



Civil Aviation Research and Development: An Assessment of Federal Government Involvement: Economics of Civil Aviation (1968)

Pages
50

Size
5 x 9

ISBN
0309342090

Ad Hoc Committee on Economics of Civil Aviation;
Aeronautics and Space Engineering Board; National
Academy of Engineering

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CIVIL AVIATION
RESEARCH
AND
DEVELOPMENT

An Assessment of
Federal Government Involvement



Ad Hoc Committee ECONOMICS OF CIVIL AVIATION

A General Discussion of Statistics and Policy Factors

AERONAUTICS AND SPACE ENGINEERING BOARD
NATIONAL ACADEMY OF ENGINEERING
" Washington, D.C.
December 1968

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The study and report by the Aeronautics and Space Engineering Board of the National Academy of Engineering were supported by the National Aeronautics and Space Administration under Task Order Contract NSR 09-012-912.

Available from

Aeronautics and Space Engineering Board
National Academy of Engineering
2101 Constitution Avenue, N.W.
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Foreword

The National Academy of Engineering established the Aeronautics and Space Engineering Board (ASEB) in May 1967 to advise the National Aeronautics and Space Administration (NASA) and other government agencies. In consultation with officials of NASA, the Department of Transportation, the Federal Aviation Administration, the President's Science Adviser, certain interested committees of Congress, and the National Aeronautics and Space Council, as well as other government and private groups, the Board selected as its first topic of study, "Civil Aviation Research and Development: An Assessment of Federal Government Involvement." The Board's report under that title was published on August 13, 1968. It summarizes reports of six ad hoc committees, including this report by the Committee on Economics of Civil Aviation.

As background information for the reader of the committee reports, the most important conclusions and recommendations of the Board are stated below (from pages v-vi, summary report).

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

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

"The most important recommendation of the Board pertains to knitting together more tightly the civil aviation research and

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

The Board's report also contained many detailed technical recommendations concerning research and development needed to ensure the continued growth of civil aviation. These pertain to most of the important areas of civil aviation, including systems and the specific areas of flight vehicles, aircraft operations, air traffic control, airport and support facilities, economics, and noise.

The Board assigned detailed work to six ad hoc committees covering the above specific areas. Each committee was composed of knowledgeable men from different parts of the aviation community; their valuable contributions are sincerely appreciated by the Board.

Board membership is listed in Appendix I. The Board wishes to express its appreciation and indebtedness to a large number of individuals beyond its membership with whom it conferred. These are also listed in Appendix I. The Board is indebted to the American Institute of Aeronautics and Astronautics, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers for conducting special studies, making available special reports, and identifying members for participation in an advisory capacity. The cooperation of these societies served to broaden the advisory base.

The Board is particularly grateful for the valuable assistance provided by the members of the Ad Hoc Committee on Economics of Civil Aviation, who are listed on the following page.

AD HOC COMMITTEE ON
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Introduction

Organization for Conduct of the Economics of Civil Aviation Study

The members of the Committee on Economics were selected on the basis of their knowledge and experience in dealing with the various aspects of the economics of civil aviation.

The chairman and vice chairman, both members of the ASEB, brought to the committee their knowledge of the fields of aeronautical research and development, transport, corporate, and rotary-wing aircraft manufacturing, and experience as private pilots. Advisers were included from the fields of economics, airline system planning and operations, long-range passenger and cargo aircraft manufacturing, transport operations, and private aircraft manufacturing.

Method of Conducting the Study

As a first step, the chairman asked each of the committee members to submit comments framed around an outline of various environmental elements affecting civil aviation, such as noise, air traffic control, airports, and safety. For each of these areas the committee was asked to review the principal problems and current state of knowledge and to recommend actions that should be taken to improve the situation.

A special report on economics of civil aviation prepared by the American Institute of Aeronautics and Astronautics was reviewed by the committee. Other sources of information included the American Society of Mechanical Engineers, the American Society of Civil Engineers, the Aerospace Industries Association, and a recent study by the Transportation Workshop entitled "Air Transportation 1975 and Beyond, A Systems Approach."

Additionally, the committee noted a 1961 report on national aviation goals (Project Horizon) sponsored by the

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Federal Aviation Administration. This report considered many aspects of the economics of civil aviation; in the opinion of the committee, most of these remain valid today.

From this information the chairman drafted a report that was reviewed and approved by the members at a meeting of the committee.

The committee considered several problems related to the economics of civil aviation and suggested actions that should be taken by government agencies, with the assistance of industrial or academic organizations in some instances, to minimize or eliminate these problems.

