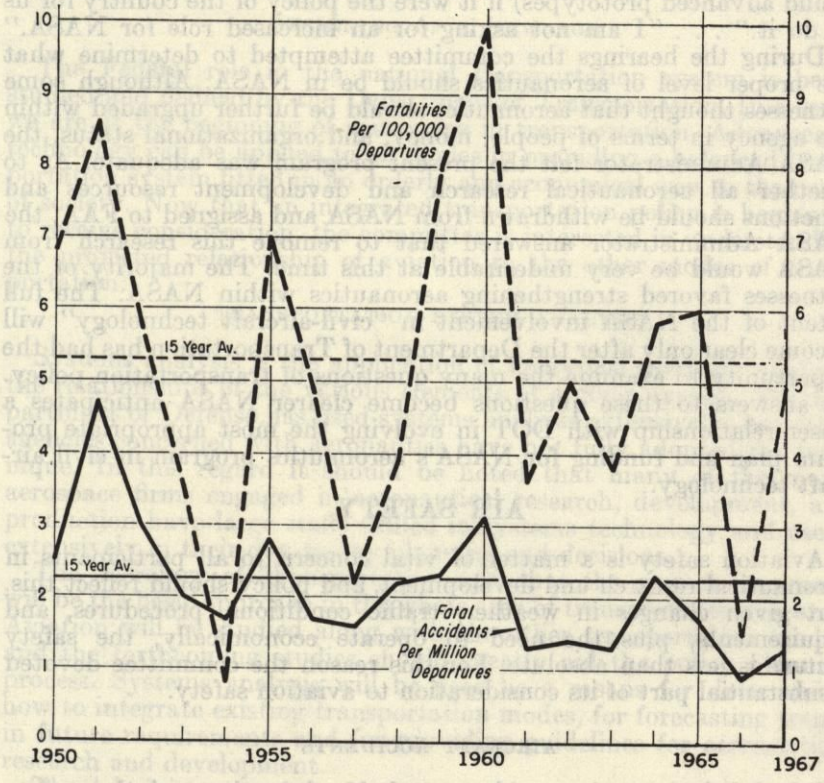

FIGURE 1.—Aviation Safety, 1950–1965 (updated through 1967).[2]

[2] Fig. 1 was taken from figure 10, p. 91 of "Policy Planning for Aeronautical Research and Development," S. Doc. 90, 89th Cong., second sess., May 19, 1966, and updated with information from the CAB and the National Transportation Safety Board. Data for 1967 are preliminary and estimated.

"Unfortunately, we do not yet approach air safety problems with the same sort of detachment and reason with which we address ourselves to industrial safety or even public safety" was the sentiment of the AOPA representative. Perhaps a sensitivity to public reaction has hampered the public discussion of aviation safety. The NASA Administrator said, "It is not a subject that anyone welcomes a large public discussion on " The ATA witness said, "We do dislike making

public statements on the technical aspects of safety, partly because their complexity invites misunderstanding. However, this dislike has never interferred with our trying to solve safety problems"

Views that aviation safety is improving were presented. The Administrator of the FAA said, "While it is true that there has been no decline in the number of fatalities per 100,000 passenger miles over the last several years . . . we have greatly increased the speed and the number of aircraft moving over the system." This represents a significant accomplishment in air safety because despite increased traffic and speed, the accidents and fatalities have not increased from what they were in the slower, less complex airspace system. The ATA spokesman summed up the subject of improved aviation safety by saying, "No matter how safe it is to travel by airlines . . . we must never let up in our efforts to make it safer."

FAA AND AVIATION SAFETY

Aviation safety is the primary mission of FAA. This mission is perceived in terms of air traffic control, airways, airports, airplanes, pilots, and maintenance men. The Federal Aviation Administration is interested in making the total aeronautical environment safer. Their safety research and development activity gives attention to all elements of the environment. As part of this mission a major effort is underway with the industry to set standards for safety that will result in safer airplanes in the future.

The level of effort in aviation safety is far more than indicated in the budget under that line item. The Administrator testified that the Federal Aviation Administration is spending many millions of dollars in improving the air traffic control system and every contribution to efficiency in operation is a contribution to safety. The ATA president said that the FAA research and development on safety is definitely not limited.

Not all witnesses agreed that the Federal Aviation Administration was meeting its responsibilities in aviation safety. The AOPA official believes that the FAA is preoccupied with air traffic control and does not like to recognize the tangible evidence as to other hazards which exist in the form of accident statistics compiled by the CAB or to formulate programs which respond to this evidence.

