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CONTRACTOR REPORT

SOCIAL IMPACTS OF CIVIL AVIATION AND IMPLICATIONS FOR R&D POLICY

SEPTEMBER 1971

PREPARED BY

THE PROGRAM OF POLICY STUDIES IN SCIENCE AND TECHNOLOGY
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16. Abstract

The purpose of this study was to identify social impacts, both beneficial and detrimental, which would or could flow from introduction of advanced civil aviation systems. This future-oriented technology assessment was performed by an inter-disciplinary team of social scientists, natural scientists, and engineers, and a broad range of social impact areas was investigated which included economic, environmental, political, sociological, psychological, legal, and urban/regional developmental factors. In keeping with the fundamentally inter-disciplinary nature of such a study, the results are presented primarily in their finally integrated form rather than as a compilation of separate disciplinary inputs.

The report is arranged into two major parts. In the first part, a series of "Major Policy Issues" are identified and discussed which appear, on the basis of the social impact study, to merit serious consideration. The discussion of each "Issue" is presented both to explain its relevance and to raise considerations which will bear on its satisfactory resolution. The second part of the report views the same overall body of information in a different manner: a series of "Findings" are pointed out from which more concrete guidance for R&D policy can be derived, and a set of "Candidate Basic Federal Undertakings" thus derived are presented.

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FOREWORD

This study was performed by the Program of Policy Studies in Science and Technology of The George Washington University as part of the Joint DOT-NASA Civil Aviation Research and Development Policy Study, under NASA contract number NSR 09-010-069. The most intensive, basic phase of the study was carried out over the period of April through August, 1970, after which a major report was submitted to the Joint Study on September 1 for internal use. During the period from September 1, 1970, through April 30, 1971, work was performed (a) to greatly condense the material in the September 1 report to facilitate its publication and (b) to pursue the analysis of the practical implications of the study findings for R&D decisions. This report is the combined product of the latter two efforts.

The contract monitor for the Joint Study was Mr. Stanley Smolensky of the Office of Policy Planning, National Aeronautics and Space Administration. Mr. Smolensky's constructive suggestions and unfailing interest throughout the study were very beneficial and sincerely appreciated.

A full listing of the personnel contributing to this study is presented as Appendix B.

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INTRODUCTION

This report summarizes the results obtained in a study of social impacts of civil aviation conducted by The Program of Policy Studies in Science and Technology of The George Washington University. The study was sponsored jointly by the U.S. Department of Transportation and the National Aeronautics and Space Administration, as part of their Joint Civil Aviation Research and Development Policy Study. The parent study is frequently referred to in abbreviation as the "CARD Study," and therefore the associated study by The George Washington University (GWU) will be abbreviated herein as the "GWU/CARD Study."

The prime reference for detailed presentation of social impact findings, discussion thereof, documentation, and description of GWU/CARD Study methodology is a report entitled Social Impacts of Civil Aviation. Published September 1, 1970, the prime report was intended for internal use by CARD Study personnel; copies therefore are not available in sufficient numbers for general dissemination, although copies are available for examination in the offices of The Program of Policy Studies.

The present report has therefore been written for publication as a publicly available document which serves both the following purposes:

- Presentation of a condensed review of the "Major Policy Issues" identified and addressed in the prime report, with integration of salient related material originally contained in supporting papers generated during the GWU/CARD Study.

- Identification of the implications for appropriate federal action which flow from the major "Social Impact Findings" summarized in the prime report.

Part I of the present report deals with the first area, Part II with the second. In keeping with the summary nature of the present report, there has been some reorganization and consolidation of items, as compared to their appearance in the prime report. In particular, both the Policy Issues and the Findings have been reduced in number from ten to nine, but this is the result of consolidation rather than deletion.

The Major Policy Issues focus upon basic questions which the policy maker needs to consider in ferreting out the bases of a socially desirable and effective civil aviation R&D policy, whereas the Social Impact Findings represent general answers as to factors which have potentially important social implications for policy. Thus, the Policy Issues and the Findings provide two different, complementary viewpoints on the broad area of social impacts of civil aviation. It should be noted, however, that a given Finding is not the "answer" to a particular Policy Issue: rather, the Findings taken as a group coalesce out of consideration of all the Policy Issues as a group. Thus, any given Finding can typically be seen as a thread which runs through a number of the Policy Issues--and by the same token, any given Policy Issue generally bears on a number of the Findings.

The Policy Issues, then, derive from and reflect various realms in which social goals may be established with regard to the role of civil

aviation; the Findings highlight areas of endeavor in which federal action can affect achievement of these goals. Clearly, it is from discussion of the latter that it is possible to discern candidate areas for federal R&D activity which are justifiable on social-impact grounds, and the discussion in Part II is oriented precisely toward such an identification of broad "Basic Federal Undertakings."

Finally, the wording of the preceding paragraphs should be noted carefully, lest the reader seek things in this report which are not present. For example, GWU considers the Policy Issues and Findings discussed herein to be highly relevant and important for establishment of civil aviation R&D policy, and has documented the sources of its conclusions both herein and--in greater detail--in its prime report, Social Impacts of Civil Aviation. However, it is by no means claimed that the social considerations so identified are exhaustive; indeed, Appendix A summarizes areas identified during the course of the GWU/CARD Study in which further study is needed. Another important point to be emphasized is the fact that the Policy Issues refer to "realms in which social goals may be established" rather than to goals which actually have been established. It should not be inferred from the discussion of any potential goal herein that such a goal has, in fact, been established by the CARD Study or by the federal government generally, except where specific legislation or regulations are quoted.

PART I

IDENTIFICATION AND DISCUSSION OF MAJOR POLICY ISSUES

PART I. IDENTIFICATION AND DISCUSSION OF MAJOR POLICY ISSUES

1. SOCIAL IMPACTS OF FUTURE SHORT-HAUL INTERURBAN AIR TRANSPORTATION SYSTEMS

SUMMARY: Short-haul interurban aviation systems are considered in relation to anticipated overall transportation needs in 1985, with particular attention to short take-off and landing (STOL) systems. The broad prospects of aviation are compared with those of ground transportation and telecommunications, by analyzing the abilities of alternative systems to provide needed service characteristics. The social impacts of short-haul interurban aviation systems are examined from the standpoints of economics, politics, human behavioral factors, urban and regional development, and the physical environment. These factors are considered with respect to three distinctive stages in the social impact process: system initiation, system implementation, and system operation. It is concluded that STOL aviation systems could meet important needs in the short-haul realm, but that the center-city STOLport concept is not the proper focus for such systems.

Introduction

The discussion below focuses upon the following specific questions: From a functional standpoint, what are the more promising civil aviation systems for short-haul interurban transportation in 1985 and beyond? What are the salient social impacts of such functionally promising systems?

The GWU/CARD Study has defined possible advanced aviation technologies for consideration in relation to both passenger and cargo needs. Within the passenger realm, the commercial categories which have been defined are Long-Haul International, Long-Haul Domestic, Short-Haul Interurban and Short-Haul Intra-Urban. General aviation has also received attention in the GWU/CARD Study.

All of these systems have significant implications in terms of poten-

tial social impacts--both positive and negative--and much was learned during the course of the social impact study that is applicable to all these systems, in varying degrees. However, particular attention was focused upon the Short-Haul Interurban systems under consideration by the GWU/CARD Study, because such systems represent a potentially very important departure from current aviation service emphases, and because their nature assures that they would spawn a great many social impacts which are likely to typify aviation in general.

The following discussion therefore focuses upon the Short-Haul Interurban aviation system concept, with particular reference to STOL technologies. In so doing, it draws upon the applicable portions of the more general social impact results presented throughout the rest of the present report, and applies them in combination to this one particular type of system.

Intercity Air Transportation: 1970 Status and Trends

There are presently 3,202 airports, 27 heliports, and 74 seaplane facilities in the National System (those having FAA towers). In 1963 there were 29.2 million aircraft operations at airports with FAA control services. By 1969 that number had risen to 55.9 million.

Practically all major airports are either already saturated or are rapidly becoming so. Major hub airports such as O'Hare (Chicago), Logan (Boston), Hopkins (Cleveland), La Guardia and Kennedy (New York), Lambert (St. Louis) and Los Angeles International presently experience aircraft operations beyond their practical annual capacity ("Pancap"); yet future projections indicate continued increases in traffic and con-

gestion. Airports around medium-sized hubs such as Memphis, Tampa/ St. Petersburg, Buffalo/Niagara Falls, Salt Lake City, Tulsa and Tucson are projected to experience phenomenal air traffic growth over the next 10 years, with air traffic more than doubling in most instances.

The presence of such congestion is in large measure due to the fact that the majority of the nation's population resides on a small fraction of the total land area: Two-thirds of the population of America is concentrated in 233 metropolitan areas. Migration to these population centers continues apace, assuring that population pressures will contribute to a worsening of congestion in the future. Thus, the capacity of existing airports, especially those near the larger metropolitan areas and in the vicinity of medium-sized hubs, needs to be augmented in order to accommodate increasing traffic. In addition, several metropolitan areas need to construct new airports if they are to relieve present congestion, improve air service and meet future demands.

The magnitude of the traffic pressures on the nation's aviation system is magnified even further by the fact that aviation's share of the overall passenger market has been growing rapidly in recent years, whereas surface modes have been either declining or holding roughly constant. Over the past two decades,the intercity travel market (in passenger-miles) served by the four prinicpal modes has evolved as follows:

	Percentages	
	1950	1970*
Auto	87	86
Rail	6+	1+
Bus	4+	2+
Air	2+	10+

*Extrapolated from 1968

Source: Transportation Association of America, Transportation Facts and Trends, Fifth Edition, 1968.

At the same time, average airborne stage lengths have been increasing, particularly for local service carriers whose market falls within the short-haul interurban distance class. Whereas about one quarter of all domestic travel over 500 miles is by air, the percentage rapidly dwindles at ranges below this level and is insignificant for distances under 100 miles.

Such stage length growth trends may indicate an impending vacuum in short-haul aviation services within the next few years, similar to that which has already developed in interurban public ground transportation. In the absence of deliberate counteracting measures, evolutionary trends could conceivably leave the automobile as the only significant means of short-haul intercity travel a decade or so hence, prior to widespread availability of new high speed ground transportation systems. Unfortunately, migration to metropolitan areas will continue, and demand for highway capacity will outstrip the supply. The resulting increase in congestion must lead either to the construction of more highways (at a rate which will ultimately be unable to keep up with demand)

or to greater emphasis on commercial air and mass ground transportation.

If innovative, forward-looking measures are not taken, congestion in short-haul intercity transportation will have become nationwide in scope by 1985 or before, and will be too severe for successful continuation of traditional approaches. The immediate problem is thus to determine which major innovations should be fostered by the federal government in order both to augment and guide the growth of existing systems and to introduce new ones. This not only applies to the areas of civil aviation and ground transportation, but also requires long-range consideration of advanced communication technologies, since these may ultimately alter the need for many trips made primarily for informational purposes.

Major advances of the type relevant to this discussion typically involve federal policy to further the public interest. Such advances could include:

- Introduction of new systems that may require removal of institutional roadblocks (such as might be imposed, e.g., by competing municipalities).
- Accelerated development of new systems (e.g., high speed rail) whose implementation would otherwise be slower than desirable because of the large capital investments required.
- Pursuit of theoretically promising new technologies requiring considerable R&D efforts and demonstration projects, with attendant risks unacceptable for private industry.

The interdependence of all modes of transportation must be taken into account in any analysis of alternative systems. The efficacy and value of a Short-Haul Interurban civil aviation system will depend to an especially large extent on the concurrent development and interfacing with efficient urban ground transportation systems. More generally, the following categories require attention if the air passenger transport system is to be planned and implemented to achieve maximum efficiency:

- Airborne scheduling to allow interconnection between flights, including commercial-commercial (route overlap, timing), and commercial-general (commonality of available airports to both sectors).
- Intra-airport processing, including connection with airport access links, passenger movement (airport layout, distance, pedestrian assisters), and baggage-handling.
- Airport access, between airports and urban areas and between different airports serving the same metropolitan area.

Possible Major Technological Innovations: 1985-1995

AVIATION: Of particular interest for short-haul interurban transport are STOL and VTOL aircraft. The former are clearly relevant for 1985, the latter probably not until 1995.

Three generic categories of airports have been considered in this study with respect to their relevance for consideration in short-haul

interurban travel by 1985:

- Center-city STOLports.
- Metropolitan distributed STOLports ("rim-ports").
- Growth-center airports.

These three airport types have differing implications for appropriate R&D. This is true not only because the "mission profile" strongly affects aircraft design, but also because land constraints and required vehicle performance depend a great deal on airport location.

From a purely functional viewpoint, there are few social benefits deriving from a center-city STOLport that could not be obtained equally well from a "rim-port" located 3 to 10 miles from the central business district. Good ground access would be very important for the rim-port but the same would be true of a center-city STOLport, particularly since the majority of intercity destinations are not to the central city but to surrounding communities.[1] In a few major cities, true center-city STOLports would appear not only possible but--from the isolated viewpoint of such a city--highly desirable due to special geographical or other features. Rim-ports appear more attractive in the majority of the larger cities, however, where center-city STOLports would be of questionable functional value and would be virtually infeasible due to political and other non-technical factors. As a result, the introduction of center-city ports may not be advisable even where they <u>are</u> possible, because of the undue influence they could exert on the design (including the required technical sophistication) of the STOL system as a whole.

Growth-center airports appear to be a necessary, though not sufficient, factor which must be provided if many small communities are to realize their growth potential.

Ground access and intra-airport transportation are crucial factors affecting the viability of short-haul travel, particularly in a system of semispecialized airports handling different types of aircraft.[2]

GROUND TRANSPORTATION: A variety of intercity high-speed ground transportation systems could be introduced to complement and compete with aviation. These include not only rolling-support (rail) systems, upgraded to operate at up to 200 m.p.h., but also tracked air-cushion vehicles operating in the 150-300 m.p.h. range. Of even greater potential are tube travel systems which would permit speeds of 200-500 m.p.h. without concern for obstacles or weather effects.

In addition to these "station-to-station" systems, a variety of "door-to-door" systems have been proposed, ranging from the auto-train (cross-country travel with one's car on a train) to multimodal systems. The latter combine the capability for local travel, under individual control with internal power, with that for intercity travel along special guideways with automatic control and power obtained from the guideway. Door-to-door systems tend to have relatively low cruise speeds (100 to 150 m.p.h.) but minimize time lost in changing modes.

TELECOMMUNICATIONS: Innovations in communications are likely to have an increasing relevance to transportation in the future. These might eventually include systems coalescing out of picturephone, cable

television, record service, and holographic technology, for example: one can conceive of conferences with the participants scattered around the globe, viewing each other by holographic projections and exchanging notes by means of input-output terminals with advanced facsimile capabilities.

Such technologies certainly are not "just around the corner," but when and if they become reality, the effect upon the need for certain types of transportation probably will be profound. Advanced communications systems could thus introduce a new degree of freedom in dealing with the transportation problem before the end of this century.

The Social Environment: 1985-1995

The social impacts which will flow from introduction of new civil aviation systems will depend not only upon the technologies themselves, but also upon the social context into which they are introduced. Brief mention of salient factors which will differ from those of today is therefore in order.

Migration from rural to urban areas will continue through 1985 and beyond, and the character of urban areas will change markedly. In many areas such as Washington-Baltimore, San Francisco-Oakland-San Jose, and Dallas-Fort Worth, the city as a discrete entity will fade as the metropolitan area merges into a growing megalopolis.[3] By 1985, 60 percent of the population probably will live on less than 8 percent of the total land area. Industry will continue to expand into suburban and exurban areas. New airport facilities located at natural conglo-

meration points will spur industrial and residential expansion into these exurban locations.

Projected population shifts will enhance the political power of urban areas and lead to a redistribution of function among governmental bodies. Higher-level governments will assume responsibility for services now provided by smaller political entities. There will be a trend toward a more unified federal-state-local tax structure.[4]

Ground transportation will remain a persistent problem in 1985. The automobile will still be the principal mode of ground transportation although vigorous efforts to develop improved public ground transportation could be beginning to bear fruit. The high costs and long lead times associated with the construction of highways and rapid transit systems will hinder growth of both, and local resistance to relocation of persons and the destructions of open spaces will retard the development of adequate transportation systems. Pressures for improved environmental quality and greater citizen participation in decision-making will continue to be significant influences upon planners.

Economic Factors

Without substantial federal support, few cities could have operational STOLports by 1985, regardless of their desirability. Any short-haul interurban STOL transportation system will involve high costs, uncertain initial demand, and long lead times for political conciliation among interested parties. These factors would tend to be most severe for STOLports located in the center of the city, a fact which militates against the center-city STOLport concept. Federal subsidies will be

required during the initiation and, especially, the implementation phase of the project. This is not unprecedented, since the federal government has provided leadership and support in the development of air transport in the form of operation subsidies in some circumstances for limited periods, certification of aircraft for safety, provision and operation of navigation controls and assistance, assignment of air routes, and regulation of fares and service.