Background

During the early phases of the ASEB study, the discussions by experts in the various fields of civil aviation and the review of Senate Document No. 90, "Policy Planning for Aeronautical Research and Development," prepared by the staff of the Library of Congress, identified major problems that are either already restricting the growth of civil aviation or that are expected to limit its growth in the future. Among the problems cited were congestion of the airways and airports, with related traffic control difficulties, safety, aircraft noise, and sonic boom associated with supersonic flights. Although attention has been given these problems, they still remain a potential retarding influence on the growth of civil aviation.

The congressional report cited the importance of the aeronautical system to the economy of the United States and described the direct and indirect impact of civil aviation on our society. As a substantial industry, aeronautics contributes materially to the desired growth of the gross national product and to the general employment and prosperity of the people. Air travel and other intermodal systems are a major influence on urban patterns of development and land use and must be considered in city planning and in beautification and antipoverty programs. The air transportation system is a major influence on the economic health of our nation and it, in turn, is vitally affected by the nation's economic health.

Scope of the Study

This report of economics of civil aviation should be read with the recognition that other ASEB ad hoc committees were active in the following areas:

- Flight vehicles and airbreathing propulsion
- Aircraft operations
- Air traffic control
- Airport and support facilities
- Aircraft noise

The committee recognized that the problems and the solutions considered by the other ASEB committees bear on economics, whether the problems were technical, social, political, or geographical in nature. The committee viewed economics as the sum of the total environment, and thus the recommendations made by other ASEB committees are closely tied to economic considerations.

The committee considered aviation economics in the context of a broad overview of the areas of interest to the other ASEB committees and in a time frame of the next ten years.

In many cases, the committee has suggested agencies that it considered appropriate to carry out the recommended actions or to participate in such actions. In its summary report the Board generally chose to omit any such references, thus giving the agencies concerned the option of determining appropriate implementing activities.

Discussion of Problems and Recommendations

Results of the committee's study have been divided into two major sections. The first, "General Considerations," presents views on the increasingly important role of civil aviation in the national transportation system. The need for establishment of goals and the relationship of civil aviation to the national transportation system are discussed. The second section, "Technical Considerations," considers various factors affecting the growth of civil aviation, which are categorized to some extent in the technical areas covered by the other ASEB committees.

GENERAL CONSIDERATIONS

Our modern society is in large part a result of transportation; it, in turn, demands better means of transportation. Starting within the last half century, and accelerating greatly within the last 25 years, air transportation of all types — civil and military — has become a major element in world affairs as an expression of national policy, corporate business policy, and individual personal policy. This discussion will limit itself to consideration of the impact of civil aviation on our modern society.

Impact of Civil Aviation on Society

Civil aviation is one of the major components of the nation's domestic and international transportation system. It both competes with and is complementary to surface transportation.

Commercial Passenger Aviation

Twenty-five years ago it was rare for a person to have taken a trip by commercial aviation. This situation has changed considerably as the following statistics show.

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1. By 1961: 30 percent of the individuals in the United States had used commercial aviation at least once, and these individuals used commercial aviation an average of 1.07 times a year.

2. By 1966: 43 percent of the individuals in the United States had used commercial aviation at least once, and these individuals used commercial aviation an average of 1.28 times a year.

3. By 1975: 66 percent of the individuals in the United States will have used commercial aviation at least once, and these individuals will have used commercial aviation an average of 1.44 times a year.

Commercial passenger aviation has successfully competed with commercial passenger surface transportation until it now carries the bulk of long-distance common-carrier passenger traffic. Figure 1 shows the past trends and estimates for the future use of the various modes of commercial transportation. It has now reached the point where the sheer bulk of commercial passenger aviation is beginning to inhibit further growth. There are already limitations on aircraft operations in the total environment; limitations in the air traffic control system, particularly at the high-density hubs; limitations in airport and support facilities - both for the air vehicles and for the passengers who have the problem of crossing multiple interfaces between the air vehicle and the other modes of travel required to get to their destinations; and limitations because of noise generation.

Solution of these self-generated problems is essential if the present growth of commercial passenger aviation is to continue. A decline in the growth rate of commercial passenger aviation would result in widespread economic problems. The first to be affected would obviously be the airline operators, but eventually the impact would be felt by the public and the entire nation. Such an impeding effect on national business transactions and productivity would eventually be reflected in a reduced gross national product.