As a regulatory agency, the FAA has incorporated many safety improvements into the system through regulations. The Administrator said "FAA regulations do now and will continue to require the highest level of safety attainable through known technology where the safety advantage is not completely out-weighed by disproportionate costs."

INDUSTRY AND AVIATION SAFETY

The Administrator of the Federal Aviation Administration testified that the present level of Federal funding for aviation safety is satisfactory, but "there has to be more effort on the part of industry." Industry appears to be interested in doing its part. The witness representing the Aerospace Industries Association asserted that the ultimate in motivation for aviation safety rests with the industry and that "no one wants airplanes to be safer than the people who build them and the people that fly them." From the designers point of view corporate existence depends on the product and that product

must be as safe as possible. The spokesman for the Air Transport Association said that the airlines are working to improve the safety record by purchasing safer airplanes and engines, by developing safer maintenance techniques and safer air traffic control, and by improving navigation, communication, and landing facilities.

NASA AND AVIATION SAFETY

The committee examined the idea that aviation safety might be improved by giving NASA a specific assignment for research in aeronautical safety. There were two distinct opinions—one from industry and one from government. The Administrator of the National Aeronautics and Space Administration said that NASA should not be given a specific safety assignment. "We are doing a good deal of work in safety now." The agencies are working together and "I think that it would be quite hard to improve on the relationships between the agencies where safety is involved." The FAA Administrator agreed and said, "I do not believe that it is necessary or desirable to give NASA as a specific safety assignment." The opposite point of view was taken by the representative from the ATA. He stated that NASA should be given a specific safety assignment in basic research and in specifically directed follow-on projects.

AVIATION SAFETY AND ENGINEERING TRADEOFFS

The increased operating efficiency of an aircraft is made possible by incorporating technological advancements into the aircraft. These involve engineering tradeoffs between increased payloads, improved safety, engine noise suppression, and other factors such as improved handling characteristics. Most witnesses felt that engineering tradeoffs should be resolved by the industry with the Government playing a regulatory role with respect to safety.

The basic responsibility for operational safety rests with the airlines and so the ultimate resolution of engineering tradeoffs rests with the airlines. The airlines and the manufacturers are concerned with increased safety as a tradeoff to such factors as payload because they want to create an environment wherein aviation can continue to grow over the long term.

Objective evaluations of tradeoffs are always hard to make and in some instances not possible. For example, an evaluation of some of the techniques for reducing perceived noise levels and its effect on safety is not possible at this time since these remain in the area of subjective reactions. There are efforts within NASA, FAA and the National Academy of Sciences to establish a satisfactory objective rating of noise to replace the current highly subjective measures.

NASA has a definite policy with respect to tradeoffs. As stated by the Administrator, "NASA's role is to provide valid technical data from which trade-off studies can be made by other agencies with confidence, to assist in proper interpretation of these data, and, when requested, to comment on the technical validity of arguments used to arrive at regulations."

III. CONCLUSIONS

1. A single national policy for aeronautical research and development does not exist. The Federal Government's policy is a composite of the separate policies of the various agencies engaged in these activities, primarily NASA, DOD, and FAA (now a part of DOT).

2. The current civil aeronautical system in the United States is healthy and growing rapidly. Testimony taken by the committee indicates that there is considerable satisfaction with the system, the various elements in the system and the relationships between them. However, technological progress is recognized as a critical need for the continued health of the system. There is general agreement that more R&D ought to be done, but there is a wide divergence of view on what and how much should be done, who should do it, and who should pay for it.

3. Insufficient attention is being given to aeronautical R&D planning, particularly from advanced development through feasibility testing, or the proof-of-concept phase. However, there are few quantitative measures to determine adequate levels of R&D funding, and there is much uncertainty as to what the degree of involvement of the Federal Government should be. The Administrator of NASA, Mr. Webb, stated that he was "unsure" of how involved NASA should become in aeronautical development. Other witnesses said that the Government should not become involved in development except when "necessary", but no one could say how or who would make such determination.

4. Testimony shows a divergence between civilian and military requirements. There appeared to be no consensus among the witnesses on how to counteract the diminishing fall-out to civilian needs from military R&D.

5. It seems likely that the divergence between civilian applications and military R&D will continue to grow. Because of the tremendous military expenditures for aeronautical R&D (approximately 60 percent of all such expenditures), there undoubtedly will be fundamental aspects of technology and general state-of-the-art developments that will be useful for civilian aircraft. Although much of the technology generated by the DOD is generally available, the military cannot assure that their vast efforts will be of benefit to civilian requirements which are clearly outside the military mission. Steadily rising overall military expenditures diminishes enthusiasm for any additional R&D tasks directed specifically to civilian benefits. How to transfer military technology to help meet civil aviation problems then becomes a primary question for continued congressional consideration.