SYSTEM INITIATION: In recent years, airport planning and development has received support from the federal government at a rate of about $74 million annually (as compared to federal grants-in-aid for highways of about $4 billion annually). The Airport-Airway Development Act of 1970 established a trust fund into which user taxes paid by airlines on tickets and waybills and by general aviation as a fuel tax will be deposited. From this fund, $250 million will be spent annually for air carrier development and $30 million for general aviation development. These authorizations are guaranteed by the federal government for a period of 5 years. In the last 5 years, about 70 percent of public funds for public airport development have been provided by local governments, 9 percent by the states, and 20 percent by the federal government. Much of the federal aid has been channeled through the states.

Federal aid is a crucial factor in airport development, as is illustrated by the fact that some 68 percent of the small-hub, 64 percent of the medium-hub, and 50 percent of the large-hub-airports cannot self-finance capital improvements. This is so despite strong

municipal efforts. The municipal expenditure for airports in 1967 was $208 million, an increase of 18 percent over the preceding year and 98 percent over 1957.

SYSTEM IMPLEMENTATION & OPERATION: For the present summary purposes, economic effects of both implementation and operation of a new short-haul interurban air transportation system will be discussed together. Implementation would involve land acquisition, facility construction or modification, and vehicle construction and acquisition, whereas operation would mean the actual provision of transportation services by airlines. These are conceptually distinct, but their economic effects tend to overlap in time--for example, land development-related economic effects around an airport occur not only because of implementation activities, but also because of anticipation of operational factors.

Economic benefits during the implementation stage will take the form of increased income and employment for those in the construction and manufacturing industries. Economic constraints which occur in this stage are associated with the large capital outlays which are necessary, while various economic disbenefits would be spawned by the necessity for relocation of families and business activities on the airport site.

In the operational stage, primary benefits will accrue to the producers and users of the end product which of course is air transportation. Economic disbenefits may also occur in this stage, in the form of degradation of residential property values in areas strongly affected

by aircraft noise; many of those affected by such disbenefits would in general be non-users.

The contribution made by all modes of civil aviation to the gross national product will increase to about 0.8 percent by 1985, and employment in civil aviation will reach about 471,000. Additional employment induced by the growth of civil aviation will create 128,000 to 192,000 new jobs by 1985.

Total sales of the civil aviation industry are expected to amount to $43.7 billion by 1985, as compared to $10.4 billion in 1970. Value added to the GNP by the civil aviation industry will increase from $6.0 billion (1970) to $25.1 billion. Of the direct inputs used by the civil aviation industry in 1985, 38 percent ($7.1 billion) will come from the manufacturing sector of the economy, 16 percent from the finance, insurance, real estate, and other services sector, 18 percent from the transportation, communication, and utilities sector and 13 percent from foreign countries. Indirect sales to the civil aviation industry might amount to as much as $17.6 billion by 1985, as compared to $4.2 billion in 1970.

New airports along radial and circumferential commuting routes attract industry into suburban areas and afford increased employment opportunities. High-density industrial parks, as well as new towns, will continue to form around highway interchanges and airports. A large airport contributes about $100 million payroll to the community, in addition to extensive indirect economic benefits. Some 750,000 passengers arrived at Fort Lauderdale International Airport in 1964,

for example, bringing with them $9.5 million to spend in that city.

Political Factors

Opposition to center-city heliports has focused on the noise and turbulence immediately overhead and the congestion of access streets. Similar opposition will almost certainly develop against other types of center-city airports. The Federal Aviation Administration has acknowledged this in stating that "city-center service is recognized as a future requirement, but is likely to be an evolutionary process because of delays in technology and siting locations."[5]

SYSTEM INITIATION: An effective short-haul interurban airport system will require coordinated and cohesive planning at the national, state and local levels. Federal policy places primary responsibility for building and operating airports upon the owner (i.e., a variety of local and state governments), but overall planning criteria are obviously necessary. The Airport-Airway Development Act of 1970 provides planning grants to the states, and other federal policies support coordination between states on a regional basis.

State constitutions tend to be excessively detailed, a significant disadvantage in dealing with the problems of modern technology. Six state constitutions specifically authorize the state government to build and maintain airports; five provide for the financing of airports; only one state (Louisiana) authorizes the state legislature to set up airport districts with the power to incur debt, issure bonds, and levy taxes.

The management of a municipal airport of medium or small size is

sometimes left to the city council, with an advisory board or a director of aviation supervising the hiring of an airport manager. Such advisory boards sometimes assume a good measure of independence and authority. True airport authorities however, must usually be created by the state legislature. In general, no budget review by the city council is authorized, and the authority can borrow, issue bonds, and often levy taxes.

An increasing number of municipalities are establishing departments of transportation, a reflection of the trend toward cooperation and centralization which is also seen in the establishment of metropolitan planning commissions and councils of governments. Airport development has tended to promote and strengthen the councils of governments, through the inducements offered by planning grants.

This strengthening of the planning process contributes significantly to decisional flexibility and rational allocation of resources. Full realization of these potential gains, however, depends upon major improvement of the mechanisms by which public participation can be enlisted in constructive ways during the planning process. At present, such public participation as occurs is neither broad-based nor highly influential, with the result that significant opposition to these plans typically develops during the process of implementation.

SYSTEM IMPLEMENTATION: The exercise of political power relative to airport location involves interactions among such participants as the airport authority, the state aeronautics commission, the mayor and council, and perhaps a planning commission. Any conflict will ultimately

be resolved by the city council, county board, or state legislature, but their decision will usually represent a post hoc recognition of the successful marshalling and use of political power at an earlier stage. At crucial points in the decision-making process, resources from outside the community (frequently federal or state grants) are used by local officials to overcome opposing forces. Therefore, the ability to obtain federal grants associated with a national airport system of any type--such as a short-haul interurban STOL system--will intensify this trend.

The citizen's role in airport implementation tends at present to be largely negative, involving attempts to force changes in airport location or delays in the project. Tactics usually include court suits, demands for additional public hearings, petitions, and sometimes active protests, disruptions, and demonstrations. A particularly effective strategy is to associate local opposition to a program with a national cause. Opponents to the Dade-Collier Airport in the Florida Everglades succeeded in terminating the project through the support of national conservation groups.

Since the early 1960's, citizen influence in the center city has become increasingly effective, as seen in the political militance of blacks in city ghettos, and the pressures for environmental quality among virtually all socioeconomic groups. Greater community participation and competing priorities for space in the center city are thus causing increased lead times in the decision-making process, and decrease the likelihood that many STOL- and VTOLports will be built

in or immediately adjacent to the central business districts of large cities by 1985.

SYSTEM OPERATION: Any adverse side-effects of a fully operational short-haul interurban airport will provoke remedial responses through various administrative and legal channels. Federal preemption of airspace control has been recognized since the Air Commerce Act of 1926. The courts have affirmed that federal control precludes local action.[6] Political pressures for aircraft noise abatement will thus be aimed increasingly at the federal government, which certifies aircraft and airports, regulates airline route structures, controls traffic, and is a party to the development of most jet airports.

Congress has already responded to such pressure by giving the Federal Aviation Administration rule-making power in regard to engine certification for noise emission and special flight procedures for noise abatement. These criteria are not stringent at present, but by 1985 may require use of the most advanced technologies for noise abatement, as well as use of non-technical measures. Growing demands on city governments for compensation for intolerable levels of noise may be accompanied by imposition of liability on the federal government for aircraft noise damage. These trends, in turn, could lead to new forms of zoning and land-use management in connection with airports.

In some cases, short-haul interurban STOLport development may be facilitated by the use of easements on air space. Where the area of dense residential development in the high-noise contour is too large for the city to buy up the land, it may be possible to purchase easements

from property owners in the outer portion where aircraft will be operating at high enough altitudes for the noise to at least be tolerable. Easements will be expensive, however, and will not prevent suits for damage resulting from the use of the port itself or from changing patterns of flight. Thus, the city or the district, as airport operator, will be constantly assuming liability risks if the easement route is followed.

Compensation in cases arising from aircraft noise has not been large in the past.[7] However, as the number of property owners affected rises, and if the courts recognize the standing of non-property-owning affected residents the amounts awarded may increase drastically, with a catastrophic effect on the financial resources of local governments. It is this factor, combined with federal authority in setting noise standards, which makes probable by 1985 the imposition of liability on the federal government in aircraft noise cases.[8]

As local opposition to aircraft noise increases, zoning practices will change. Zoning ordinances may limit construction in the vicinity of airports to appropriate industrial categories. Comprehensive planning arrangements could permit the amortization of non-conforming land uses, during which time the landowners can recoup losses and relocate. As alternatives, the airport developer might acquire all land within the critical noise contours and develop this land for compatible uses; or the federal government might assume responsibility for land-use regulation on a national basis.

Behavioral Factors

SYSTEM INITIATION AND IMPLEMENTATION: A short-haul interurban airport facility located within an urban area could, as the highly visible vanguard of technological progress, become a nucleus around which various social irritations would coalesce and multiply. Issues associated with center-city ports may trigger additional hostility and frustration reactions which spring from political, economic, and social stresses quite unrelated to aviation. This would probably be particularly true in the case of a center-city STOLport, since the typical central-city population of today includes a relatively small proportion of people who can afford air travel, and who could therefore perceive redeeming features of the STOLport to counter balance the unpleasant side effects such as noise, pollution, and ground congestion.

Overall reactions of center-city STOLport neighbors would depend upon the degree to which the utility of the system--in terms of travel convenience, and other attractive features--outweighs the stress it produces. The hiring of skilled and unskilled center-city residents to implement a new air transportation system would help to counteract the anticipation of unwelcome operational side effects. Increased automation in the construction industry, by contrast, would reduce manpower requirements, with the result that the hiring associated with STOLport construction would be reduced, and there would be less of an opportunity for this factor to enhance STOLport acceptance by its neighbors.

For a STOLport located in the suburbs, the balance between stress and utility would probably be somewhat different, since a much larger

proportion of the residents would utilize services provided by the system. It is unlikely, however, that the noise and pollution levels characteristic of present-day airport facilities would be tolerated in moderately dense suburbs, which implies that such STOLports would need to be relatively small and quiet. Residents of the suburbs, who are typically more affluent and politically sophisticated than center-city residents, will insist upon participation in decisions throughout the planning and implementation process.

SYSTEM OPERATION: A center-city to center-city system would encourage further development (and further congestion) of core urban areas as distribution points and as terminals for goods and services. Employment opportunity would lead to the expansion of aviation-related courses in inner-city schools and vocational schools. However, should there be no effective route into aviation industry jobs for the poorest and least-skilled ghetto residents, serious frustration and social tensions would be likely to ensue.

A rim-port system, by increasing the availability and convenience of air travel for those most able and inclined to use it, would probably tend to foster greater use of air travel in general.

Urban and Regional Land-Use Factors

The incentives to be employed in directing the growth of short-haul interurban air transportation systems must be determined at the federal level. The structuring of federal legislation will profoundly affect the levels of cooperation and planning achieved at the metropolitan and regional levels, especially where interjurisdictional means of implemen-

tation are prerequisite to the receipt of grants, loans, and guarantees. Airport legislation could have an analogous influence on metropolitan areas to that which Title I of the 1949 Housing Act has had on the development of planning tools for individual cities.

SYSTEM INITIATION: If a new civil aviation system is initiated with the benefit of competent, comprehensive planning, few problems should arise in the implementation and operational phases. However, if traditional methods of promoting, planning, and implementing airports are applied to the development of STOLport facilities, implementation of a STOL system will be next to impossible. The implications of placing such an intensive and potentially disturbing land use within reasonable proximity to center-city business districts are particularly complex. To be successful, an approach will require meticulous application of comprehensive land-use planning, land development controls, and widespread public participation programs.

A critical factor in determining the location of short-haul interurban air terminals is demand (a function of area density of initial points of origin). A paradox arises in this regard: high travel demand would be an absolute prerequisite in justifying a center-city STOLport, yet this high demand can only be expected to exist where the land is extremely valuable for non-aviation uses. Thus, the more desirable a center-city STOLport is functionally, the less is the likelihood (in most cases) that its actual implementation will be economically and and socially feasible. Travel loads on the urban transportation networks providing access to the airport must likewise be considered,[9]

and here again, it is likely that the greatest potential demand for a center-city STOLport will be in an area which could not tolerate the additional congestion it would spawn.

Available data on the demand for center-city ports are inconclusive. A 1966 study indicated that only 20 percent of deplaning passengers have the center city as their ultimate destination.[10] Another study concluded that 24 cities could have supported center-city V/STOL services in 1965. The cities identified included Boston, Chicago, Cleveland, Dallas, Houston, Kansas City, Los Angeles, New Orleans, New York, Philadelphia, Pittsburg, San Francisco, St. Louis and Washington, D.C.[11]

The cost of land acquisitions to provide a noise buffer for STOLport operations will vary according to land use patterns in the vicinity of the STOLport. Under existing interpretations of eminent domain responsibility, occupants in residential or business districts must be properly relocated. Average center city residential density is 20 to 60 units per acre; average occupancy per unit is nearly 4 persons. In many areas the density is much higher. Aside from relocation costs, some contemplated sites may be so politically sensitive that their acquisition would be essentially impossible. If an appreciable part of the land to be acquired for a port is in a residential district, the problems encountered will be comparable with those that arise in connection with large urban renewal projects.

The problem of aircraft noise, which is a serious problem anywhere in an urban area, also militates against the center-city location of a STOLport. For example, a 50-passenger, four-engine turboprop aircraft

making 50 operations a day would subject a 50-acre area to a noise level that is so substantial (30 NEF) that the Federal Housing Administration would not guarantee mortgages on houses located in the zone.[12] Some estimates suggest that a 200-acre noise buffer would be required for a center-city port. If land is also required for new access roads, or a mass transit facility, its cost must be added to the facility and relocation costs.

The possible costs of implementing a network of center-city STOL ports can perhaps be grasped most easily by comparing such a program with the National Urban Renewal Program. In the first 16 years of the Renewal Program, 42,000 acres were redeveloped at a cost of about $5 billion and much bitterness from opponents who charged that these were "Negro removal projects."[13] The financial costs per acre of a center-city STOLport would generally be enormously higher than those typical of Urban Renewal, both because choice STOLport sites are often valuable--not blighted--and because adversely affected parties could in many cases prove to be affluent and politically powerful. Furthermore, in those areas in which ghetto minorities were affected rather than economically valuable commercial activities, STOLport projects would reap the benefit of years of self-education by these parties as to the politics of obstruction of unwelcome developments.

For STOLport sites outside the central business district, efficient and attractive access must be provided. Existing routes may be overloaded and/or require restructuring; however, to the extent that the needed improvements can be integrated into broader urban transportation

developments which benefit the community as a whole, this factor may not be a decisive disadvantage. Furthermore, installation costs would be much lower for suburban STOLports, and this cost advantage over the center-city port could be used to help defray the expense of better ground access.

SYSTEM IMPLEMENTATION: A VTOLport would require from 3 to 7 acres (3-8 gates) for operational space. A single-runway STOLport with a runway 1500 feet long and 100 feet wide, would require 10 acres, while a two-runway port would need 26 acres.[14] However, the total space required for a port consists not only of that required for operation, but also for parking and additional facilities. With these inlcuded, the figure for a STOLport could reach 200 acres.

Air space requirements for a STOLport would also be important, though less extensive than for a conventional airport. Airport authorities must also either own or control strips of land (clear zones) to insure that no vertical development interferes with aircraft operations; for a metropolitan STOLport, the airport authority must acquire control of a 750-foot clear zone by fee title or easement.[15] Such easements will be expensive and will not prevent suits for damages alleged to result from the use of the port itself or from changing patterns of flight. The effects of noise and the requirement for clear zones may eliminate significant tax-producing areas from the city tax rolls, a factor which might be an important element in a V/STOLport decision.

SYSTEM OPERATION: The major benefits from development of the civil aviation system will accrue only after the operational stage is reached.

Even then, increases in employment resulting from a center-city STOLport may be insignificant, since proposed metropolitan ports are small. A suburban port, by contrast, would attract airport-related services such as hotels, barber shops, and restaurants, and could in fact catalyze general land development in its vicinity. Indeed, it is possible that a system of several small rim-ports placed around a metropolitan area could serve to focus land development into nucleating patterns, arresting the indiscriminate sprawl which now prevails in major urban areas.

Ecological Factors

SYSTEM INITIATION: A primary ecological consideration in the planning of an aviation system is the selection of a suitable site. Factors such as topography, meteorology, water supply, and drainage patterns determine whether a given location will present environmental problems during and after development, and whether the site can support a given level of urbanization without ecological damage.

SYSTEM IMPLEMENTATION: Soil erosion and silt transport create a potentially dangerous ecological problem during construction. A study of sedimentation in streams in the Eastern United States revealed that sediment yields from urbanized or developing areas ranged from 1,000 to more than 100,000 tons per year.[16] Flooding of the natural paths of drainage is also possible, since an increase in the percentage of impervious surface increases the volume and the rate of flow of run-off water. The hazard of flooding can be minimized by adherence to established procedures and techniques of hydrologic plants.