Commercial Cargo Aviation

Commercial passenger aviation, however, is only one part of civil aviation. Commercial cargo aviation presently

ESTIMATED PROJECTION OF DOMESTIC
INTERCITY TRAVEL BY PUBLIC CARRIER

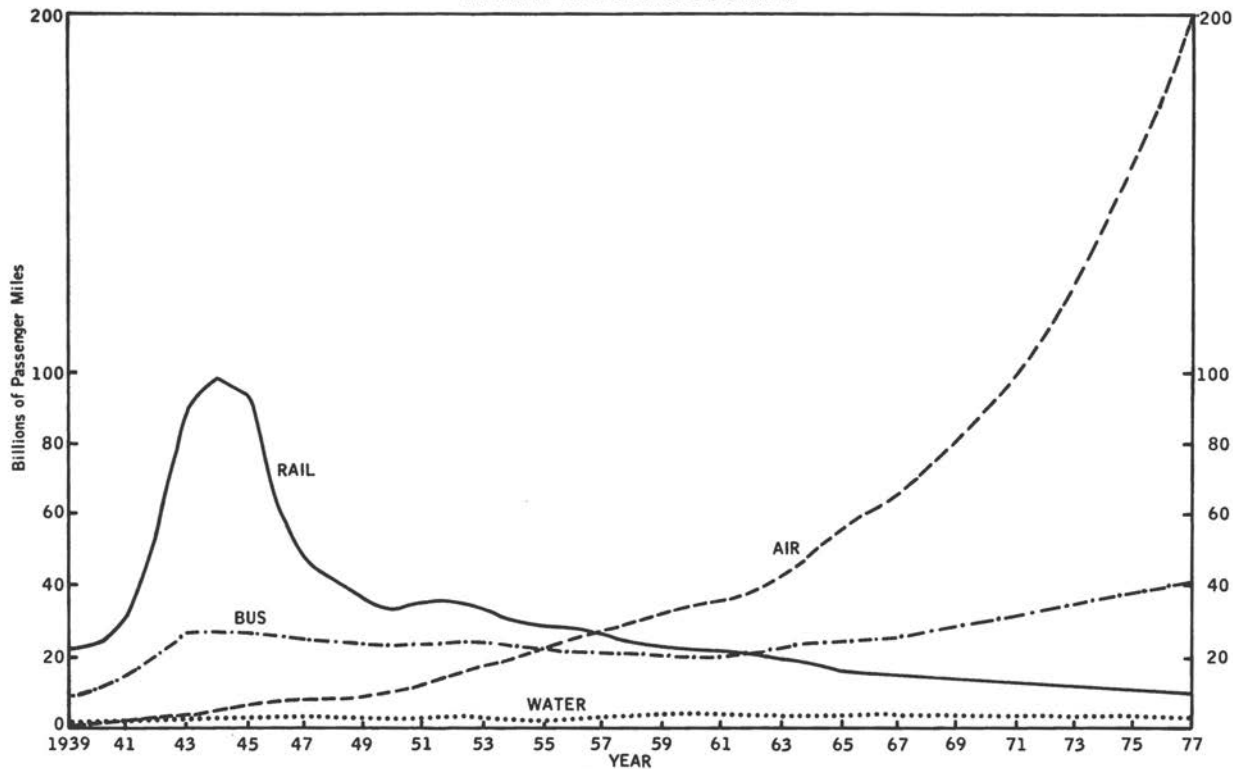


Figure 1

Source:

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

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does not have the overall economic value of the passenger activity, but it is one of the fastest growing parts of commercial aviation.

The transportation of goods is one of the most evident features of our modern society and is vital to the continuing economic growth of the nation. There has been a consistent yearly increase in cargo transportation over the past 25 years. Air cargo transportation accounts for a small but increasing portion of the total movement of goods in the United States. The percentage of air cargo transportation is expected to increase by more than a factor of 5 over the next ten years, as shown in Table 1.

Table 1
Cargo Transportation

Year	Total Cargo per Capita	Air Cargo per Capita	% Air Total
1966	9,000 ton miles	10.8 ton miles	0.12
1975	11,300 - 12,300 ton miles	75.0 ton miles	0.66-0.61

Air vehicles are becoming available that can make these projections come true; but the factors inhibiting such continued growth are essentially the same, except for some differences in detail, as those that are now starting to limit expansion of commercial passenger aviation. With society's increasing dependence on more sophisticated and higher-valued products, it is obvious that a slowdown in the growth of commercial cargo aviation should be avoided if at all possible because of its serious effect on the economy of the nation.