6. The range of possible useful aeronautical vehicles and systems is broad. Also, there is considerable engineering and scientific talent in other nations of the world. Because of these considerations, the testimony questioned the economic feasibility of a policy which would assure U. S. preeminence in all phases of aviation. A less ambitious and more realistic policy makes it extremely important to select carefully

those areas where technical superiority is desired, and to implement the R&D necessary to see that these goals are met.

7. Coordination and cooperation among the various Federal agencies appear to work reasonably well, but on an *ad hoc* basis treating specific problems as they come along. For example, NASA alone participates in 27 committees involved with one aspect or another of aeronautics with one or more other Federal agencies or other groups.

8. Despite the fact that the National Aeronautics and Space Council is only an *advisory* group to the President, it is the one existing mechanism in the Federal Government that provides the possibility of high-level consideration of aeronautical R&D policy. Unfortunately, they have not pursued aeronautical matters actively in recent years.

9. The operations of the new Department of Transportation can have an important impact on the course of research and development in the aeronautical process. The committee is hopeful that the DOT, if it is able to pursue the policies outlined in the testimony, will supply a heretofore missing element in the aeronautical process, namely to help determine a better understanding of operational aviation requirements as a guide for research and development activity.

10. Although NASA was established on the foundation of excellence of aeronautical research of the National Advisory Committee for Aeronautics (NACA), this important activity has receded into the background within NASA. This is particularly evident in the "D" (development) area because of some doubt (see No. 3 above) as to how involved NASA should be; however, there is a growing awareness of this problem within NASA, and there has been more activity in this area within the last 2 years. Subsequent to the committee's hearings, NASA has upgraded aeronautics organizationally by creating a position of Deputy Associate Administrator for Aeronautics. However, this still does not place aeronautics on a level that is consonant with the importance of this responsibility of NASA.

11. There seems to be no serious support for transferring—to the DOT for example—the responsibility for aeronautical R&D out of NASA.

12. Insufficient attention has been given to the aeronautical area identified as "general aviation" (privately owned and business aircraft). This growing segment of aeronautical operations is substantial and is becoming an essential part of our national transportation system. Little research is being done in this area and the problem of traffic control and intermixture of operations with large commercial aircraft has not received the attention it requires.

13. The committee found that aviation safety is not improving, regardless of the statistical yardsticks chosen. Year-to-year fluctuations do occur. Testimony presented for 1966 purported to show a remarkable improvement as compared with previous years. Unfortunately, the experience in 1967 has shown a reversion to the 15 year average. Further, two of last year's fatal accidents and 104 deaths have been caused by mid-air collisions.

The only logical conclusion which can be drawn at this time is that safety (expressed as fatalities related to departures) continues on a plateau which forecasts an increased number of fatalities as air travel volume grows.

IV. RECOMMENDATIONS

1. The Nation should adopt a more comprehensive and coherent policy for aeronautical R&D. The following are specific recommendations that the committee believes will help develop such a policy.

2. An in-depth study should be made to analyze the relationship between benefits that accrue to the Nation from aviation and the level of aeronautical R&D effort. The study should try to determine—or at least develop criteria for such a determination—what level of R&D should be maintained in order to achieve the desired results. This study could be an in-house effort of NASA and the Department of Transportation or accomplished under contract by the private sector. The study might also include a detailed analysis of the divergence of military and civilian aeronautical requirements in order to assess better the diminishing benefits to civilian needs from military R&D. The committee recommends that NASA and the Department of Transportation jointly sponsor such a study.

3. As soon as the results of the study are available, the National Aeronautics and Space Council, with the Department of Transportation and the Bureau of the Budget as participants, should determine the level of Federal Government involvement, and the relative effort of participating agencies.

4. Pending the results of the study, NASA should continue to expand its aeronautical efforts, particularly in the development phase. Specifically, more attention should be given to proof-of-concept testing as a means of providing a larger variety of options to aircraft designers and systems engineers.

5. A specific mechanism is needed to act as the focal point for the development of a more comprehensive and better coordinated aeronautical R&D policy. It would appear that the National Aeronautics and Space Council should be in the best position to do this. If, within some reasonable time, it does not or cannot, then the Congress should consider the establishment of a board or group that would fulfill this important function.

6. If better aeronautical R&D policy machinery existed, then it should be possible to reduce the excessive number of "coordinating" committees.