SYSTEM OPERATION: Air pollution from aircraft and ground vehicles, water demands, and sewage and waste disposal constitute the major ecological impacts of an operational airport. If the airport were operated as a remote enclave, with minimal on-site facilities and prevention of dependent land development, environmental damage would be minimal.

Research has shown that, for an urban area, aircraft exhaust emissions currently represent an almost insignificantly small proportion of air pollutants.[17] In Los Angeles County, for example, aircraft produce about 0.8 percent of the total pollutants (motor vehicles contributed almost 96 percent).[18] In the New York metropolitan area, aircraft also contributed less than 1 percent of total pollutant emissions.[19] The Department of Health, Education, and Welfare has concluded that state or local aircraft emission control regulations are not required at this time.[20]

However, it is not safe to conclude that aviation will not become a significant contributor to air pollution in the future: aviation is continuously increasing its share of the transportation market, and non-aeronautical pollution sources are under pressure to "clean up." As a result, the status of aviation could well change, over the next decade of so, from its present "low-pollution" rating into that of a very significant offender. Indeed, the 141 pounds of pollutants released in every landing or take-off by a present-day multi-jet transport would represent a significant proportion of the pollutants in a rural area, where large regional airport complexes may be built. Technological

advances in engine design and improved fuels, which will be important factors in reducing aircraft exhaust emissions,[21] are therefore clearly of importance.

Although aircraft themselves do not contribute significantly to water pollution, terminal activities can exert significant effects on both surface and ground water through demands imposed on local water supplies, waste water discharge, or changes in drainage patterns. Municipal water systems use a daily planning factor of 150 gallons per resident. Industrial demands vary widely, but aircraft maintenance facilities and terminal activities can be expected to equal at least the factor quoted. If an airport employs 10,000 people, the daily water requirement will thus be 1.5 million gallons. The satellite communities that develop around an exurban airport will create additional demands for water.

Equally important is the sewage disposal problem created by both the terminal itself and adjacent developments. Data on average waste disposal requirements indicate that an airport employing 10,000 people would produce approximately 42,500 pounds of solid waste daily.

Although sewage treatment at future airports will include chlorination or a similar germicidal process, such treatment does little to appreciably alter the nitrogen or phosphorus compounds which are the principal cause of eutrophication (premature aging) of lakes and streams. Tertiary treatment of sewage, with reuse of water or recharging of ground water, will be mandatory if the quantity and quality of natural water resources are to be maintained.

It is also possible that pesticide and fertilizer run-off from an exurban or suburban port will flow into adjacent waterways. Recent restriction of the use of persistent pesticides will reduce the hazard, but the inorganic fertilizers used in landscaping unpaved areas continue to present a potential threat. Wastes from products used for aircraft maintenance can also damage the quality of water unless adequate precautions are taken.

Conclusions

Present trends in transportation, in conjunction with those in population growth and distribution, suggest that the nation's overall transportation system will be in a state of congestive crisis by 1985 if corrective measures are not taken. In the forefront of this problem will be short-haul interurban transportation, where public ground transportation has all but disappeared in comparison to the private auto, and where civil aviation presently exhibits warning signs that it could do the same over the next decade or so.

Capacity-growth limitations exist for auto travel, imposed by technological, economic, and social factors, and they will ultimately make it impossible for highway transportation by itself to keep pace with growing demand. There is clearly a long-range need for high speed ground transportation (HSGT) facilities along dense demand corridors; however, the long lead times which will be associated with these imply a strong need for relief before their influence can be felt. In addition, there are short-haul needs in connecting smaller population centers with one another and with major urban centers, and these call more for flexi-

bility in routes and frequency of service than for the very high-capacity corridor-travel capabilities of ground transportation.

Thus, there clearly is a need for short-haul interurban air transportation systems, and STOL aircraft appear to hold real promise in this role. However, it is equally clear that the concept of center-city air transportation--attractive as it seems on the surface--would not be the proper focus for a STOL short-haul system intended to serve the social needs of the 1980's. In fact, focusing on the center-city concept might possibly lead to technological approaches which would cause civil aviation to forfeit its ability to serve in the roles in which it could potentially be of great importance. Instead, a network of "rim-ports" in metropolitan areas and growth-center STOLports at small population centers appears potentially capable of meeting all three of the major needs for STOL transportation a decade hence:

- Augmentation of total interurban transportation capabilities along dense travel corridors.
- Interconnection of smaller population centers.
- Provision of good travel capabilities between smaller growth centers and major urban markets, with a minimum of capital outlay in ground facilities.

Any brief yet meaningful summary of all the many social-impact considerations involved in a short-haul STOL system is extremely difficult to make, both because of the number of factors involved and because of their complex interrelationships. However, a summary of some of the

more salient factors discussed above is presented in Tables 1 through 3, with the intention of their serving as a guide for review and reference to the text discussions.

TABLE 1

SOCIAL IMPACT CONSIDERATIONS FOR SHORT-HAUL INTERURBAN AVIATION: INITIATION AND PLANNING

ECONOMIC	POLITICAL	BEHAVIORAL
Comparative analysis of alternative modes of interurban transportation. Determination of opportunity cost of air systems. Demand analysis of traffic routes, coefficients or responsiveness to income, fare, and time.	Development of system of coordination between governmental jurisdictions (e.g., special authorities or metropolitan councils of government). Special-purpose authorities would aid in development and operation of facility and, in some cases, own it.	Attitudinal analysis of residents affected. Public reaction will be shaped by a balancing of anticipating conveniences against noxious side-effects such as noise and congestion.
URBAN AND REGIONAL LAND USE		ECOLOGICAL
Determination of terminal. Center-city ports must be compatible with existing land use; size of port is a critical factor. VTOLport would require between 3 and 7 acres for operational purposes; single runway STOLport requires 10 acres and a two-runway port 26 acres. Consideration of zoning changes for parking and other facilities		Evaluation of long-term ecological effects of airport construction and operation. Analysis of natural factors (geographic location, size, topography, meteorology, and biotic associations) and operational factors, number of flights, passengers, and support facilities.

TABLE 2

SOCIAL IMPACT CONSIDERATIONS FOR SHORT-HAUL INTERURBAN AVIATION: IMPLEMENTATION

ECONOMIC	POLITICAL	BEHAVIORAL
Analysis of production and operating costs. Estimate of derived demand for the number of vehicles to be produced. Benefits (in the form of increases in income and employment) accrue in the construction and manufacturing industries.	Federal grants used to overcome forces opposed to airport facilities development. Citizens may employ such tactics as court suits, public hearings, petitions, active protests and alignment with national conservation groups to oppose airport development. Political feasibility of building a large number of center-city ports by 1985 highly questionable.	Stress in center-city based on materialization of anticipated employment and income. Stress in suburbs related to such environmental factors, as noise, pollution, and congestion.
URBAN AND REGIONAL LAND USE		ECOLOGICAL
Clear zones of at least 750 feet to prevent vertical development around STOLports must be acquired by fee title or easement. Noise considerations and the high cost of relocating residents suggest that center-city ports be located on non-residential waterfront or railroad yard properties. Non-urban ports have a comparative advantage over urban ports, but cost of access facilities may eliminate advantage.		Air pollution control (construction). Water pollution control. Soil erosion control. Minimal changes in natural environment.

TABLE 3

SOCIAL IMPACT CONSIDERATIONS FOR SHORT-HAUL INTERURBAN AVIATION: OPERATION

ECONOMIC	POLITICAL	BEHAVIORAL
Projected increases in total direct employment in civil aviation from 311,000 to 471,000 and in sales from $10 billion to $44 billion between 1970 and 1985. Employment and income impacts of a V/STOL system would depend upon the size of the facility. Proposed metropolitan ports would have little effect. Short-haul interurban ports would increase competition between aviation and other modes of transportation and increase aviation's relative share of total market. Convenience factor would induce more business and pleasure travel by air.	Increased pressure on federal governemnt to abate adverse side effects of aircraft and terminals. Noise control policies might involve use of easements, demands on municipal governments to compensate for damages, recognition of liability of federal governemnt for damages, and new forms of zoning and land use management.	Expansion of air transportation systems will accelerate improvements in the curricula of vocational and high schools. Expansion of air transport systems will continue to provide status blue-collar jobs. Possible drain of high-skill and high-status blue-collar jobs away from other industries and into aviation industry.

URBAN AND REGIONAL LAND USE	ECOLOGICAL
Suburban port would attract various airport-related service industries. The center-city usually has such service available already. Expansion of center-city ports to the exclusion of non-urban ports would reduce exurban sprawl of satellite businesses and residential communities.	For an airport operating as a remote enclave, ecological damage is minimal. Ancillary activities and the encroachment of induced urbanization are main sources of environment degradation. Technological advancements in engine design and improved fuels may realistically be expected to substantially reduce polluting exhaust emissions. Aircraft noise is significant as a nuisance factor but not as a factor in ecological deterioration.

2. ECONOMIC CONSIDERATIONS IN FEDERAL SUPPORT FOR CIVIL AVIATION R&D

SUMMARY: The benefits to be derived from an investment of public funds in civil aviation R&D are analyzed and compared with those to be expected from equivalent public support of R&D in other transportation systems. Employment and income trends are outlined. Productivity data are presented for railroads and airlines. The trend in the ratio of taxes paid to subsidies received is shown to be strongly upward for the airlines. It is concluded that additional federal support of civil aviation R&D is economically justifiable at this time.

Introduction

The following discussion of economic benefits focuses upon the following specific question: Will an investment of public resources for research and development in civil aviation yield higher returns than investments in alternative modes of transportation?

Transportation is the lifeblood of the national economy, in that it facilitates--indeed, enables--movement of people and goods for both business and recreational purposes. From this fact alone, it is clear that there is an inherent federal interest in the transportation arena: the nation's overall transportation system must never be allowed to lose some minimum level of functional viability, because the results would be disastrous. Having established this basic fact, the question of federal involvement in transportation ceases to be one of "whether or not" and becomes one rather of "how much and with what emphases."

From an economic standpoint, there would appear to be two very important aspects for consideration in answering the latter question:

- The desirability of specific transportation developments in terms of "functional" economic impacts on society.
- The desirability and feasibility of such developments in terms of "industrial" economic considerations.

The "functional" aspect is placed first because it is, in one sense, more basic than the "industrial": transportation exists strictly as a service to enable activities to be carried on which depend upon movement of people and goods. Transportation demand is thus essentially a derived demand rather than a direct one. Since the great bulk of human activity does involve such movement, it is obvious that the influence of transportation is felt throughout the nation's economy. The industrial aspect, however, is also a basic factor to be considered: this refers to the nature of transportation considered as an industry in itself. As a large and important industry, aviation is a vital component of national economic health.

The present discussion of economic factors gives explicit attention only to the industrial aspect. This approach was necessary because of the necessarily limited scope of the economic analysis: the present study, which was only a small part of the overall CARD study effort, had to address not only economic considerations but also a host of other social impact areas. Nevertheless, some tangential indications of the importance of functional economic factors do appear as by-products of the industrial-economic analysis: for example, the input-output concept embodied in Figure 3 serves as a tacit indicator of the role of civil aviation in the nation's total transportation system.

The field of transportation is therefore discussed as an industry of carriers, with a view to extracting criteria to help guide government decision-making with regard to aviation--the focus of the CARD Study--as compared to the other elements of the national transportation system.

Government participation in the productive process of a free enterprise economy can be justified (a) to enable the government to maintain itself and fulfill its statutory functions, and (b) to initiate or promote activities, undertakings, and institutions that are necessary for the functioning and progress of a free enterprise economy but that would not be undertaken by private enterprise because of excessively high cost, high risk, or insufficient prospects for profit. The potential of civil aviation as a tool for promoting and maintaining full employment, as spelled out in the economic philosophy of John Maynard Keynes[22] and embodied in the Employment Act of 1946, falls under criterion (a) as do satisfying other statutory responsibilities such as mail service, government personnel travel, and reserve airlift. The promotion of new developments in the field of commercial aviation as an important factor in U.S. economic growth, progress, and world trade considerations such as the balance of payments, on the other hand, are important aspects of criterion (b).

Both goals serve to contribute to the public welfare, yet they can be in conflict when technological progress leads to technological unemployment. For the civil aviation industry, however, government forecasts indicate both increased employment and technological progress

over the next few years. The federal government may therefore be justified in making major R&D investments in the civil aviation industry, because it holds more promise for the direct fulfillment of key economic policy objectives than other existing industries in the transportation sector.

Employment Trends in Civil Aviation and Other Transportation Industries

Despite increased productivity, the civil aviation industry tends to be labor-intensive, and large increases in employment are anticipated during the 1970's and 1980's. The civil aviation work force more than tripled between 1950 and 1965 and is presently estimated at 353,000 (1969) persons. According to the U.S. Department of Labor, "continued rapid growth in employment is expected during 1965-75 to meet the anticipated expanding demand for both passenger and cargo air transportation services, resulting from rising business activity, personal disposable income, and leisure time."[23]

Transportation's share in total employment will drop from 4.5 percent (1968) to 2.8 percent by 1985, but the proportion of civil aviation workers in the transportation labor field should increase from 14 percent (1968) to 28 percent (471,000 workers) by 1985. In contrast, employment in the railroad industry declined 47 percent between 1950 and 1965, from 1.391 million to .735 million. Employment in water transportation dropped substantially as a result of the 80 percent decline in the number of ocean-going ships after World War II. The Department of Labor predicted[24] that employment in that industry would reach a plateau between 1965 and 1970, and recent trends serve to support that prediction.

The only public transportation industry other than aviation for which the employment outlook is bright is that of trucking and warehousing. The government contributes heavily to the economic health of this industry through public highway construction and maintenance, which enables trucking to function without the burden of right-of-way property taxation such as that imposed on railroads. This more than offsets road-use charges and taxes paid by the trucking industry.

Income Trends in Civil Aviation and Other Transportation Industries

Table 4 shows that the output of the transportation sector in 1969 amounted to 3% of the GNP--rather impressive in light of the fact that this sector consists of only a handful of modal industries, contrasting with (for example) the mammoth manufacturing sector which includes myriads of industries. Table 4 indicates that this share will gradually decline, but not in order-of-magnitude terms. The importance of transportation as a catalyst and tool of economic activity, moreover, far exceeds the magnitude indicated in the national income accounts. Even a relatively minor strike in this sector can have major effects on the economy.

The civil aviation system accounted in 1968 for about 14 percent of income in the transportation industry (Table 5) and coincidentally also 14 percent of its work force. And while the contribution of transportation to the GNP has been declining since 1960, civil aviation income has more than tripled over the same period, from $1.4 bilion to $4.6 billion. Such rapid growth greatly exceeded the rate of growth of the nation's economy as a whole, with the result that the civil aviation contribution to GNP rose from 0.27 to 0.48 percent.

TABLE 4

COMPOSITION OF THE GNP

Selected Industry Groups

(billions of $)

Type of Good or Service	1960	1961	1962	1962	1964	1965	1966	1967	1968	1969	1970	1975	1980	1985
Manufacturing	125.8	125.0	137.0	143.8	155.1	172.6	191.5	195.6	215.4	229.1	247	317	432	589
Transportation	18.2	18.3	19.1	20.0	21.4	23.2	24.9	25.1	27.2	29.0	31	36	44	52
Wholesale or Retail Trade	64.4	66.2	70.3	73.4	79.1	84.3	91.4	97.5	105.2	112.5	122	154	213	296
Services	44.5	47.2	50.7	54.1	58.9	64.1	71.1	78.3	86.1	94.4	101	135	189	265
Government	52.9	56.6	60.7	64.7	70.0	75.2	84.7	94.1	105.0	114.8	123	160	224	310
Finance, Insurance, and Real Estate	45.8	48.0	50.7	53.6	57.1	61.9	67.4	72.3	78.2	85.2	90	116	158	216
Mining and Construction	26.5	27.2	28.5	30.2	32.4	35.2	38.3	39.4	42.9	48.0	51	65	89	122
GNP	503.7	520.1	560.3	590.5	631.7	684.9	749.9	793.5	865.7	932.1	1000	1282	1749	2385

Note: The minor statistical discrepancies that appear result from the variety of sources consulted and from rounding.