General Aviation

There is widespread recognition of the growing importance of commercial aviation to the national economy. However, the fastest growing sector of civil aviation is not commercial aviation, but general aviation.* It is estimated that the general aviation fleet will grow from 95,000 aircraft in 1965 to over 180,000 in 1977. But this is not the only indicator of general aviation growth.

*General aviation includes private, corporate, executive, and air-taxi aircraft.

Historically, general aviation has accounted for a relatively small but rising proportion of en route instrument flight rules (IFR) traffic. The number of IFR aircraft handled - that is, the total of radio contacts for departure, landing, and transfer of aircraft between traffic control centers - is one measure of IFR activity. In fiscal year 1966 the number of general aviation aircraft handled rose to 1.7 million, representing 13 percent of the total, up 35 percent from the number handled in fiscal year 1965 and approximately double the number handled in fiscal year 1962. The continuing growth and upgrading of the general aviation fleet, particularly as turbine-powered and other more fully instrumented aircraft enter into service, should result in a further rise in IFR flying by general aviation. The forecast for fiscal year 1977 is for approximately 9.0 million general aviation IFR aircraft handled, a more than fivefold increase over that of fiscal year 1966. This rate of increase is almost double that forecast for similar operations by commercial air carriers.

This increase will be a result of the demands of the nation's economy and the changing geopolitical character of the nation. General aviation also plays a part in energizing the national economy and in providing the means of modifying the geopolitical aspects of the country.

The United States has moved, just in the twentieth century, from a primarily rural country to a primarily urban one with masses of population and industry concentrated in a few large geographical areas. This has been made possible by the very high degree of mechanization of our agriculture, which has produced an increasing abundance of agricultural products while the percentage of the population engaged in agriculture has been continually declining. The result is the highest industrialization and standard of living of any country in the world and an economic capability to support greatly improved transportation of all types, which, in turn, is essential to the continuing economic growth and high standard of living of the country.

However, industry has recognized that continued crowding into large densely populated centers inhibits industrial growth. As a result, for the last two or three decades, industry has found it necessary to decentralize its activities to some extent in order to find the proper work force, facilities, and economic conditions needed for the production

of more numerous and more sophisticated industrial goods. With the increasing decentralization of factories out of metropolitan areas and the continued growth and diversification of corporations in the United States, there is a growing need for corporate communication. Electronic communication helps, but it is far from adequate and must be reinforced by face-to-face communication. More and more corporations are finding that the most effective way to solve this problem is to use corporate aircraft. The ever-widening use of aircraft such as the "business jet" affords better corporate control by higher-level people, and at the same time it permits company officials to spend more time at corporate headquarters - and with their families. From all indications this trend will continue. By 1975 the business aircraft fleet is expected to approximate 33,000 aircraft including about 7,500 turbine-powered multiengined types.

These factors have resulted in a general increase in all forms of transportation, and air transportation has accounted for a major portion of the increase because of its time-saving feature. Most of the longer-haul air passenger transportation is by commercial carrier. However, it is being found that it is often quicker to go from one outlying location to another outlying location by using corporate or private aircraft. In addition, many travelers from outlying locations need to travel to the population centers to take advantage of commercial aviation for long trips. With surface transportation becoming increasingly congested in the hub areas, such travelers are making more use of corporate or air-taxi aircraft to move to and from major air terminals. Air-taxi and commuter airline operations are now one of the fastest growing segments of general aviation and are transporting an increasing percentage of the passengers using commercial aviation.

Another reason for the growth in nonairline aviation arises from the fact that the scheduled airlines serve only 523 points, whereas there are almost 10,000 airports in the United States. It is interesting to note that 45 percent of all U.S. commercial airline passengers enplane at 10 cities, and 96 percent enplane at 142 cities. The United States has 211 metropolitan centers of over 50,000 population, but 14 of these are not certified for scheduled airline service. One third of the nation's people live in cities of less than

10,000 people or in rural areas, but only 60 cities of this size are now certified for scheduled airline service. Forty cities have lost airline service in the last few years, and 20 more are on a basis of "use it or lose it."

Corporate and private aircraft have been criticized as adding considerably to problems of air traffic control and airport and support facilities. This is true primarily at the few large air terminals handling a major portion of commercial aviation operations. At these hubs it appears to be essential and in the interest of commercial aviation to provide adequate facilities to get the air-taxi passenger to the hub airport and to and from commercial aviation aircraft. The nonairline passenger generally would prefer not to go to the hub airport, and if suitable alternative facilities were provided to permit him to get easy and rapid air transportation to his final destination, he would use these other means. The facilities are required at a few major air terminal hubs now, and as civil aviation continues to grow, such provisions must be made a basic part of the planning for expanded or new air terminals.