7. Aeronautical activity in NASA should be upgraded to a major office level and directed by an Associate Administrator.

8. Immediate attention needs to be paid to certain previously neglected aspects of civil aviation—i.e., aircraft noise, traffic control, sonic boom, safety, airport design, and the disparity between speeds in the air and on the ground—which have come to equal in importance basic aircraft design. These problems must be solved in the context of the total transportation system and therefore involve system management decisions. Most of these problems depend, for optimum solution, on the availability of new and proven technological alternatives. The usual performance parameters such as speed, engine power to weight ratio, direct operating cost, etc., do not reflect all of the economic

and social criteria for evaluating a mode of transportation. A reoriented and more equitable emphasis of technical efforts may well come from the systems approach being undertaken in the Department of Transportation. But the results of this analysis may be some years away. In the meantime, noise, safety and congestion demand improvement now. Scientific and engineering ingenuity must be rewarded for advancement in these areas as well as in conventional aeronautical R&D.

9. More attention needs to be paid to the operation of smaller aircraft and private aviation in general. In the area of research on smaller aircraft, emphasis should be given to improving utility and safety of these aircraft when used by less experienced pilots. The committee especially recommends that the critical problem of traffic control and the intermixture of large and small aircraft, particularly in the vicinity of major airports, be given immediate attention.

10. The testimony supports the inseparability of aeronautics and space R&D. And yet it is clear that the rewards from being involved in space projects have commanded the attention of most of the best scientific minds within NASA, industry and the universities. Two recommendations are offered.

a. By management decisions and emphasis, competent scientists and engineers should be attracted to meeting the challenges of aeronautical problems. They will not do so unless the rewards are competitive with those in space technology. A sincere, credible, dedication to aeronautical progress by industry and Government must be demonstrated.

b. A purposeful effort to transfer space technology (the bits and pieces of know-how, not just packages of equipment) to use in aviation should be initiated. Teams of competent technical people could be put to work identifying, evaluating, selecting, and applying technology from the space program—an extension of the ongoing NASA Technology Utilization program. At the same time aeronautical engineers could redefine their problems in more fundamental terms. The objective would be a more successful and rapid transfer of knowledge into the field of aviation.

It is clear that the transfer of complete machines or devices (aircraft, guidance equipment, or communications apparatus) will be increasingly rare. The technology is the more important commodity in any event. But technology transfer is difficult to achieve and some overt effort by the aerospace community will be necessary to bring aviation the full benefits of space research and development results.

11. Air safety can be improved through application of imaginative technology. In setting priorities for the allocation of limited science and engineering resources in aeronautical R&D, the committee recommends that projects related to safety be given preference. Studies should be made of air accidents and of technology which would have helped avoid them. From this effort, a measure of the adequacy of present funding for aviation safety could be developed to serve as a basis for additional support for R&D directed to improve safety.

V. APPENDIX

ISSUES FOR FURTHER CONGRESSIONAL CONSIDERATION [3]

The central issue which this study has revealed is concerned with Government policy toward aeronautical research and development, primarily as it relates to civil rather than military aviation. Today, that policy is to support certain research through NASA and the FAA which may have broad applicability. The application of the research, development, and the demonstration of new devices and techniques for the benefit of civil aviation has traditionally been left up to the manufacturing industry and the air carriers; although recently the FAA has been given the responsibility to underwrite the development of a commercial supersonic transport.

Government policy toward military aviation is aimed, of course, toward the operational use of such aircraft as may be needed to fill both offensive and defensive military requirements. Toward this end, the Government spends great sums of money in aeronautical hardware development, as well as research. Transfer of technology from these military developments has been, and will, no doubt, continue to be a major factor in the advancement of civil aeronautics; however, this may not be sufficient for the future.

What is clear is that the old patterns are changing and there are numerous issues regarding policy toward aeronautical research and development which are in need of further consideration by both the executive and legislative branches of the Government. This section lists some of these important issues, although it does not presume to be all inclusive, nor are all of these issues necessarily covered in this report. Furthermore, it is obvious that many of these questions are not under the jurisdiction of, or of direct nterest to the Committee on Aeronautical and Space Sciences. Nevertheless, a logical sequence of ssues is presented, followed by questions that are raised in each instance.

A. The principal issue is concerned with the adequacy of present policy.

1. Is the Nation satisfied with the status of our civil aeronautical system?

2. Is the rate of progress sufficient to meet future public needs?

3. Should the United States attempt to maintain worldwide superiority and market dominance in all phases of aviation, or select only certain areas for concentrated research and development? What foreign competition in aeronautical development can be expected in the near future?