Sources: 1960-1964 Office of Business Economics, U.S. Dept. of Commerce, The National Income and Product Accounts of the United States, 1929-1965, Statistical Tables, p.17
1965-1967 Office of Business Economics, Survey of Current Business, July 1969, p. 21
1968-1969 Office of Business Economics, Survey of Current Business, March 1970, p. 9

Table 5--THE RELATIONSHIP OF CIVIL AVIATION TO THE TRANSPORTATION INDUSTRY AND THE GROSS NATIONAL PRODUCT

YEAR	GNP (billions of $)	Transportation Industry Income ($) (millions)	Transportation as a Percent of GNP	Civil Aviation Income ($millions)	Civil Aviation Income As a Percentage of	
					Transportation Income	GNP
1960	503.7	18,177	3.6	1,400	7.7	0.27
1961	520.1	18,252	3.5	1,443	7.9	0.27
1962	560.3	19,060	3.4	1,664	8.7	0.29
1963	590.5	20,025	3.4	1,881	9.4	0.31
1964	631.7	21,372	3.4	2,229	10.4	0.35
1965	684.9	23,150	3.4	2,697	11.7	0.39
1966	749.9	24,853	3.3	3,027	12.2	0.40
1967	793.5	25,092	3.2	3,387	13.5	0.42
1968	865.7	27,156	3.1	3,786	13.9	0.43
1970	959	27,900	2.9	4,600	16.4	0.48
1975	1282	35,300	2.7	7,400	21.0	0.58
1980	1749	46,400	2.6	11,900	25.6	0.68
1985	2385	61,200	2.6	18,600	30.4	0.78

Source: 1960 to 1968, United States Department of Commerce, Office of Business Economics.
1970 to 1985 are extrapolations.

Between 1970 and 1985, income from the transportation industry as a whole should rise from $28 billion to $61 billion. The civil aviation share of this income is expected to rise from $4.6 billion (0.48 percent of GNP) to $18.6 billion (0.78 percent of GNP). This means that nearly a third of transportation income by 1985 could be accounted for by civil aviation alone.

The level of promotion of science and technology in a given industry is indicated by several factors. These include the amount of expenditures for research and development, the proportion of scientists, engineers, and technicians in the labor force, and the rate of productivity increases. Data on R&D expenditures for transportation sector proper are available only for the sector as a whole, so that airline R&D activities cannot be weighed against those of rail, trucking, and waterway transportation in a direct manner. However, an indirect indication is provided by the fact that the aerospace manufacturing industry, from which the air transportation industry obtains its most important hardware, has consistently been the largest R&D spender of all industries.[25] In the manpower category, the group of professional, technical, and kindred occupations represents about 15 percent of the labor force in civil aviation, as compared to 3 percent in the railroad industry and less than 1 percent in the trucking industry.[26]

A major payoff of technological progress is an increase in productivity. Transportation industry productivity data, available only for the railroads and civil aviation, reveal that of these two civil

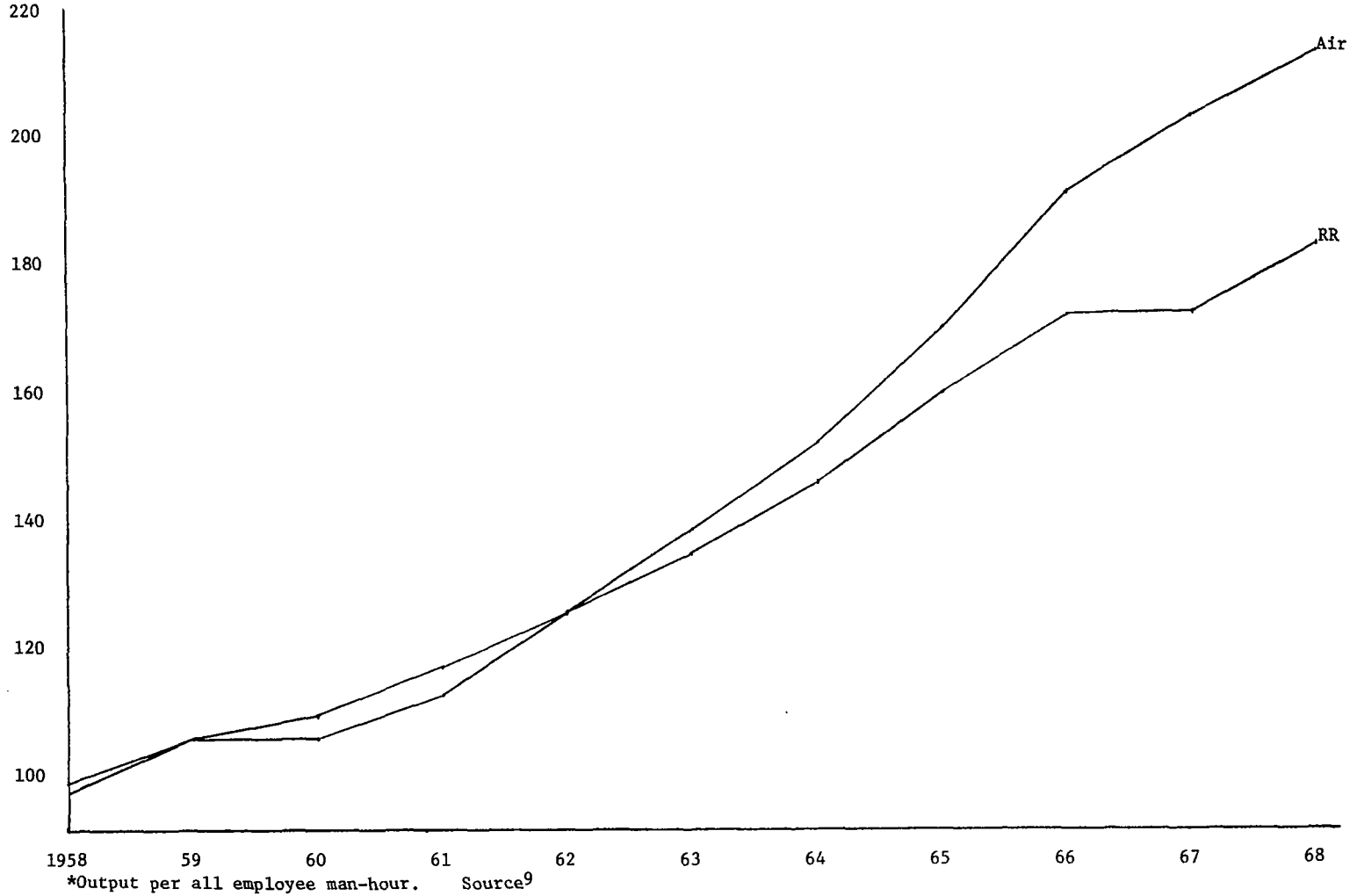
aviation has consistently exhibited the higher rate of productivity increase (Figure 1). This is true in spite of the fact that the actual size of the labor force has increased in civil aviation and declined drastically in railroads. Projections through 1985 (Figure 2) reflect an anticipated continuation of the trends in Figure 1.

Subsidies paid by the federal government to the airlines are shown in Table 6 for comparison with direct and indirect business taxes paid by the airlines. It should be noted that the ratio of taxes paid to subsidies received has increased several times over in recent years, this ratio presently standing at a value around 10. The composition of these subsidies and the philosophy behind them has of course changed over the same period, so that these figures must be interpreted with caution; however, they do serve as rough indication of the growing overall viability and self-sustaining attributes of the air transport industry.

Impact of Civil Aviation on Related Industries

In considering the investment of public resources, the civil aviation industry must also be evaluated in relation to its potential to generate productivity in the innumerable industries serving its needs. The employment impacts of civil aviation are illustrated in Figure 3 (for 1970) and Figure 4 (for 1985), inwhich the three boxes contain information on the contribution of civil aviation to the GNP or, conversely, the incomes generated in the process of production. On the basis of the data given in this modified industrial input-output table,

FIGURE 1 LABOR PRODUCTIVITY IN THE CIVIL AVIATION AND RAILROAD INDUSTRIES COMPARED*: HISTORICAL, 1958-68



*Output per all employee man-hour. Source[9]

FIGURE 2 LABOR PRODUCTIVITY IN THE CIVIL AVIATION AND RAILROAD INDUSTRIES COMPARED: PROJECTED, 1970-95

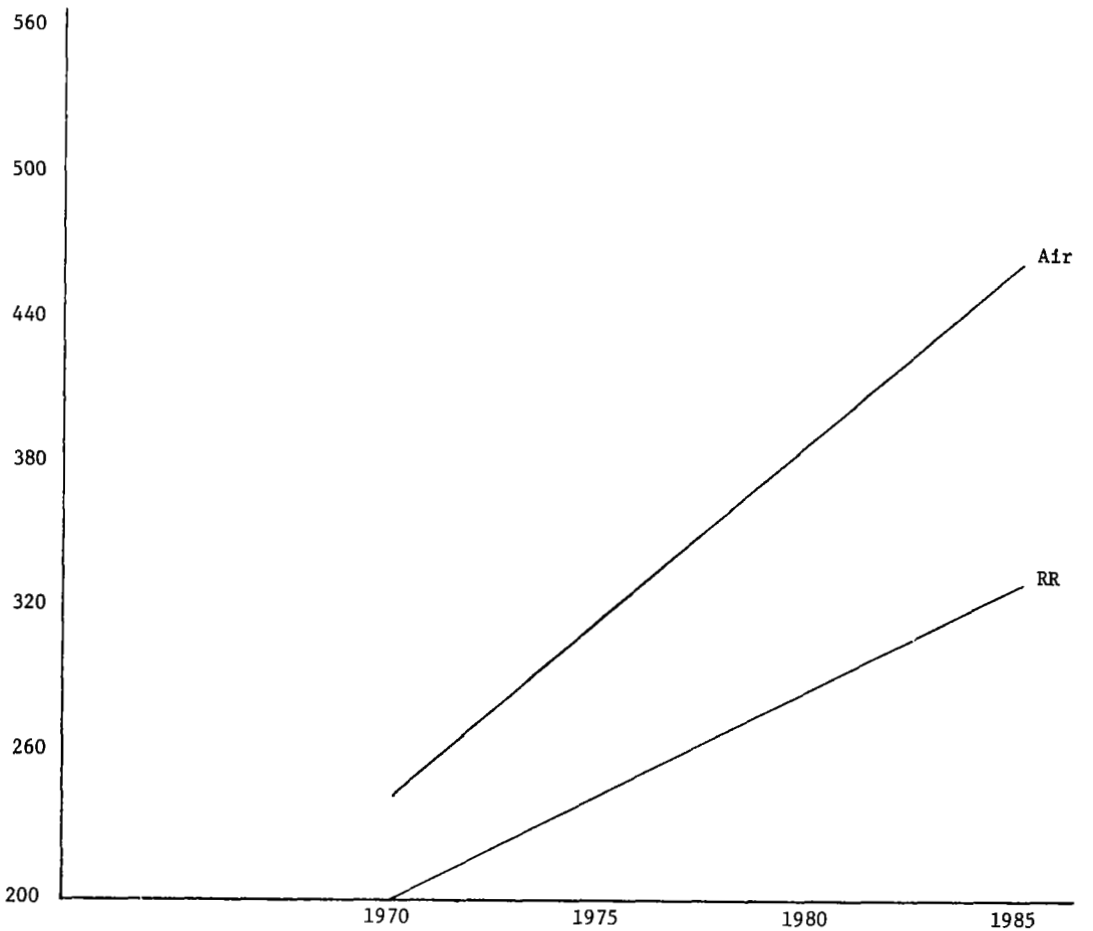


TABLE 6 SUBSIDY TO THE CIVIL AVIATION INDUSTRY VERSUS TOTAL BUSINESS TAXES PAID BY THE CIVIL AVIATION INDUSTRY

($ thousands)

Year	Subsidy	Direct and Indirect Taxes	Taxes/Subsidy
1960	$ 68,164	$ 246,794	3.8
1961	78,952	230,625	3.5
1962	82,393	299,984	3.6
1963	82,222	296,105	3.6
1964	82,806	374,088	4.4
1965	80,622	437,740	5.4
1966	65,619	514,570	7.8
1967	59,912	525,231	8.8
1968	46,745	444,590	9.1
1969	41,200 (approx.)		Avg.=5.5

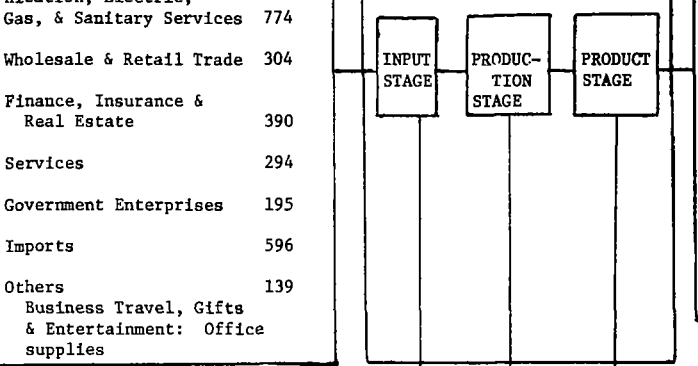
Source: CAB, Handbook of Airline Statistics, GPO: 1969.
Unpublished data from US Dept. of Commerce, Office of Business Economics

Fig. 3

Economic Aspects of the Civil Aviation Industry, 1970
(million of dollars)
Employment Impacts

Industry Requirements for Intermediate Inputs			
Indirect inputs industries		Direct inputs industries	
Agricultural, Forestry & Fisheries	190	Agricultural, Forestry & Fisheries	12
Construction	159	Construction	18
Mining	566		
Manufacturing	1546	Manufacturing	1686
Transportation, Communication, Electric, Gas, & Sanitary Services	469	Transportation, Communication, Electric, Gas, & Sanitary Services	774
Wholesale & Retail Trade	187	Wholesale & Retail Trade	304
Finance, Insurance & Real Estate	419	Finance, Insurance & Real Estate	390
Services	316	Services	294
Government Enterprises	76	Government Enterprises	195
Imports	184	Imports	596
Others Business Travel, Gifts & Entertainment: Office supplies	73	Others Business Travel, Gifts & Entertainment: Office supplies	139

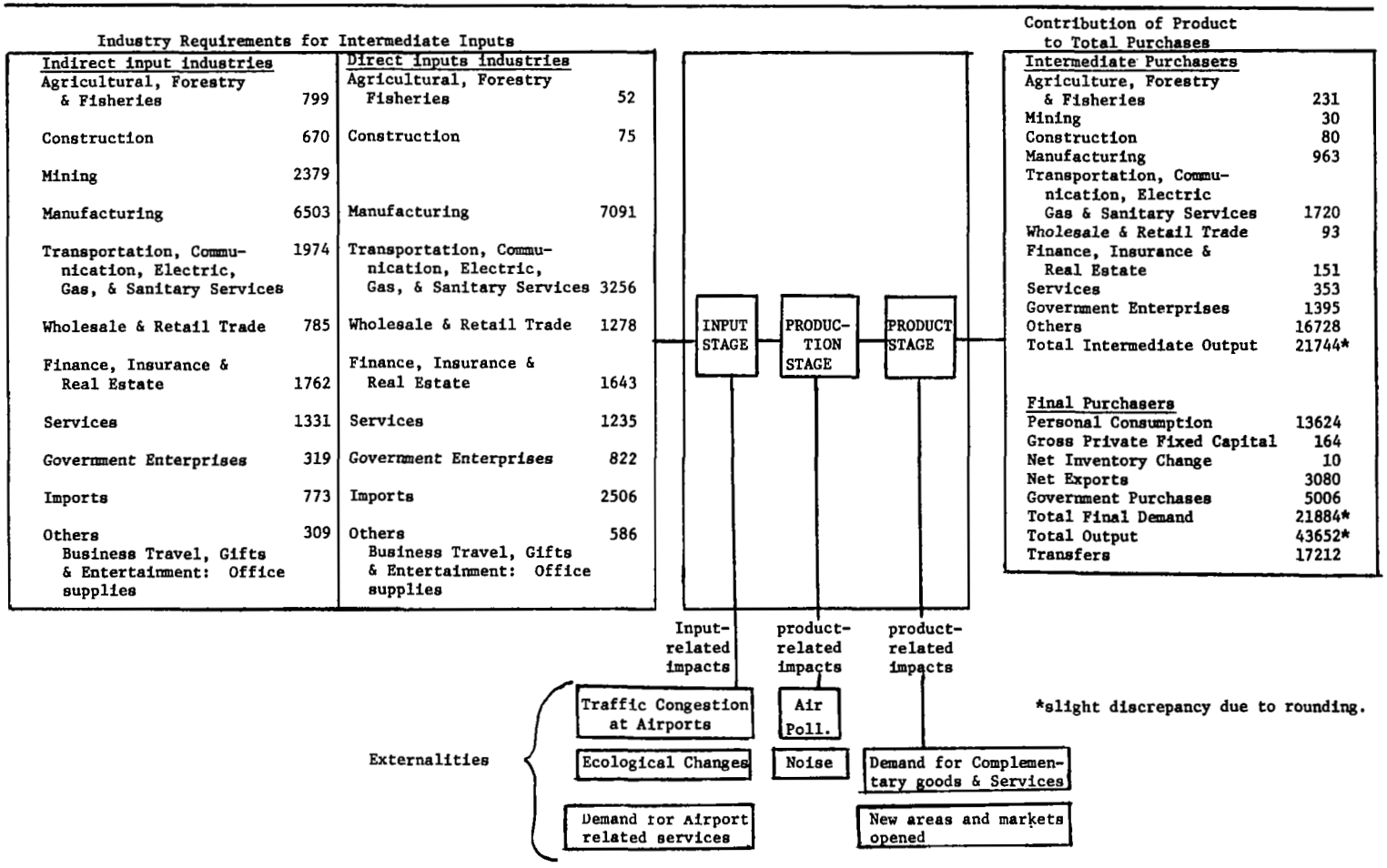
Contribution of Product to Total Purchases	
Intermediate Purchasers	
Agriculture, Forestry & Fisheries	55
Mining	7
Construction	19
Manufacturing	229
Transportation, Communication, Electric, Gas & Sanitary Services	490
Wholesale & Retail Trade	22
Finance, Insurance & Real Estate	36
Services	84
Government Enterprises	331
Others	3,977
Total Intermediate Output	5,169*
Final Purchasers	
Personal Consumption	3,240
Gross Private Fixed Capital	39
Net Inventory Change	2
Net exports	732
Government Purchases	1,190
Total Final Demand	5,203*
Total Output	10,378*
Transfers	4,092



*slight discrepancy due to rounding.