Aside from the corporate and air-taxi elements of general aviation, there is a considerable amount of private aircraft activity in areas such as agriculture, flight instruction, and recreational flying. Seldom do any of these activities have significant interaction with commercial aviation, unless convenient secondary airports are not available in a hub area. Agricultural and flight instruction aircraft normally use the air traffic control system only to a limited extent, and usually at airports that are outside the hub areas. Private flying for recreation is making increasing demands on air traffic control facilities for operations under IFR conditions, but generally such aircraft are flown at the lower altitudes that are no longer used by commercial aviation aircraft.

V/STOL Aircraft in Civil Aviation

Thus far the discussion has concerned itself primarily with conventional takeoff and landing (CTOL) aircraft, which account for most of the current civil aviation activity. There is, however, growing use of vertical or short takeoff and landing (V/STOL) aircraft in civil aviation.

Up to the present time the primary use of this type of

aircraft (e.g., VTOL aircraft of the helicopter type) has been in general aviation, mainly for short interplant transportation of passengers and cargo and for such general activities as support of offshore oil drilling sites, assistance in construction activities, and emergency use. Their use in commercial aviation is presently limited to intracity short-haul transportation of passengers and cargo between population centers and their related hub airports or between airports in a hub area for connecting commercial aviation passengers.

With increasing ground traffic congestion in population hub areas, it appears that it is becoming economically desirable for commercial aviation to expand its use of either VTOL or STOL aircraft, for both intracity and interairport transport. It is interesting to note that although the long-haul portion of commercial aviation accounts for most of the passenger miles (75 percent of the passenger miles are developed by trip lengths of 600 miles or more), the short-haul portion carries most of the passengers (more than 50 percent of the air passengers travel 500 miles or less). Table 2 shows the number of passengers traveling at the shorter distances in 1965.

Table 2
Percentage of Passengers Traveling 500 Miles or Less

Trip Length	% of Total Passengers
Less than 100 miles	1.9
Less than 200 miles	15.0
Less than 300 miles	30.8
Less than 400 miles	43.1
Less than 500 miles	51.6

Much of the present congestion is caused by short-haul traffic flow at major airport hubs. If a reasonable amount of this short-haul traffic could be operated from city-center to city-center instead of airport to airport, the air traveler would benefit from more convenient travel and reduced trip time. VTOL transport development is beginning to show acceptable economic characteristics for ranges of about 200 to 300 miles. Removal of this portion of short-haul passenger traffic from our major airports would significantly reduce airport congestion and thus improve longer-haul operations from those airports.

The committee viewed these statistics as indicative of the increasing importance of civil aviation to the economic growth and strength of the nation. At the same time, the committee recognized that if civil aviation is to continue to grow, many problems – both economic and technical in nature – must be solved.

Analysis of the National Transportation System

It would not be out of order to say that the future of civil aviation, in its several parts, bears directly on the economic aspects of civil aviation. Many economic problems involved in civil aviation need to be solved in the next few years if air transportation is to continue its rapid growth and its increasingly important role in the economic development of the nation.

Economics implies a cost-benefit relationship so that modern methods of systems analysis should be useful in basic economics investigations. It does not seem feasible initially to model the total national transportation system in all of its infinite detail. However, modeling to provide frames of reference appears reasonable with today's analytical tools. Subsequently, more detailed modeling of individual elements of the transportation system, such as civil aviation, may be feasible. As a further breakdown, modeling of certain subelements of the civil aviation portion of the total transportation system may be useful. It should be cautioned that although system analysis of subelements, such as airport and support facilities, is most desirable, the system analysis for such elements must be specially handled, to provide for both their common interface with the other elements of the civil aviation system, as well as their special and different interfaces with each local transportation system.

National Transportation System Goals

If anything meaningful is to be obtained in the area of economics of civil aviation, it first appears essential to establish a framework in which to consider civil aviation. Civil aviation is part of the national transportation system; thus, it is most desirable to relate the goals for the civil aviation system to the goals of the national transportation

system.* Going one step farther, it is obvious that the national transportation system must have goals that are compatible with the goals of the nation. It is recognized that establishment of these planning guides may be difficult and it may be possible to derive only general statements of objectives. Nevertheless, such statements are necessary to give meaning to recommendations for improving all aspects of civil aviation considered by the ASEB in its study.