B. If the Nation is not satisfied with the present system, and is not confident that the existing process for aeronautical R&D will bring

[3] Reprinted here is Chapter IV, pp. 11-13, "Policy Planning for Aeronautical Research and Development", Staff Report, S. Doc. 90, Committee on Aeronautical and Space Sciences, U.S. Senate, 89th Congress, 2d Session, May 19, 1966. These issues in this chapter formed the basis for the hearings upon which this report is based (see p. 2).

future improvements in a timely and efficient manner, then it may be in order to consider a new or modified policy. The issue becomes one of the degree and type of involvement by the Federal Government.

1. Should Federal funds be placed in direct support of new civil aircraft developments?
2. Are direct incentives effective, i.e. tax credits for R&D or new investment?
3. Can regulatory and subsidy policies be used to increase the rate of technological change?
4. What are the nontechnical barriers (e.g., political or institutional considerations) to civil aviation advancement?
5. How important is the antitrust enforced separation of the industry into airline operators and manufacturers, with regard to implementing new technology?
6. What can be learned which is useful for American aviation from the experience between government and industry in other countries?

C. Regardless of the level of Federal involvement, many private sector interests are important to policy determination. The initiative of nongovernment institutions will affect the Government role.

1. How much will the aerospace industry independently contribute to an improved national aeronautical system?
2. How may projects which will have broad application in industry be chosen for support with Federal funds?
3. How should the risktaking in advanced aeronautical development be apportioned between the public and private sectors of the economy?
4. How will the great management and technological competence of the aerospace industry be utilized in the development of transportation systems (whether for aviation or other modes)?
5. How will aeronautical research and development policy be affected by the unique capabilities of universities, nonprofit research institutes, and professional societies?

D. In connection with new or additional Federal involvement in civil aviation, the entire transportation system must be considered.

1. How do funding requirements for transportation research compare with those for other highly technical public needs such as pollution abatement?
2. What role will aviation have among other transport modes?
3. What are the R&D needs in these other fields which would compete for resources with aeronautical R&D? To what extent can R&D be made mutually beneficial to all transportation modes?
4. How extensively will systems analysis techniques be adopted for studies of the transportation system, and how effective will such analyses be in providing specifications for aircraft development?
5. Is aviation receiving too much or too little attention with respect to other modes in the national transportation system development?

E. Several agencies in the Federal Government are obviously involved in future policy.

1. What groups within the executive branch are dominating the policy and planning for aeronautical R&D?

2. Is there a long-range plan and a mechanism to coordinate the work of various agencies?

3. What is the role of the National Aeronautics and Space Council?

4. What would be the role of the proposed Department of Transportation?

5. Should the Federal expenditures for aeronautics be budgeted and considered by the Congress as a separate package, regardless of the agencies which will eventually do the work?

F. The process of aeronautical progress is in need of examination, particularly the critical development phase.

1. Are those test facilities in being adequate and conveniently available to development organizations in industry and the Government?

2. Are future facilities being planned with the needs of civil aviation in mind?

3. How can the "requirements merry-go-round" be broken to allow costly demonstration of advanced hardware without firm mission requirements?

G. To accelerate aeronautical progress, it may be necessary to designate a Federal "lead" agency.

1. Should the NASA be instructed and funded to proceed in the advanced development and operational demonstration phases of aeronautics?

2. Should aeronautics be upgraded within the agency or perhaps even removed from NASA?

3. What alternatives are there for using the talents and facilities in the sense of the old NACA?

4. Should the Defense aeronautics program be required to be coordinated better with civil aircraft needs at the outset?

5. Could incremental additions in funding bring wider applicability of R&D results?

6. Should concerted attempts at technology transfer be federally funded to utilize military facts now available?

7. What is the proper role of FAA in aeronautics development?

8. Can the responsibilities in the FAA Act be reconciled with the placement of competence and facilities in NASA and the DOD? How?

9. To what extent would the proposed Department of Transportation be involved in stipulating the direction of aeronautical research and development?

H. Safety of air travel has not improved in recent years. Only a few million dollars per year is spent in research directly related to safety.

1. Why isn't more research done by the FAA to improve air travel safety and the safe operation of aircraft in general?

2. Does a sensitivity to public reaction hamper the discussion of aviation hazards and the request for more funds to develop safety procedures and devices?

3. Should NASA be given a specific assignment for research in aeronautical safety?

I. Increased operating efficiencies of future aircraft made possible by technological advancements can lead to realistic engineering tradeoffs between (a) increased payloads (lower fares), (b) improved safety features, (c) decreased perceived noise levels on the ground, or (d) improved handling characteristics.

1. How can these tradeoffs be objectively evaluated?
2. How far should Federal regulatory procedures go toward requiring the fullest possible use of these technological advancements for improved safety noise abatement, and schedule reliability, rather than for increased payloads?

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