Fig. 4

Economic Aspects of the Civil Aviation Industry, 1985
(million of dollars)
Employment Impacts



the value of the income multiplier activated by the civil aviation industry is calculated to be 1.8--that is, every dollar contributed to the GNP by the civil aviation industry causes another 0.8 dollars to be contributed by other industries.

Policy Implications

As the data presented above indicate, civil aviation serves as an important component of the national economic system and thus is subject to considerations stemming from national employment goals and requirements for advancement of science and technology. In addition, there is a close feedback relationship between civilian and military aviation technology. In fostering civil aviation, the federal government would receive the additional benefits inherent in this relationship. Furthermore, there are many very significant economic factors involved in civil aviation which spring from international considerations; these are explored in the discussion of Policy Issue #9.

The conclusions reached concerning aviation-related economic factors investigated in this study might be criticized by advocates of other modes on the basis of equity considerations and the claim that all industries are equally entitled to federal R&D support. This argument has a certain validity, but it must be pointed out that none of the public transportation sectors can claim to have been free of government subsidy in one form or another at some time in its development. Truck transportation is vigorous and effective in part because it utilizes publicly provided rights-of-way which

are by no means paid for entirely by the trucking industry. Waterway transportation is almost universally dependent, in varying degrees, upon building and maintenance activities of the Army Corps of Engineers. Probably the most cogent complaints with regard to subsidy practice could be lodged by the rail industry, which is unique in owning and maintaining its own rights-of-way and having to pay property taxes on them to boot; even here, however, it should be pointed out that the railroad industry owes its very existence to investment and promotion by the federal government during the last century.[27]

Employment, productivity, and technological progress are volatile phenomena in industry and must be kept under constant surveillance. Better statistics are needed on the performance of R&D in the civil aviation industry, in the form of a breakdown of the "transportation" category as listed in National Science Foundation statistics into the component industries. It should also be noted that the recent unfavorable profit situation in the civil aviation industry has tended to produce a shift in priorities. The aviation industry is not at present in a position to undertake substantial research and development with its own resources, and some government support will therefore be necessary if civil aviation R&D is to continue to produce improved capabilities fast enough to maintain American dominance of this economically important and dynamic field of technology.

3. POPULATION DISTRIBUTION AND REGIONAL DEVELOPMENT

SUMMARY: The effects of civil aviation systems on regional development and population distribution are analyzed. Future population patterns are outlined, and the economic, social, and political impacts of regional airports and STOL systems are reviewed. It is concluded that through careful planning, civil aviation can be used as a useful tool in implementing national policies in these areas.

Introduction

The following discussion focuses upon the following question: How could civil aviation systems assist in the implementation of national population-distribution and regional-development policies?

The growth patterns of the United States have been shaped largely by available transportation corridors and technologies and their relationships to raw materials and markets.[28] The patterns themselves have been significantly affected by governmental policies and legislation.[29] Because the civil aviation system is now approaching maturity as a broad capacity transportation mode, the air terminals of the 1970-1995 period and the activities which evolve around them will play a major role in the developmental patterns which will shape the United States during the next century. This potential is becoming significant at a time when earlier patterns of development are rapidly approaching intolerable levels of imbalance and dysfunction,[30] and when the economy of the United States is shifting from an industrial to essentially a service base. The United States in 1970 was at a major point of change in its developmental history, and since the role of civil aviation is

still evolving, its potential for adaptation to the needs of the future is perhaps greater than that of any other existing transportation mode.[31]

For many decades, migration trends in the country have concentrated increasing proportions of a growing population into very small segments of the available land. The resulting social and economic imbalances have created counter-trends towards more dispersion of the population, but in the absence of rational management, the result has largely been urban sprawl. Growing awareness that there are more satisfactory possibilities for population distribution has stimulated demands for appropriate national policies and programs.

The civil aviation system can play a critical role in stimulating balanced population distribution and regional development. Of particular interest in this connection are:

- Contribution to revitalization of existing non-metropolitan cities and urban areas, such as those in the Appalachian region, where aviation can serve as a catalyst to the generation of sound growth potential.
- Development of independent new communities in the 100,000 to 1,000,000 population range. Proper airport design and creative structuring of the civil aviation system to serve such communities can make the airport the hub of the community and a major stimulant to its successful development.
- Minimization of further urban sprawl through the development

of "new town" growth modules surrounded by essential open spaces. STOL systems have great potential in this area.[32]

Future planning and development within the civil aviation industry must be coordinated with that occurring in all other modes of transportation. Transportation planning itself must in turn be responsive to governmental policies concerning regional development, population distribution, and improvement of the natural and social environment. Without such integration, the full potentials inherent in the civil aviation industry cannot be achieved.

Future Population Patterns

The overburden imposed on the 12 emergent metropolitan areas in the United States by continued population growth and existing migration patterns has created dangerous imbalances in the largest urban centers. Some Urban Regions are rapidly becoming Urban Belts (See Table 7). Projection of the data in Table 7 suggests that by 1985 60 percent of the population will live on less than 8 percent of the total land area.

A counter-trend toward decentralization and the emergence of new nodules of concentration is also evident, however;[33] the extent to which this counter-trend will lead to a redistribution of the population overgrowth and to a more tolerable living environment will depend on the degree of support and guidance from federal, state and local governments in the planning and implementation phases. If future growth is to be oriented toward self-sustaining, independent communities in new locations, the role of civil aviation will be a central one. An airport cannot insure a successful future for a new community,[34] but

TABLE 7 MAJOR URBAN REGIONS: GROWTH AND PROJECTION

1960 to 1980

REGION AND SUBREGION	1960 Land Area	1960 Population (000)	1960 Dens.	1970 Land Area	1970 Population (000)	1970 Dens.	1980 Land Area	1980 Population (000)	1980 Dens.
ATLANTIC SEABOARD	50,553	37,453	741	51,011	42,773	839	59,361	52,034	877
Boston Zone	13,729	6,807	496	13,729	7,390	538	13,729	8,114	591
New York Zone	12,988	18,228	1403	12,988	20,790	1601	12,988	24,196	1863
Philadelphia Zone	8,235	5,738	697	8,235	6,710	815	8,235	7,786	945
Pa.-N.J. Piedmont Zone	3,384	1,203	381	2,829	1,334	471	3,440	1,545	449
Pa. Anthracite Zone	4,815	1,091	227	4,815	982	204	4,815	943	196
Washington-Baltimore Zone	7,402	4,385	567	7,860	5,567	708	11,423	7,175	628
Virginia Urban Zone	(see below)						4,731	2,275	481
Albany Zone #	(see below)								
LOWER GREAT LAKES	57,410	27,698	482	66,260	33,610	507	80,981	43,920	542
Central New York Zone #	3,704	867	234	6,121	1,439	235	6,646	1,674	252
Niagara Frontier Zone	5,260	2,411	458	5,260	2,679	509	5,656	3,087	546
Cleveland Zone	7,476	4,022	538	7,476	4,684	627	7,476	5,508	737
Pittsburgh Zone	10,647	3,972	373	10,647	3,963	372	10,647	4,172	392
W. Central Ohio Fringe	2,702	360	133	3,111	431	139	4,038	550	136
Detroit-Toledo Zone	13,617	6,407	471	14,188	7,598	536	18,728	10,278	549
Chicagoland	14,004	9,659	690	17,289	11,749	680	19,398	13,978	721
Columbus, Ohio Zone	(see below)			2,168	1,067	492			
Miami Valley U.R.	(see below)						8,392	4,673	557
Central Indiana U.R.	(see below)								
METROPOLITAN BELT, TOTAL	107,963	65,151	603	117,271	76,383	651	140,342	95,954	684
REGIONS AND ZONES ADDED:									
Hampton Roads Zone	1,491	865	580	1,491	1,156	775	Merge with Va. Urban Zone		
Richmond Zone	1,542	515	334	2,007	644	321			
Albany Zone	3,125	766	245	3,125	829	265	3,125	907	290
Columbus, Ohio Zone	1,728	837	484	Added to Lower Great Lakes Region					
Miami Valley U.R.	4,009	2,265	565	4,009	2,687	670	Added to Lower G.L. Region		
Central Indiana U.R.	6,021	1,558	259	6,430	1,857	289	8,785	2,654	302
Grand Rapids Zone	1,930	612	317	1,930	722	374	Added to Detroit-Toledo Z.		
Rock Valley Zone	2,438	546	224	Added to Chicagoland Zone					
FLORIDA PENINSULA	11,320	3,344	295	12,760	4,973	390	17,074	8,087	474
Florida East Coast Zone	4,370	1,836	420	4,500	2,822	627	6,060	4,877	805
Central Florida Zone	4,360	589	135	4,360	783	180	6,372	1,259	198
Florida West Coast	2,590	919	355	3,900	1,368	351	4,642	1,951	420
CALIFORNIA REGIONS	29,195	13,751	471	29,195	19,040	652	41,800	27,160	650
Southern California	16,443	8,899	541	16,443	12,630	768	21,950	18,200	830
Bay Area-Central Calif.	12,752	4,853	381	12,752	6,410	503	19,850	8,960	451
MAJOR URBAN REGIONS, TOTAL	148,478	82,246	554	159,226	100,396	630	199,201	131,201	659
% of Conterminous U.S.	5.0	46.1		5.4	49.1		6.7	54.9	

Onodaga-Mohawk Valley Urban Region is divided into Albany Zone and Central New York Zone.

Source: Jerome P. Pickard, Dimensions of Metropolitanism, Urban Land Institute, Research Monograph 14, Washington, D.C. 1967, p. 23.

failure to incorporate effective air transport service into such communities may preclude the possibility of independent survival. Projections indicate that from 24 to 34 new communities having populations of up to 320,000 will be developed around large regional airports between 1970 and 1995.[35] Perhaps one-third of the additional population growth expected in the United States from 1970 to 2000 could be most beneficially accommodated through new communities.[36]

Economic Effects

The influence of a regional airport on community economic development can be substantial. Studies for the proposed Louisville, Kentucky, Intercontinental Airport predict creation of over 1000 jobs per year during the construction phase, 10,000 jobs in occupations associated with aviation and aviation-related services, and 20,000 jobs through commercial utilization of adjacent land.[37] This airport complex will purchase goods and services valued at approximately $270 million from a multi-county region in Kentucky, and these purchases will, in turn, generate demand for an additional $370 million in goods and services.[38] Estimates for the Dallas-Forth Worth airport forecast the creation of over 46,000 jobs and purchases of $266 million in the North Central Texas Region by 1975.[39] Washington National Airport, with its 8,400 employees, ranks among the top ten employers (excluding government) in the entire state of Virginia.[40]

Political Factors

In spite of these potentials, serious delays in the initiation and implementation of airport developments may be anticipated, owing to the necessity to conform to demands such as those imposed by the Environmental

Policy Act of 1969.[41] Furthermore, the Urban Land Institute reports that only "rarely will an industrial district of more than 100 acres be sold out in less than 10 years,"[42] which implies limitations on what can be accomplished by following the industrial airpark approach. On the other hand, the New Communities Act of 1968 (Title IV of the Housing and Urban Development Act of 1968) and the Airports and Airways Development Act of 1970 provide powerful support for new airport communities. Tax incentives could be used to accelerate industrial locations within these new cities.[43]

Current government programs and legislation could provide a substantial base for departure in the development of civil aviation's role as a catalyst in achieving beneficial population distribution patterns. Much remains to be learned, however, concerning the criteria which affect local decision-making; such understanding will be needed, if situations such as that which led to cancellation of the Miami-Dade County jetport are to be avoided. If opposition to a project is justified from the standpoint of the affected region as a whole, this should be recognized at the earliest possible stage, in order that alternatives can be developed or services expanded by the modification of existing facilities. Such constraints may limit the growth of major cities, creating a demand for alternative growth locations. Decision-making becomes extremely complex in such situations.[44] A much more sophisticated, coordinated, and dependable planning and implementation process should be developed than is presently available.

STOL Aviation Systems

Metropolitan rim-ports served by STOL aircraft could serve to stimulate a more systematic, nodular type of suburban development in place of indiscriminate sprawl that now typifies large urban areas. Furthermore,

the use of two or three such rim-ports in large urban areas would help to reduce ground congestion at any one location--avoiding, in particular, the extra traffic which a center-city STOLport would generate in an area where ground transportation is already badly strained. An urban area may thus, through the rim-port approach, benefit from the contributions which a STOL system can make toward both urban decongestion and more systematic metropolitan development. It must be noted, however, that for maximum effectiveness, the aviation system must interface efficiently with appropriate urban transportation, preferably including public mass transit and perhaps for geographically extensive areas, intra-urban air systems.

The introduction of STOL systems to regional airports would encourage the development of functional regions comprising one or more major urban hubs and a number of smaller exurban cities. The latter, with populations of 100,000 to 500,000, are presently considered optimal from the standpoint of economic and governmental efficiency. With judicious selection of STOLport locations, this approach could enhance the attractiveness of many areas now struggling for survival (e.g., the Appalachian Region) and might lead to a degree of regional economic balance not possible under the time-distance constraints of other travel modes.

An effective STOL system would help smaller communities to develop their independent potential, while retaining a satellite status for services and entertainment provided by the regional urban center. By stimulating the growth of such satellite cities, STOL service might also prove to be the forerunner of mass high-speed ground transit segments that otherwise would not have evolved.

The short-haul STOL system must be flexible enough to operate economically at several levels of service frequency and passenger-carrying capacity.[45] Since the functions of a STOL system will vary considerably for different regions, it is essential that all capabilities be carefully explored before final decisions are made regarding vehicle technology, ground-support facilities and locations, and linkages with other modes of transportation. Planning considerations must include such factors as economic feasibility, transitional potentials, mission profile, airport location, and the interface with surface transit systems. It is also essential to determine whether design goals can be implemented or whether they will be usurped by other user demands.

Policy Implications

It is important that the development of civil aviation be integrated with other public and private programs having similar goals. Coordination is particularly necessary for STOL and VTOL systems and for regional airport hubs. Only through analysis of the full potentials of a flexible STOL system, judicious location of regional airports, and integration of the aviation system with other national and regional development programs and policies can civil aviation serve as a major force in enhancing the living environment.

All the implications of site selection for major regional airports need to be thoroughly examined, from both the environmental and the socio-economic standpoint. Evaluative criteria and institutional decision-making mechanisms must be improved. Without such an effective assessment capacity any funds made available may be improvidently allocated and/or progress toward essential national goals impeded.

4. FEDERAL PERSPECTIVES AND ROLES IN CIVIL AVIATION

SUMMARY: The role of civil aviation in a national transportation system is analyzed in relation to alternative and complementary modes of transportation. The National Airport System Plan is considered, and federal options in fostering and implementing the development of appropriate modes of transportation for specific localities are outlined. Mechanisms for coordinating decision-making at the local level with planning at the national level are discussed, and areas in which federal support may be appropriate are noted.

Introduction

The discussion below focuses upon the following specific questions: To what extent is federal action necessary to achieve an integrated, effective national transportation system? What is the role of civil aviation in such a system?

The national transportation system consists of the totality of all transportation vehicles, terminals, and rights-of-way in use throughout the nation to move people and goods from one place to another. It includes intra-urban as well as intercity travel facilities, and its scope ranges from very localized pedestrian travel -- the least glamorous but most basic form of travel -- all the way to transcontinental jet transportation, involving aircraft, airports, and airways components.

Taken as a whole, the national transportation system is thus much more than a mere economic asset (though it is this, too): it is the lifeblood upon which much of the functioning of our entire society depends. The "public good" is therefore an inseparable factor, in varying degrees, in all transportation developments. For this reason it is in the nationwide public interest for the federal government to

assume certain roles in transportation.

The part played by civil aviation as part of the national transportation system is pre-eminently in the realm of intercity travel, with its importance being emphasized for long-distance travel. It therefore is not surprising that federal responsibilities with respect to aviation are many and varied, and in most areas outweigh those at the local level. The responsibility for promoting aviation R&D, for certificating air vehicles, for regulating air routes and providing needed navigational and air traffic control services, and for many other areas of concern is federal. Indeed, the most salient area in which responsibility rests primarily at the local level is that of airport development; and even here federal standards and financial participation are involved.