It is essential that the goals for the national transportation system be formulated to provide a general long-term guide for the development of the system and its component parts. It thus appears that the first general area of effort concerned in the economics of civil aviation should be:

The establishment and statement of the long-term goals of the national transportation system as related to the goals of the nation.

- It is recognized that the statement of these goals will be subject to modification from time to time as the financial, political, and technical conditions change within the country. However, it appears most desirable that a reasonably firm statement of the goals should be established for the period at least through the 1970's.

- Much information is available that can be useful in establishing the goals of the national transportation system. It is to be hoped that the DOT will make full use of this information although it may need to be categorized and codified as a basis for establishment of the transportation goals.

- With the capabilities and techniques that have been developed in the last several years, it is to be hoped that the stated goals will be the result not only of pious hopes and random ideas but of broad-gauge system analysis. If the DOT does not have within its organization the full capability to perform such analyses, it should arrange to use existing capabilities of other governmental departments or to

*During the time that the Committee on Economics of Civil Aviation was making its study and preparing this report, the DOT was engaged in formulating a statement of goals and objectives for the department. The DOT goals and objectives document was published on May 13, 1968, after this report was drafted. The committee's views on this subject should, therefore, be read with the understanding that they were developed before the issuance of the DOT document.

contract with universities or other nongovernment organizations having special competence in this type of systems analysis.

- The government's role in this area is primarily that of collecting, collating, and making available the basic information in the field of transportation and providing necessary financing for a systems analysis as a basis for establishment of sound transportation goals for the 1970's. The government departments primarily involved are the Department of Transportation, the Department of Commerce (DOC), and the Department of Defense (DOD). In addition, information may be obtained from many other sources, including the Civil Aeronautics Board (CAB) and the Interstate Commerce Commission. Information is also available from various industrial organizations dealing with both surface and air transportation, as well as from certain individual operators and manufacturers in this field.

Civil Aviation and the National Transportation System

Subsequent to establishment of the long-term goals of the national transportation system, the relationship of civil aviation to the national transportation system should be determined. This should include the major elements of civil aviation, including commercial (passenger and cargo operations) and general aviation (including private, corporate, executive, and air-taxi operations). The driving forces for each of these elements have much in common, but they also have very significant differences. As a result it would appear that the second general area of effort in the economics of civil aviation should be:

The determination of the relationship of civil aviation to the national transportation system.

- The basic correlative factors for the several elements of civil aviation within the national transportation system should be determined. Estimates should be made of how these elements will tend to change for the period through the 1970's, assuming that there are no inhibiting factors. Projections of transportation costs, gross national product, discretionary income and leisure time, and future geopolitical changes should be made and evaluated in such a study.

- Information on past trends of these elements is available. The determinant effect of each such element should be assessed in terms of its impact on civil aviation relative to the national transportation system.

- Aerospace manufacturers, airline operators, consulting organizations, academic institutions, and government agencies all have some insight on the specific relationships of the various elements of civil aviation to the national transportation system. It appears, however, that an attempt should be made to systematically analyze and correlate the effects of these basic factors on the potential growth of civil aviation in the United States.

- The primary responsibility for gathering available information for a systematic analysis should rest with the DOT, with help from the CAB and other government or industrial organizations having relevant data. The analysis and correlation might be done within the DOT or under contract with either academic or "think tank" institutions. The basic information and results of the analysis should be made available on a timely basis to the civil aviation industry, including operators, manufacturers, and consulting organizations.

TECHNICAL CONSIDERATIONS

Turning from broad issues, the committee identified and discussed from an economic point of view the several factors that could affect the continued growth of civil aviation. The technical areas considered here are discussed in more detail in the reports of the other ASEB ad hoc committees noted in the introduction to this report. In this section the committee offers guidance on the role of government agencies in the study of the economic aspects of these problem areas and suggests actions that might be taken to initiate investigation of these factors.

Factors Affecting the Growth of Civil Aviation

Civil aviation is developing to the point where certain factors may either inhibit or limit the further development of civil aviation during the 1970 to 1980 period. In order

that government organizations such as NASA can apply their research and development efforts more effectively to solution of the problems that may inhibit or limit the growth of civil aviation, it is necessary to consider the cost-benefit relationships involved in the solution of these problems. The committee concluded that the primary productive, inhibiting or limiting factors affecting civil aviation during the 1970's include the following points.