In the future, the role of civil aviation as well as that of the federal government may change with respect to the national transportation system. For example, growing needs for short-haul travel capabilities may well warrant increased emphasis for air services in this sector. And the growth of serious difficulties in the relationship between airport and community development, combined with the failure of most local governments to cope with these problems, may imply a need for increased federal participation at the local, airport-oreinted level.

National Transportation System Considerations

Technological progress in transportation over the next two or three decades will necessarily include both incremental improvements and innovative breakthroughs. The latter will require major research, development, and demonstration programs. When breakthrough developments

are called for under public policy decisions, public financing or incentives frequently will be necessary to supplement private R&D investment. Additionally, with reference to the "public good" aspect of transportation, some commitment of public planning and resources will inevitably be a necessity to protect the general interest.

Potential social costs of new transportation systems, such as noise, air and water pollution, and adverse influences on community development, must be assessed along with the potential benefits of these systems. Many of the costs are borne neither by the industries responsible for them nor by the direct beneficiaries (users) of the service provided, but by the society at large. As a result, private-sector decision-making concerning transportation mode emphasis, system development, rights-of-way, terminal facility (including airport) location, and operating procedures has been generally conducted without regard to such external costs and their secondary consequences such as alienation and civil disorder. Federal actions which serve to internalize such costs, e.g., through performance standards and other regulatory devices, might drastically change some of these decision-making processes in a manner which would be socially desirable; at the same time, however, the federal government may have to take accompanying actions to insure that this internalization of costs is not done in such a manner as to terminate the viability of desirable types of development.

An appropriate overall federal objective in transportation would appear to be to generate and maintain the broadest practical range of options for future transportation developments. One aspect of this is the

promotion of R&D required to make needed new forms of transportation a reality. Another is the supporting of high-risk or low-profit options which, despite the economic unattractiveness for the private sector, exhibit unusually high potential for overall social benefits. A third aspect of this objective is the preservation of certain currently disused facilities which appear to have a high probability of being needed once again in the future. For example, in order to implement the objectives of regional development or a future policy to encourage development of a modified national population distribution, a beginning might be made with civil aviation; this might then be followed by a need for good high-speed ground transportation between new growth centers and existing cores of major activity. In some such cases, rights-of-way which exist today could be utilized for innovative new systems such as air cushion vehicles or improved rail systems, thus saving the costs of land acquisition, but there has been a tendency for rail rights-of-way no longer in use to be sold to the private sector and thus removed from the public domain as potential routes for transportation systems. If such options are not to be lost, therefore, some type of governmental action may be called for. One possible course of action would be "land banking" of relevant public-owned land, including disused military facilities whose location suggests future usefulness.

Federal activities will inevitably change gradually in response to changing national transportation needs. Directions in which the federal involvement can be expected to go, or at least which deserve consideration, include the following:

- The overall planning function in the Department of Transportation should be strengthened and unified. It should be directed toward formulation of national transportation policy, and while drawing upon the resources and soliciting the participation of each constituent administration charged with a single transportation mode, the planning function should be independent of all these administrations.
- A National Transportation Trust Fund might be established to supersede the Highway Trust Fund and the Airport Trust Fund. Such a move would encourage the funding of alternative modes of transportation on the basis of local and national considerations and comparison of social impacts and competing priorities. Single-mode trust funds are inflexible, and prevent sensitive use of budgeting to achieve changing objectives. It is true that there are valid questions to be raised relative to taxing a given mode to support development of another, but it is more demonstrably true today that inflexible re-investment of tax revenues from a highly viable mode to support further development of that mode tends to lead to imbalances in total transportation development.
- In its broadest form, a National Transportation Trust Fund might include legislation allowing state and local officials to use Fund monies on mass transit facilities, airport access, and other critical transportation needs -- subject always to federal approval. Such a plan may, however, be opposed by officials

who are responsive to non-urban constitiencies; and deficiencies in local planning mechanisms could lead to inadequate planning for future growth, if localized use of monies were not carefully monitored. Fragmented Congressional committee responsibility might also tend to perpetuate the present mode-competitive situation under the guise of a single Trust Fund.

The Role of Civil Aviation in the National Transportation System

A decision to foster civil aviation as either an alternative or a complement to other modes of transportation should include a consideration of such factors as the number of potential users, relative depletion of national resources, environmental perturbations and competing land uses, public subsidy required, behavioral and psychological constraints, and political institutions necessary to implement and control the systems.

Ultimately, the role aviation can play as part of the national transportation system depends upon two basic factors:

- The types of airports in existence, and the manner in which they are geographically distributed.
- The efficiency with which air travel interfaces with complementary modes.

A full discussion of the latter factor appears elsewhere in the present report, but the need for federal attention in this realm must be noted here. The private sector, which consists largely of single-mode companies, cannot assure proper interfacing because of anti-trust laws and other hindrances. Because of the mix of private and public ownership and fragmented regulatory mechanisms, local and state governments

likewise are not in a position to assure proper interfacing.

With regard to the basic airport system factor, further discussion is relevant here as regards the role of the federal government. This discussion of airport development can be further broken down into considerations regarding:

- Development of a National Airport System Plan.
- Generic categories of new airports.
- Regional planning and land use.

National Airport System Plan Considerations

A National Airport System should be planned and implemented on the basis of coherent national objectives. Such objective should embody policies concerning desired national population distribution trends, balanced regional development, and protection and enhancement of the physical environment. However, it should be noted that:

- Constraints built into airport/airways legislation in the form of allocation of grants according to hub size and population density will lead to difficulties in achieving these goals.

These constraints could serve simply to perpetuate current trends toward megalopolis. By contrast, if this trend is to be reversed:

- The National Airport System Plan should aim at drawing demand away from overly congested hubs and toward selected smaller population centers identified as having the potential for significant growth and sustained socio-economic viability.

Additionally, if existing airports are to be upgraded and future airports built in such a manner as to promote both high transportation utility

and improved overall social desirability:

- Broadened federal airport criteria and regulations, based on sound information and analysis, should be adopted concerning noise, safety, access facilities, land use, and environmental protection. Where necessary and appropriate, these criteria and regulations should be made more stringent than at present, so as to force both the private sector and local governments to make greater efforts at technological improvements, including more effective interfacing.

Generic Types of New Airports

New regional airports are desirable in some areas to stimulate regional economic development, induce population redistribution from congested areas to new growth centers, or draw traffic from overloaded airports. These large airports should either serve several population centers or create new centers. They require very large initial capital investments, and their development is difficult because of jurisdictional rivalries and the uncertainties of route awards. If very rapid development along this route is seen as desirable, therefore, federal inducements and initiative will have to be increased beyond present levels.

Construction of center-city STOLports or VTOLports for airborne airport access from downtown and for direct flight between city centers is today a subject of considerable interest. The following two-pronged finding of the present study is therefore relevant:

- Center-city STOLports are likely to be politically and economically feasible in very few of those large city centers in which the demand for center-city air travel potentially exists. This con-

clusion is based not only upon noise and pollution factors -- which might be solvable technologically a decade or two hence -- but also upon factors such as existing ground congestion and inadequate prospects for improved ground transportation in the terminal vicinity; land use considerations, particularly with regard to competition between aviation and other possible uses at the STOLport sight; and the social disruptions and unrest caused by displacement of prior activities (residential or otherwise) at the STOLport sites.

- Central STOL- and VTOLports, planned as integral parts of New Towns, would escape at least some of the political costs incurred in redeveloping existing densely populated areas and would offer benefits in the form of recruitment of industry and commerce, increased mobility for residents of new communities, and, insofar as they reduce the need for automobile transportation and highway building, environmental enhancement. However, the justification for central location is by no means as clear in this case as it would be for the large city, since good access -- the prime justification for central location -- is readily obtainable in the case of a smaller town even if the STOLport is on the edge of town.

An interesting and socially attractive alternative to the center-city STOLport is the rim-port -- i.e., a STOLport located on the "rim" of a large metropolitan area, 3 to 10 miles from the center of the central business district. As discussed elsewhere in the present report, this

concept offers a promising approach to STOL transportation which could enable both large metropolitan areas and smaller growth centers to be served effectively.

Finally, the federal government could explore the feasibility and desirability of developing "National Airports" in selected areas. Such airports could significantly stimulate the growth of an underdeveloped region, where they could serve several population centers. They might also be of interest where local public resources are inadequate for development of regional airports, where critical geophysical conditions obtain (i.e., water-borne jetports), and where jurisdictional rivalries or disparities of resources threaten to impede the rational selection of airport sites in accordance with the National Airport System Plan. Obstacles to such programs may include the possibility of little or no return on public investment, conflicting political commitments among state and local officials, and -- perhaps most importantly -- hostility against federal intrusion.

Regional Planning and Land-Use Considerations

Proper integration of airports into the community requires that the land in the airport vicinity be utilized by activities which are compatible with airport presence. However, local land-use regulations frequently frustrate national or regional policies and goals accepted in the context of the larger society. Zoning laws and building codes are often used less for their declared social objectives than to protect special interests or to block unwelcome changes such as low-income housing or racial integration. Furthermore, the absence of adequate land-use

regulations and controls allows incompatible land development in high-noise areas around airports, in needed green space, or where there is a delicate ecological balance. For airports, the resulting social strains limit airport utility to the community and create opposition to expansion of existing facilities or the development of new ones.

Clearly, the key to correction of this situation lies in improvement of airport-related urban planning processes, and of the procedures used to implement plans. Local planning -- at least, the portions thereof which actually reach the implementation stage -- tends to be dominated by limited spatial concepts and oriented toward current and near-future demands. An infusion of longer-range perspectives is clearly needed, but is unlikely to occur spontaneously at the local level:

- Current urban problems are typically so urgent today that they leave the local official -- even the basically far-sighted one -- little or no time to devote to long-range matters.
- The longevity of local political administrations is usually short and precarious enough to make the distant-future rewards of long-range projects relatively unattractive.

Another important factor in the airport planning process is the fragmentation of local political authority, which implies at best that extensive coordination is necessary, and at worst that competition and feuding can block progress altogether. Local jurisdictional boundaries, often a legacy from the days of primitive transportation and communication, typically are now dysfunctional for programs involving complex technology, economic development, and environmental management.

Interjurisdictional cooperation and coordination are essential in locating and developing airports, and this can be enhanced in several ways, such as the utilization of economic development districts and regional councils. The recent, federally fostered movement toward regionalism in planning and toward coordinated planning at the state and interstate levels must be continued and strengthened. It is relevant to note that:

- The goal should be to locate every governmental function at the optimal level of jurisdiction in order to assure both economies of size and reasonable access to decision-making by the citizens affected.[46] In this connection, some 30 states have delineated districts for coordinating federal programs and grants, and various small or semi-rural jurisdictions are developing mechanisms for sharing public services and planning processes.

The realm of community participation in major urban land-use decisions -- including, in particular, those concerned with airports -- remains an area of great and critical weakness. Community participation as it presently occurs is generally ineffective, both in influencing decisions and in reducing later public opposition as plans are implemented:

- Present techniques such as public hearings create false expectations of "success" and at the same time fail to convey a real perception of response or of having been "listened to."[47]
- Public hearings often merely reinforce the citizen's negative opinions and solidify opposition to a proposal.

Effective and productive community participation is, nonetheless, an absolute necessity for the functioning of a truly democratic system at

the local level. Thus:

- There is a pressing need for a participation mechanism which is representative of the whole community and which allows the public interest as a whole, as well as competing special interests, to be represented.

Policy Implications and Alternatives

The preceding discussion suggests a number of areas which deserve consideration in the formulation of policy concerning the nation's transportation system, including civil aviation. These cluster into the following broad categories:

- Development, broadening, and preservation of resources for future transportation development.
- Assistance in, and promotion of, effective planning and implementation of advanced transportation systems.

The term "resources" is used here in the broadest possible manner, meaning not only material resources but also provision of funds of knowledge from which needed information can be drawn in creating viable new systems. Some of the federal activities which would relate to this area would include:

- Creation of a federal land bank to preserve critical land areas and existing but disused rights-of-way in the public domain, where these are expected to become crucial to needed future developments in transportation. This might involve anticipated development in air travel (airports) as well as ground transportation (rights-of-way).

- Systems research and development, to generate a coherent structure, pattern, and technology base for continuing transportation developments.
- "Public interest" research and development, insuring adequate progress in areas such as mass transit, quiet aircraft engines, and the like where the private sector is not in a position to perform the needed R&D on its own. Direct economic return on such investments may typically be low, and/or development risks abnormally high.
- "National interest" research and development, carried on primarily to maintain a competitive position in world markets and/or for national prestige purposes. These two areas appear to be interrelated, although there is no empirical validation for the premise that prestige translates directly into power or economic gain. A selective approach to world markets may therefore be most practical and compatible with other national aims.[48]

The process of planning and implementing transportation systems, both in aviation and in ground travel, is a very complex and, today, an unwieldy and relatively inefficient one. A number of areas have been discussed which may warrant new or increased federal activity, and these are summarized here:

- Promotion of improved regional land-use development and planning relative to transportation -- particularly with respect to airports. This could involve imposition of appropriate federal land-use guidelines or regulations. It should also include measures to

reduce the extreme lead times which now characterize decision-making and implementation in airport development.

- Promotion of coordination and interfacing among complementary modes. A particularly relevant problem here is that of providing efficient airport access in urban areas, as well as improved passenger/baggage processing within the airport complex.
- Internalization of social costs through legislation and regulation. This would involve charges for air and water pollution, application of stringent standards and criteria which set upper limits for socially undesirable side effects, and the like. In some cases, however, it must be noted that complete internalization of these costs by a given industry (for example, the airline industry) may imply destroying the economic viability of that industry. To the extent that the service performed is seen to generate social benefits which render elimination of the industry unacceptable, compensating subsidies, tax relief, or other financial assistance would be warranted in such cases.
- Federal initiative in terms of research, development, demonstration, and subsized initial implementation of highly innovative new transportation systems, such as certain kinds of STOL, VTOL, and high speed ground transportation systems. Due to the high risks and inability to conclusively demonstrate acceptable demand for entirely new services before sizable investments, these developments cannot be expected to come about in a timely manner wholly through industry initiatives.

- Introduction of "National Airports" in areas where they are crucial to the implementation of a National Airport System Plan and are locally desirable, but where local resources are insufficient for development of such an airport in the traditional manner.

5. STOLPORTS, RIM-PORTS, AND EXPANSION OF EXISTING AIRPORTS

SUMMARY: Alternative approaches to the problem of airport facilities are evaluated, with particular reference to Short-Haul Interurban civil aviation systems. The most promising alternatives involve some combination of improvement of existing facilities, construction of metropolitan distributed STOLports (rim-ports), and development of STOLports for selected growth centers; the center-city STOLport concept appears relatively unattractive. Discussion is presented relative to the implication of these approaches in terms of social impacts in the critical areas of access, noise, and urban land development.

Introduction

The discussion below focuses upon the following specific questions: What alternative approaches are available for creating new types of airport facilities and upgrading present airports to avoid the impending national congestion crisis? Which approaches are preferable in relation to the full spectrum of social implications associated with each alternative concept?

The first means which logically deserves consideration in meeting projected increases in the demand for air travel is that of expansion and upgrading of existing airport and air traffic control (ATC) facilities. This approach has been studied and found to hold very significant potentials for improved, higher-capacity service, and these potentials will need to be capitalized upon if the ability of aviation to move people and goods is not to become saturated and degraded.

However, there are definite limitations in the foreseeable gains to be realized through such attention to existing facilities. In particular, important new needs are emerging for civil aviation services in the short-haul interurban category, including not only improved service

along existing routes, but also new types of service to areas which at present are served ineffectively or not at all. If civil aviation is to meet the short-haul challenge. therefore, it appears that the improvement of existing facilities must be complemented by the construction of new facilities in some locations. These new facilities, oriented toward short-haul functions, would consist of STOLports and their associated ATC facilities.

Social impact considerations bearing on the problem of choosing an appropriate "mix" in the development of needed future facilities spring particularly from three critical areas:

- Airport access.
- Urban land development.
- The problem of aircraft noise.

Some relevant considerations in these three areas are discussed below, after which the following three alternative approaches in airport development are explored:

- Expansion and modification of existing facilities.
- Center-city STOLports.
- Metropolitan distributed STOLports (rim-ports).

Access Considerations

The feasibility of any method of expanding air facility capacity will be strongly influenced by the character of supporting access systems. Poor ground access can construct the effective passenger-handling capacity of an airport just as surely as does the limitation on possible aircraft operations per hour imposed by safety and ATC requirements, though perhaps in more subtle and diverse ways.