Financing

Several elements must be considered. Financing of airborne equipment requires the investors to be reasonably assured that the operators of the equipment will be able to repay the financing with suitable return. Financing is also dependent upon the welfare of the national industrial community being such as to permit purchase of aircraft for general or corporate use. Another element is the influence of discretionary income on the purchase of smaller aircraft for private use. The future of various types of air transportation, whether CTOL or V/STOL, will depend upon the feeling of the financial community as to the probable economic feasibility of such operations. There also are the general financial requirements for the continued development of advanced flight vehicles and propulsion systems, airports, air traffic control systems, and other elements that make up the air transportation system. The area of financing could be an inhibiting or even a limiting factor in the continued development of civil aviation during the 1970's. An analysis should be made to ascertain the cost-benefit aspects of the financing of major civil aviation operating systems and to determine the elements that might limit civil aviation growth.

Flight Vehicles and Propulsion Systems

The development of new flight vehicles and their related propulsion systems continues apace because it appears that overall markets will justify financial support of these developments by private capital. The supersonic transport development has been considered to be beyond the financial capabilities of the private sector of the

economy, and as a result this development is being guaranteed by the federal government. There may be other areas where this government guarantee will apply. For example, if inter- or intracity operation of VTOL-type aircraft appears to have a proper cost-benefit effect on the overall transportation system, it could well be within the policy of the government (considering its previous attitude toward transportation) to provide assistance in the form of subsidies for a limited period of time to encourage development and operation of VTOL aircraft until that system becomes financially self-supporting. We can look forward to continued improvement in quality of transportation as well as continued reduction in cost of transportation as measured in real dollars. Continued development to improve the operating efficiency of flight vehicles and propulsion systems appears to be mandatory to counter some of the inhibiting factors that may develop during the 1970's.

Aircraft Operations Problems

Expanding areas of operation and increasing numbers of aircraft in civil aviation use make air safety a matter of growing concern. The hazards of air collisions or clear air turbulence can have a definite economic effect on civil aviation. Solution of the collision avoidance problem appears to be technically feasible, but information is needed to determine the amount of effort that should be made in this area and its cost-benefit relationship. Atmospheric turbulence is under continuing study, but again information is needed on the amount of benefit to be gained from the effort expended. All of these factors should be subjected to cost-benefit analyses as a basis for decisions on the proper level of support needed to develop solutions for the operational problems resulting from greatly increased civil air traffic.

Air Traffic Control System

The capacity of the air traffic control system is of increasing concern as the volume of air traffic increases. The present air traffic control system is becoming a limiting factor for civil air operations in high-density air traffic areas. At the present time there are only five or

six of these high-density problem areas in the country. By 1980 (if air traffic growth is not impeded by other factors), it is predicted that there may be as many as 20 high-density traffic areas in the United States. Unless steps are taken to improve the control and expedite flow of air traffic into and out of these hub areas, the increasing delay and cost will seriously inhibit the growth of civil aviation. Studies should be made to develop cost-benefit relationships and determine the areas in which effort should be applied to provide optimum improvement for the money expended.

Airport and Support Facilities

It is unfortunate that in the United States the general problem of airports—including access, terminal facilities, parking, and other factors involved in air travel—has been handled too late, in a piecemeal and relatively ineffective manner, at least as far as the major air hubs of the country are concerned. Inadequate facilities are limiting air operations at certain major hub airports now. Access and egress, passenger processing, and baggage handling are becoming more difficult. With the increased flow of air traffic anticipated by 1980, problems can be expected to be much more serious. There are definite indications that unless aircraft operators adopt schedule changes practices, unless the government improves its air traffic control procedures, and unless provisions are made for compatible operations by both commercial aircraft and general aviation aircraft (including VTOL or STOL aircraft used in feeder operations), this situation will continue to get worse and will become an inhibiting if not a limiting factor in civil aviation growth. This situation needs to be analyzed to some extent in general, but at each of the major hubs where this can be expected to be limiting through the 1970's, specific analyses must be made of the interfaces within the local transportation system. Remedial action must start very soon if civil aviation is not to be limited by outdated and overloaded airport facilities.