Airport access today is predominantly by automobile. Over 90 percent of the ground access to airports in this country is by automobile; the "longest trips in a metropolitan area are to airports, and they can be among the largest trip generators."[49] About 76 percent of all resident air travel trips start at home. Only 3.3 percent of all resident trips originate in the central business district, and in most large cities "resident and non-resident air travel trips may approximately balance."[50] For a more selective sample of cities, trips made by air passengers to the airport from central business districts represented 15 to 28 percent of the total trips made by the group; furthermore, total airport trips are divided about equally among air passengers, employees, and visitors.[51] Future decentralization of businesses and residences will further disperse the points of origin, leading to even greater reliance on automobile access if present trends continue.[52]

This trend toward ever more complete dependence on the auto for airport access cannot continue indefinitely, however. This is true partly because the auto imposes penalties in efficiency of airport space utilization: a large fraction of the land area at the typical large airport of today is given over to roadways and parking facilities, from which the air passenger must generally make a long and sometimes hazardous walk to the terminal. Even more importantly, however, typical large urban areas served by air are becoming so saturated with auto traffic that the marginal costs of supplying streets, highways, and parking are becoming astronomical. For example, plans for Washington, D. C., indicate that, for each additional car brought daily into the central

business district by 1980, "capital investment in highways, not including parking, will tend to increase by $23,000."[53] One-fourth to one-third of the land use area in residential districts is already devoted to streets;[54] in the central city as much as 40 percent of the area may be taken up by parking and streets combined.[55] In 1980, 120 million motor vehicles will travel over 1.2 trillion vehicle miles in the United States. This total will include over 700 billion urban vehicle miles, more than all motor vehicle travel in the United States in 1960.[56]

Such unbearable pressures on the urban fabric must inevitably lead to new developments in urban transportation which can reduce dependence on the auto. Indeed, the revival of active development of mass urban transportation systems in large American cities after decades of disinterest signifies that the urban trend away from the automobile has already begun. Clearly, this offers the prospect of greatly improved airport access, and hence enhanced utility for aviation, in the decade ahead--but this prospect will be fully realized only if the airport access is developed hand-in-hand with urban transportation in general. This is true in a functional sense because of the metropolitan-wide dispersion of origins and destinations which relate to the airport; and it is emphasized by the political fact of life that urban priorities must be on services which benefit the maximum possible number of community residents on a regular basis. The latter factor militates against any airport access schemes which might appear to be "special-purpose" projects.

Fortunately, rail mass transit systems of the type existing in some cities and being built in others do show promise in relation to

airport access. A recent study concludes that, for Kennedy International Airport, "there is much more likelihood that a severe backup in movement will occur on the roads than on the runways if rail service is not rushed." The same study indicates that "rail service to Kennedy Airport could be one of the best transportation buys in the region, comparing costs and benefits as usually calculated for transportation investment.[57] Critics of the rail/airport access concept point out that, although the airport is an intense trip generator, the number of trips to a specific high-density area such as the central business district is typically insufficient to support a rapid rail link. This argument fails to take into consideration three important factors which can improve the feasibility of rail/airport access:

- Such facilities may be shared with other high-intensity uses with only a slight increase in travel time, if airport placement allows the appropriate rail route structure.
- The costs of providing a similar level of access by another means may be prohibitive.
- The presence of rail access is likely to generate the demand needed to support it, as land-use patterns adjust to capitalize on improved access.

Urban Land Development Considerations

The demands placed on any transportation system are largely determined by the spatial distribution and relative intensity of various land uses. However, the reverse also holds true: the existence or provision of adequate transportation facilities may help to shape the land-use

patterns which develop.[58] Under certain conditions, therefore, the long-term end result of increased transportation capacity may be aggravation of the congestion problem, since increased efficiency permits more intensive and extensive development which leads ultimately to even greater transportation demand. Therefore, the decision-maker should weigh carefully the respective effects and social impacts of the following types of alternatives:

- Satisfying the existing or projected demand for movement between predetermined locations, emphasizing the existing land-use patterns.
- Employing the transportation system as a public facility for guiding and controlling development.
- Reducing the demand for certain types of movement by restructuring land-use patterns.

For air transportation, the primary influence on land use tends to be restricted to a relatively localized area in the vicinity surrounding the airport, rather than in the linear and matrix patterns associated, respectively, with rail and automobile modes. Airports themselves thus have a nucleating effect on land development, while the modes used for airport access may have secondary linearizing or dispersing results. Where the demand for airport access is satisfied by automobile, an overall decentralizing influence will tend to be exerted,[59] whereas a direct rapid-transit tie between the airport and central business district would have the opposite effect.

Control of the overall effect on land development of an airport and

its access provisions clearly calls for maximum use of comprehensive land-use planning, stimulation of which may be accomplished through federal pressures. It is conceivable that authority in certain aspects of land-use regulation could be transferred to the federal government.[60]

Land-use control problems for airports in existence today, as opposed to future new airports, stem from the fact that much of the adjacent property is either already developed or rapidly developing. Expansion, therefore becomes increasingly difficult for both economic and legal reasons.[61] The approach of state and local legislatures has been to attempt to control land development around the airport by means of zoning ordinances. The constitutionality of such ordinances must be determined. It should also be noted that the purchasing of 'avigational" easements is a poor alternative to the regulation of land use through police power, since these may be as costly to obtain as complete title to the land.[62]

Aircraft Noise Considerations

Two measures have been developed for use in determining the level of noise irritation produced in the community surrounding an airport--namely the Composite Noise Rating (CNR) and the Noise Exposure Forecast (NEF). Both are computed on the basis of the perceived noise level of particular aircraft at a given point on the ground, the mix of aircraft, the frequency of exposure, and other factors. NEF contains additional corrections for the average duration of each exposure and pure tone qualities. Noise exposure levels of 30 and 40 NEF closely approximate those of 100 and 115 CNR, respectively. Below a level of 30 NEF "essentially no complaints would be expected.... The noise may, however,

interfere with certain activities of the residents." Between 30 and 40 NEF, "individuals may complain, perhaps vigorously...concerted group action is possible." Above 40 NEF, "individuals' reactions would likely include repeated, vigorous complaints...concerted group action might be expected."[63]

The Federal Housing Administration has stated that, for a noise exposure level above 30 NEF, "it may not be possible to develop properties that will be acceptable for mortgage insurance." For levels in excess of 40 NEF, "no new residential development should be considered.[64] Even commercial and industrial land uses should be avoided unless "an analysis of noise reduction requirements is made and needed noise control features are included in building design.[65] Table 8 summarizes land-use compatibility criteria for airports.[66]

Table 9 indicates the magnitude of the noise problem at existing airports.[67] Significant numbers of people are subjected to a noise level of 30 NEF or greater, due to the high level of land development which has come into being in airport vicinities. A study of 21 large hubs conducted by HUD in 1967 showed that, of the 36 airports within these hubs, 12 were almost completely surrounded by intensive development and 16 others were at least 50% surrounded. There are already some 44,000 residential units in three jurisdictions within the high-noise area of National Airport near Washington, D.C. The high-noise area surrounding Los Angeles, O'Hare, and Kennedy alone is now nearly three times the size of the acreage redeveloped in the first 16 years of urban renewal at a public cost of $5 billion. In Inglewood, California, near Los Angeles Airport, it has been revealed that classroom

TABLE 8

LAND USE COMPATIBILITY FOR AIRPORTS

NOISE EXPOSURE FORECAST (NEF)	LAND USE COMPATIBILITY					
	Single Family Dwellings	Apartments	Commercial Industrial	Offices, Public Buildings	Schools, Hospitals, Churches, Theatres	Outdoor Recreation (Non-Spectator)
LESS THAN 30	YES	YES	YES	YES	YES*	YES
BETWEEN 30 AND 40	NO	YES*	YES	YES*	NO	YES
GREATER THAN 40	NO	NO	YES*	NO	NO	YES

*Noise Attenuation Features Should be Considered in Building Design

TABLE 9: NOISE-SENSITIVE LAND USES LOCATED WITHIN CURRENT AND PROJECTED ZONES OF HIGH NOISE EXPOSURE--NEF 30

	Los Angeles (International)		Chicago (O'Hare)		New York (John F. Kennedy)	
Airport	1965	1975	1965	1975	1965	1975
	a	b		c	d	e
Population	210,200	312,800	236,000	432,600	665,700	1,747,600
Schools	58	84	86	142	80	112
Hospitals	8	9	4	6	3	12
Parks	18	22	48	60	19	37
Land Area, sq. miles	34.4	43.9	71.9	122.9	79.8	121.2
Airport Size, sq. miles	5.0	5.0	8.1	8.1	7.2	7.7

Notes:
a. Estimate based on County records for 1967.
b. Preliminary estimate
c. Based on Chicago Area Transportation Study projection for 1980.
d. Estimate based on records available for 1963.
e. Projected figures for schools, hospitals, and parks reflect only existing facilities to be encompassed by contour of 30 NEF by 1975.

time lost because of noise sufficient to drown out speech amounts to 11% of each day or one day every two weeks for several thousand students. "Sound-conditioning" of classrooms would add about 15% to the cost of construction.[68]

This is clearly a social environmental quality problem of the first order, and projections indicate that it will worsen considerably. Increases in the number of operations or in the noise levels of individual aircraft can greatly expand the area encompassed by the 30 NEF contour--and it is anticipated that the above-mentioned hubs studied by HUD will experience dramatic increases in air traffic operations over the next decade. It is estimated that by 1975, the number of people who will live in high-noise areas around these airports will reach, for example, 312,000 in Los Angeles, 432,600 around O'Hare in Chicago, and 1,747,600 around Kennedy airport in New York.[69]

As the need for airports becomes critical and as local opposition increases, zoning practices will undergo some changes. Airport zoning may be made non-cumulative, with only appropriate industrial development allowed. A more equitable alternative involves comprehensive planning arrangements which allow amortization for nonconforming uses, during which time the landowner can recoup losses and relocate. The best arrangement, where possible, is one in which the airport developer acquires all land within the critical noise contours and develops this land for compatible uses.

A possible development by 1985 is the recognition of federal government liability in aircraft noise cases, with the result that airport

development will be much more difficult in congested areas, since federal grants would require extensive safeguards against noise. The CAB would be inclined to reroute or to drop routes which produced complaints about noise, leaving some communities with heavy investment in an under-used facility. Individual problems might, however, be dealt with more equitably and more effectively through federal complaint machinery than through state and local mechanisms.

Expansion of Existing Facilities

Considerable potential exists for increasing the capacity of both airports and airways. Contributions to increased capacity are possible through construction of additional facilities on existing airports; through improved navigation, ATC, data acquisition, and communications technologies; and through effective airport and regional planning.[70] Expansion of the capabilities of existing airports may quite possibly represent the most beneficial approach both economically and socially in many cases: for example, runway modifications are possible in some locations which could increase airport capacity while simultaneously decreasing size of the high-noise exposure area; and introduction of efficient, high-speed mass transit airport links could reduce ground congestion in the airport vicinity by decreasing dependence on the auto for airport trips.

Many improvements in airport ground facilities, including both air-side and landside systems, will rely on a high level of automation. The capacity of such congested airports as Kennedy International might be increased by 80 percent through modifications in the configuration of runways and reductions in their lateral spacing. With a higher

level of automated control and the resultant reductions in longitudinal spacing, capacity might be increased by 200 percent. Additional capacity could also be developed at existing airports through the establishment of separate STOL runways.[71] The closer spacing of aircraft, uniform approach speeds, and high runway exit speeds involved in these modifications would not be compatible with operation of small, low-performance aircraft, however, and these would tend to be forced out of such airports--or at least barred during rush hours when maximum air traffic handling capacity is required.

Thus, upgrading of existing facilities appears to be a desirable and potentially very fruitful course to follow in serving increased air traffic in the next few years. However, it should be noted that this approach probably cannot meet all needs by itself: projections by the Air Transport Association[72] and the FAA[73] indicate an overall increase in passenger demand of 345 percent in the next 15 years. Some new airports will be needed if this demand is to be satisfied.

Center-City STOLports

The center-city STOLport, located within a mile or two of the heart of a major city, represents a conceptual attempt to reduce the demand and time for ground transport access from existing airports to the central business districts of large urban areas. It is an intriguing technical concept, and appears very attractive at first blush; unfortunately, very serious objections arise on closer consideration.

The center-city STOLport, by giving the heart of the city an advantage in intercity transportation, would tend to have a centralizing effect

on urban land development analogous to that of good railway access; however, the STOLport would serve more as an elite link between business and cultural centers than is characteristic of rail travel. A STOLport would also encourage a relatively homogeneous land-use pattern in the center-city, made up of those activities able to capitalize on the STOLport's presence.

But alas, a paradox arises here: the same factors which generate the demand for a center-city STOLport make it extremely difficult to find an acceptable site for the facility. The costs of land acquisition for the STOLport and for associated renewal projects can range from $4.00 per square foot to several hundred dollars per square foot. Total costs could range up to several hundred million dollars. By the same token, close proximity to large numbers of people serves to increase the impact of all the undesirable features of any airport.

Since the prime justification for placing a STOLport in a center-city location is its supposed advantage in terms of access, it must be noted that the center-city location would not be an unmixed blessing in this regard. Its central location would enable such a facility to share in the benefits accruing from any investment in urban transportation designed to provide improved access to the central metropolitan area, but this is a two-edged sword: since over 70% of resident air travel trips start at home[74] -- largely in suburban areas -- the center-city location could prove to be a net handicap in the absence of excellent radial access. In particular, wherever travel in the center-city is primarily or wholly by automobile, the results of introducing a center-city STOLport are likely to be severe congestion and complete overstraining of parking facilities.

Thus, efficient interfacing of center-city STOLports with area-wide mass transit systems will be virtually essential if access time and facility costs are to be acceptable. A radial area-wide transit system would be highly advantageous for both commuters and air travelers, in that it could serve both dispersed and concentrated origins and destinations. Where city size or density does not justify such a system, however, it is likely that the need for a center-city STOLport would be very questionable because of the absence of a need for high-capacity access to a specific location.

Noise would be one of the critical factors in the siting of a center-city STOLport, since it determines the amount of land that must be controlled to ensure permanent compatibility with future operations. Where natural buffers are not available--and these are generally absent in most center-city locations--land rights may be purchased, in which case the impact may be quantified. To the extent that they are regulated or ignored, the impact must be examined in a more qualitative vein, with consideration of social, legal, and political aspects.

To get a rough measure of the dimension of such noise factors, consider a hypothetical "typical" future STOL aircraft capable of 7.5° approach and departure path inclinations, and using a 2000-foot runway. Such a STOL vehicle generating a noise level of 85 PNdB (perceived noise in decibels) at 1000 feet to the side and 2000 feet from the end of the runway would expose an elliptically shaped sector of approximately 210 acres to a noise level of 85 PNdB or greater.*

*Ambient outdoor noise in an urban residential area in the daytime is 60-70 PNdB; normal conversation is 65-75 PNdB; high-speed automobiles generate 75-85 PNdB.

A rate of operation of two landings or take-offs per minute would produce a noise level of 30 NEF, with about 25 acres of land being exposed to 40 NEF or greater. For the sake of comparison, existing STOL prototypes would expose the same 210-acre parcel to 95 PNdB or greater (40 NEF for the entire 210 acres and 30 NEF for over 1000 acres.)

The 85-PNdB vehicle would probably expose less area to 40 NEF than would be required for operation of the STOLport (40 to 50 acres), even at take-off and landing rates of one aircraft every two minutes, and no additional land acquisitions would be necessary. The 95-PNdB plane, by contrast, would require from 160 to 170 acres of additional land for noise abatement, since all noise-exposed property within the 40-NEF contour would have to be purchased. If land costs were shifted entirely to the passenger, the resultant increase in fare would be roughly .6 cents per passenger mile. Noise considerations are thus of utmost importance in the design of STOL vehicles.

Metropolitan Distributed STOLports (Rim-ports)

The designation of "rim-port" will be used here to mean a STOLport located within a metropolitan area but at a distance of 3 to 10 miles from the central district--that is, on the "rim" of the city proper. The rim-port concept involves placement of two or more such STOLports within a given large metropolitan area, thereby reducing the necessary size of a given rim-port and making STOL air service more accessible over-all for metropolitan residents. Even in those few cities in which center-city STOLports might be desirable, rim-ports could complement the

center-city interurban air service; additionally, they could perhaps help reduce ground congestion at the center-city location by acting as intra-urban aviation terminals.

Access to the central city will be determined by the interaction of land use and transportation in the metropolitan area as a whole. Where land use intensity and/or other public policy considerations require a rapid transit commuter system, joint development might permit the successful interfacing of an outlying air terminal with the commuter rail system. Where access needs are more widely dispersed, a more flexible mode such as the automobile would be required. Rapid rail access will not eliminate reliance on the automobile, but can reduce appreciably the automobile congestion occasioned by a given amount of total air capacity provided a metropolitan area.

A system of rim-ports in a metropolitan area would tend to decentralize residential land uses while reconcentrating commercial and industrial uses around such facilities, especially where public incentives encouraged them to do so. These effects would be especially pronounced where a rapid-transit line diminished the time separation to the central business district. For those cities with an existing or developing suburban-to-center-city rapid-transit system, there would be several advantages to the selection of a rim-port site which could interface with the transit system directly or through the construction of relatively short extensions:

- The transit system would provide rapid, dependable transportation to and from the center city.