Aircraft Noise

Power creates noise, and aircraft, in general, are using more and more power. Studies are underway in

many areas to learn how aircraft noise might be reduced. Noise abatement is one area in which NASA can play a large part by continuing and expanding fundamental studies on the causes of aircraft noise as the basis for design of quieter aircraft engines. Aircraft noise can be controlled to some extent by changes in flight pattern, but this has a degrading effect on the economics, efficiency, and, sometimes, safety of air operations. The determination of the mechanism of noise, in order to do a better job of controlling noise, is obviously an important matter. Premature legislation to regulate aircraft noise levels can do a great disservice, not only to civil aviation but to the country as a whole. A better scientific understanding of the mechanisms of aircraft noise generation, propagation, and suppression is required before realistic restrictions can be applied to abate the noise of aircraft. Reductions in aircraft engine noise can be achieved but not without appreciable cost. It is important, therefore, to have a cost-benefit analysis made in the area of aircraft noise to determine the best combination of technical and operational steps that can be taken to achieve the desired reduction in aircraft noise.

Recommendations

Study of the various productive, inhibiting or limiting factors is currently underway, and technical effort is continuing to develop solutions to the problems besetting civil aviation. Much consideration is also being given to the problem of financing. The multiple cost-benefit analyses that have been recommended should be designed to rank each of these areas in order of importance and identify the areas offering the most benefit from the available resources. Analysis of trends in business and technical research and development as well as assessment of the contribution of the areas discussed are needed to determine the extent of effort that should be applied in each area. In addition, an attempt should be made to determine which of the factors are likely to inhibit or delay progress and which might represent a totally limiting barrier to the growth of civil aviation.

From the overall standpoint, the DOT has the prime interest in seeing that the analyses are carried out.

Information and assistance will be required from NASA, the FAA, the DOD, the civil aviation industry, and the financial community. The multiple system analyses should be performed by personnel from within the DOT if they are available. Otherwise, other departments of the government organizations having systems analysis capabilities might undertake the studies with support and direction by the DOT. Information from such studies should be made available to the civil aviation industry for its guidance in working out solutions to specific problems within the overall framework. It is emphasized that, in the committee's view, such analyses should precede any regulatory action by the government on matters involving civil aviation in order that the effects of such regulations or controls can be properly assessed.

The role of the government should be to direct and support the analyses to ensure an unbiased study and report. If basic problems in the technical areas are disclosed (such as aircraft noise, air traffic control, or airframe and engines), the government, preferably through an organization such as NASA, should be prepared to finance the necessary basic research and make the results available to the aviation industry. The basic work should be done well ahead of the expected time of application; it is relatively inexpensive when done this way. The applied work in practically every case should continue to be conducted by the private sector of the nation. This envisions, in effect, restoring the excellent working relationship that existed between the National Advisory Committee for Aeronautics (before it became NASA) and the private sector of American industry, and which contributed significantly to the preeminent position of the United States in world aviation.

Suggested Actions

Throughout this report the committee has made frequent reference to the need for cost-benefit analyses of the various factors affecting civil aviation. To illustrate the type of information and the actions that the committee believes are necessary to conduct such studies, the following examples are suggested.

Comprehensive Information Systems

Comprehensive and current information on traffic and economics (including interchange of information between military aviation and commercial-general aviation) are needed to support the systems analysis method. A suggested approach is to acquire for commercial and general aviation (United States and international) historical and projected information on passenger, cargo, and mail movements, covering origin-destination and mode and type of travel (i.e., business or nonbusiness) or type and size of cargo.

Data on historical and projected movements of aircraft are also required, including aircraft size and speed characteristics and time-of-day distribution. This must include interactions among general, commercial, and military aircraft movements.

The DOT, through its FAA, would appear to be the logical government agency to take the lead in establishing and coordinating this activity. Other government agencies that would be involved include the DOC, the DOD, and the CAB. In this connection, it was noted that CAB Form 41, "Uniform System of Accounts," might be a useful source of information if its data were computerized and revised to show cost by time and flight cycles and maintenance cost elements segregated in accordance with Air Transportation System Specification 100 or an equivalent specification.

Cooperation Between Civil and Military Aviation Activities

Increased joint effort between civil and military aviation appears necessary to provide as broad a data base as possible for an analysis of the air transportation system. More attention should be given to cooperation in developing power plants, airframes, and aeronautical systems and in blending compatible design requirements. There should be continuing and increasing coordination between the civil and military activities engaged in air cargo transport activities, including the Air Force Military Airlift Command and the Civil Reserve Air Fleet (CRAF) program. Greater military representation at airline and general aviation meetings should be encouraged as a means of

fostering a better understanding of common problems and development of compatible solutions.

Government agencies most concerned with the above civil and military air transportation activities include the DOT, the DOD, and NASA. The views of the aviation community outside the government could be obtained through the organizations representing the various elements of the aerospace industry and commercial aviation.

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Appendix I

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