- The airport would supply a desirable high damand at the outer extremity of the transit route, and the transit system could be designed to serve as a catalyst for the development of outlying employment centers.
- These centers, in turn, situated in relatively low-density areas, could be sued as the focal point for developing well-planned residential communities which would not have to depend upon the center city for their major economic base or for access to intercity air transportation.

The rim-port also enjoys advantages over the center city STOLport with respect to aircraft noise:

- The noise-exposed land around a rim-port would be relatively undeveloped or developing, compared to the intensely developed situation prevailing around a center-city site, so that there would tend to be fewer people exposed. An exercise of the regulatory powers of the local community might more effectively elicit compatible land-use development than would be feasible in the city center.
- The sharing of air traffic among several rim-ports would favor use of smaller--hence quieter--STOL vehicles than would be required at center-city ports, since a sine qua non for a center-city STOLport would be high capacity. In the same vein, a given metropolitan-wide demand would not necessitate as many daily operations at any given rim-port as at a center-city STOLport. Both of these factors, which of course are not independent, tend to

reduce the size of the noise-affected area of a rim-port below that for a center-city port.

It should be noted, though, that these rim-port advantages in the noise arena may be offset somewhat by the fact that ambient noise levels in outlying areas are generally much lower than in the center city, where traffic movement can produce levels as high as 95 PNdB. Thus, any added noise would tend to be more noticeable in the suburban case.[75]

A further advantage of the rim-port approach lies in the degree of flexibility it provides in trading off STOL vehicle characteristics against runway length, although such tradeoff considerations clearly point to the preferability of STOL over conventional aircraft. The land in the vicinity of a rim-port would be much less costly than that around a center-city STOLport; therefore, converting some additional land into longer runways would be more feasible in the rim-port case, which would reduce direct operating costs for the vehicle. By extending runway length from 2000 to 4000 feet, direct operating costs could be reduced from 1.3 cents to 1.2 cents per seat-mile.[76] For such an increase in runway length, however, an additional 140 acres might be exposed to 95 PNdB or greater (40 NEF or more at peak operating rates) and would thus have to be acquired. At a land value of approximately $3.00 per square foot, the savings in direct operating costs would be offset by the .10 cents per seat mile in increased land expenditures.

Assuming the same situation at the point of destination, the savings and cost will balance at a land value of about $1.50 per square foot. Given the preferred location next to a rapid transit line and the

trends in suburban land values, the shorter runway would be a sounder approach for vehicles with noise emission characteristics similar to those in the example. Thus, STOL capabilities are certainly relevant to the rim-port, but there is clearly more flexibility in the exact vehicle requirements which must be imposed.

The rim-port approach could lead to an exceptionally flexible inter-urban system in which an individual could fly directly to any one of several locations in a metropolitan area. Smaller-capacity aircraft would be required in order to maintain adequate frequency of service--a requirement that is parallel to that for service to smaller, non-metropolitan population centers. In this connection, development of a large number of 30- to 60-passenger vehicles to serve "less dense" areas has been recommended.[77] Several STOLports in one urban area could thus serve several STOLports in another area. Each would draw from a relatively small segment of the metropolitan population, and interfacing with a dommuter rail system could meet demands for access to the center-city. An adequate rim-port system will require two or more facilities located on or near the suburban fringe, adequate inter-facing with an area-wide rapid transit system, and circumferential auto-mobile access.

Policy Implications

The preceding discussion indicates that upgrading and modification of existing airport facilities can be a very fruitful and relevant route in extending aviation capabilities in coming years. However, these efforts will have to be directed toward increasing the efficiency and

capacity of airports by means other than by simple geographic expansion, since major airports are typically encircled to a great extent by urban development. An important related factor will be the need to bring about the improvements in airport functional capabilities in ways which simultaneously help to reduce--or, as an absolute minimum requirement, do not increase--community disturbances associated with airport operations. Meeting all these intertwined challenges will require substantial innovations in aviation technology, guided by and coordinated with system-wide planning which gives full attention to non-technical as well as technical factors.

It is also apparent that STOL aviation systems hold considerable promise for meeting emergent needs in the Short-Haul Interurban travel realm. STOL systems not only can be useful in connection with existing airports (modified to take full advantage of STOL advantages, such as efficient utilization of airspace), but also may justify the introduction of additional pure STOLports in major metropolitan areas. It is important to note, however, that the social utility and feasibility of such a STOL system depends very much on the kind of STOLports which are envisioned, and in this connection that the popular center-city STOLport concept suffers from a great many serious drawbacks. A much more proper focus for STOL system development for the 1985 time frame would appear to be smaller, less sophisticated rim-port installations located some distance from the city center but within the metropolitan area. Such a system appears

to promise an optimum in terms of many factors, including flexibility of system usage; advantages in airport access, urban land development effects, and aircraft noise; and a sufficiently short lead time to help forestall a congestive crisis in short-haul intercity travel.

6. PERTURBATIONS OF THE NATURAL ENVIRONMENT

SUMMARY: The conditions under which aircraft and airports can function with minimum detrimental effect upon the natural environment are reviewed. Since ideal environmental conditions are not attainable in real-world situations requiring tradeoffs among economic, political, demographic, and social factors, several compromise options are offered. These alternatives represent approaches to provide for maximum environmental quality, within the constraints imposed by a highly developed technological society.

Introduction

The discussion below focuses upon the following specific question: How can effective civil aviation systems be planned, implemented, and operated so as to produce minimum detrimental perturbations to the natural environment?

The contributions of aircraft and airports to the deterioration of the natural environment are, at present, minor in comparison to the overall effect of urban and industrial development, the chief agents of environmental degradation. The absolute and relative contribution of civil aviation systems to air pollution may be expected to increase, however, as civil aviation grows and as other sources of pollution diminish.

It is noted that aircraft noise, which is most definitely a social environmental problem, is not discussed here because it is not a natural environmental problem--that is, it has no detectable effect on biological balances or on the physical makeup of our world. It is therefore discussed separately elsewhere in the present report, as an important problem in its own right.

Aircraft

Aircraft produce approximately the same kind of exhaust products as do automobiles: particulate matter, organic hydrocarbons, carbon monoxide, carbon dioxide, and oxides of nitrogen and sulfur. In the presence of sunlight, oxidants develop as a function of the concentrations of hydrocarbons and oxides of nitrogen. It has been amply demonstrated that these primary and secondary products of exhaust emission, at the concentration levels found in urban areas, cause eye irritation and respiratory distress in humans and in domestic animals, soil property, destroy rubber, and damage vegetation.[78] Although current technology can eliminate the visible plume of aircraft exhause smoke, it should be noted that this represents less than 1 percent of the total emission of pollutants by an engine.

The proportional contribution of aircraft to urban air pollution levels is presently quite low (for example, less than 1% of total emissions from fuel consumption in Los Angeles County and in the New York metropolitan area[79]). It must be recognized, however, that:

- As pollution from ground vehicles is more stringently controlled, and as the aviation share of the total transportation market continues to grow, the relative contribution from aircraft will become much higher.
- Aircraft distribute their pollutants in a unique manner: a small fraction is deposited within urban areas, the rest at higher altitudes. As a result, civil aviation eventually could prove capable of producing unique meteorological dis-

turbances for which it would be found clearly accountable.

- The "visibility" of aviation in the social sense makes it unusually vulnerable to retribution for any infractions of which it may be guilty. This social "lightning rod" effect makes it important that civil aviation set an unusually high standard relative to environmental as well as other factors.

SST or other traffic at extreme altitudes may produce corridors of persistent contamination in the stratosphere, where no sources of air pollution now exist. If significant concentrations of ice crystals and carbon dioxide from the exhaust accumulate at this altitude, global climatic conditions could be affected. Turbidity in the atmosphere would increase the earth's reflectivity (albedo), and the amount of solar radiation reaching the earth's surface might decrease enough to cause a drop in the mean temperature of the earth.[80] Data is required concerning long-term environmental consequences of an operational SST.[81]

Airports

With adequate environmental planning, the airport itself can cause minimum damage to the natural environment. To eliminate air stagnation and thermal inversions, a site should be selected with no sheltering barriers and with strong prevailing winds which favor dispersal of air pollutants. The downwind area below an airport should be studied to make certain that airborne pollutants will not aggravate problems of human health or cause damage to vegetation.

Available water supply must be such that the water demands of the airport do not adversely affect human and natural use patterns.[82] The site must be chosen so as not to critically alter drainage patterns. Special measures may be required if the surrounding system is fragile (e.g., The Florida Everglades). "Wilderness" areas should not be selected for airport development, since these are often in a state of delicate ecological balance and are an irreplacable natural resource.

Measures are currently available which can be utilized to minimize damage during implementation of an airport. These include:

- Full tertiary treatment of sewage: bacteriological sterilization, removal of nitrogen and phosphorous compounds, re-use of water, and recharging of the water table.
- Full control of soil erosion and silt transport.
- Retention of natural drainage patterns. This might be facilitated by the development of a permeable runway material, allowing water to drain directly into the underlying substrata.
- Retention, where possible, of existing vegetation. This practice would minimize soil erosion and reduce the damage to an ecosystem which results from the removal of natural habitat.
- Use of pollution-free construction vehicles. Vehicles should be outfitted for maximum suppression of exhaust emissions; alternatively, non-polluting fuels should be employed.

These measures should be continued during the operational phase of an airport. As the airport moves into full operation and water usage increases, water conservation measures and full tertiary treatment of sewage become increasingly important.

A fully isolated airport, containing only aircraft and essential aircraft maintenance facilities, could have a minimum detrimental effect on the natural environment. In such a situation, airport terminal facilities (pasenger and baggage processing) would be located in an urban area, perhaps 30-60 miles distant from the airport proper, and access would be via high-speed mass transport. Such isolated airports may become necessary to achieve minimal ecological damage, and mandatory for regions having a fragile natural ecosystem.

Overall Aviation System Considerations

The goal of minimum damage to the natural environment can be achieved if more emphasis is placed on coordinated long-range planning, and if ecology is given equal consideration with demographic, economic, political, and other social factors. Such an approach is economically as well as ecologically desirable, since remedial measures cost more than preventive measures and are generally less effective as well.

Indications are that neither high-density conditions such as exist in present urban areas nor low-density dispersal of the population into relatively empty lands (which currently contain natural life-supporting ecosystems) is an optimum way of human life. "Nucleation" of human population centers could be the best means of preserving natural ecosystems while simultaneously providing a pleasant and efficient social environment. Such an arrangement involves a clustering of employment and dwelling units into relatively high-density "community clusters," arranged into a larger urban metropolitan complex containing a large proportion of open space.[83] Social services and amenities would be

available within the community, and the chief mode of transportation would be pedestrian. It is possible to envision transportation systems, including both ground and air, as both linking these clusters and fostering their development in ecologically sound locations.

Alternative work-dwelling modes offering minimum ecological perturbation may be developed to provide a variety of life styles from which to choose. These could be planned at the same time so that transportation networks, including both ground and air, would foster their development in ecologically suitable sites. To minimize the detrimental effects of transportation systems upon the environment, the following problems relevant to aviation require attention:

- Determination of the relative ecological effects (on the basis of passenger miles) of air transportation and ground transportation.
- Investigation of the ability of metropolitan rim-ports to foster urban development in ecologically sound patterns, and to connect urban areas to each other and to large regional airports in a manner similar to that presently accomplished by the Interstate Highway System, but with less detrimental environmental impact than that of the Interstate system.

Policy Implications

The most overriding policy consideration which derives from the discussion above is that damage to the natural environment must be prevented, rather than addressed with after-the-fact corrective measures. The truth of this statement can be seen from many viewpoints, including:

- The irreversibility of some types of environmental damage. Many poignant examples of this are available in the biological realm, and growing evidence suggests that these could be mere harbingers of much more catastrophic effects--biological, meterological, and otherwise--which are future possibilities in the absence of foresight.
- Comparative economic costs. Remedial measures are typically disruptive and more expensive than the appropriate preventive measures, and are less effective as well.
- Growing societal sensitivity to environmental quality. Even in those instances in which detrimental environmental effects may be reversed after their occurrence, the period during which environmental disturbances are allowed to persist before correction will be attended by unfavorable social impacts, ranging from irritation and aesthetic disgust to medical problems, depending upon the nature and severity of the environmental problem. And these negative effects on people, once they occur, cannot be erased from the ledger merely by removing the irritant.

7. AIRCRAFT NOISE

SUMMARY: Aircraft noise is at present a serious problem in the vicinity of airports. With the introduction of new types of aircraft, noise problems may occur along air routes as well. Since different solutions will be required, local and en route noise are discussed separately. Particular attention is devoted to the noise source, the path or procedures used in flying or controlling the aircraft, and the affected parties or receivers of the noise.

Introduction

The discussion below focuses upon the following specific question: What factors need to be taken into account in making a coordinated effort to solve the aircraft noise problem, and what are the implications of these factors for future R&D?

Noise from aircraft operations has become, and will continue to be, a critical problem in civil aviation planning. Indeed:

- Unless effective means are found to alleviate the noise problem, public reaction will both retard the introduction of new aviation systems and hamper the operation of existing aircraft and airports. Citizens' groups such as NOISE (National Organization to Insure a Sound-conditioned Environment), Citizens Against Sonic Boom, and Citizens for a Quieter City have already begun to employ tactics such as congressional lobbying, ad hoc protests, and attempts to obtain judicial remedies.
- Even if quieter aviation systems are developed to the point where airport noise as perceived in the nearest population center at peak periods does not exceed the ambient traffic noise, it is likely that the resentment will persist because aviation will

be perceived as a major factor in the generally objectionable level of environmental noise.

- Noticeability, rather than absolute noise level, tends to be the principal factor in objections to aviation noise.

Even though the noise produced by a given aircraft operation may decline, air and ground traffic will increase. Attempts will be made to expand existing center-city airports or use them more intensively. As a result:

- The disparity between benefits conferred on airport users and airport-stimulated businesses on the one hand, and the social costs to the host neighborhood on the other, will make airports a continuing source of dissension and controversy.

Aircraft noise is problematic only to the extent that it affects people and their activities. Noise per se poses no operational problems. Solution to the noise problem can thus be directed toward minimizing the effects as well as the generation of noise, with careful attention to human factors. While no single complete solution to the noise problem is foreseen, many partial solutions can be used in concert for effective noise abatement.[84] In this regard:

- Although noise measurements are of intrinsic interest, they are of less importance than noise standards which relate those measurements to particular activities affected by aircraft noise.
- Technological approaches to noise abatement can be used to render complementary nontechnical approaches less complex and easier to implement.

- If jurisdictional and other conflicts are to be avoided, coordination of all noise abatement efforts at the federal level must be pursued vigorously.

In the following discussion, the problems of local noise (concentrated near airports) and en route noise are addressed separately. Local noise is discussed first, since it is a current and growing problem. Under each noise category, the noise problem is broken down for consideration in what has become a standard manner: noise source, noise path, and noise receiver.

Local Noise: Source

The current effort to reduce the generation of noise by the aircraft engine (the "quiet engine" program) represents the fundamental route toward a solution, since local noise is basically a propulsion problem. However:

- The success of this approach may be limited by the basic physics of thrust generation. There is hope for considerable noise reduction, both through aerodynamic techniques to reduce noise generation and through use of acoustically absorptive materials in the engine nacelle, but these purely technical developments cannot be expected to completely eliminate the generation and propagation of noise.
- To the extent that it becomes technologically possible to significantly reduce noise, however, the technical approach will be the easiest to implement, since it will be within the power of the aviation industry itself to make changes in engine design and construction without external cooperation.

Unfortunately, technical solutions will be expensive. It has been estimated that, for one type of retrofit, the cost of installing quiet engines

with acoustical treatment of the nacelles would lead to a 58 percent increase in direct operating costs.[85]

Federal regulations restricting noise generation from aircraft are an essential part of any noise-reduction program. New conventional aircraft must presently conform with the Federal Aviation Administration's regulation FAR, Part 36, Appendix C, which sets noise standards for the certification of new types of subsonic transport-category aircraft (such as the 747, DC-10, L-1011, and L-500) but does not apply to such existing aircraft as the 707, 727, DC-8, and DC-9, to helicopters, to STOL vehicles, or to supersonic transports. The regulation established a baseline noise level of 108 EPNdB which must not be exceeded at three measuring points: approach (noise level measured at 1 nautical mile from the landing threshhold); take-off (noise level measured at 3.5 nautical miles from the start of take-off roll); and sideline (noise level measured at 0.35 nautical miles to the side of the extended center line of the runway for four-engine planes and at 0.25 nautical miles to the side of the runway for two- and three-engine planes). Tradeoffs are permitted among three measuring points, with extremes set at 111, 110, and 103 EPNdB for four-engine planes and 110, 109, and 105 EPNdB for two- and three-engine planes. These standards represent a compromise between what is desirable and what is technologically and economically feasible at present. Regulations affecting the SST and STOL aircraft are expected to be announced in the near future.

The costs of coping with the noise problem at the source can be borne by the public (in the form of taxes or borrowing) or by the civil aviation industry.

- By raising fares, the industry could shift all or part of the cost of noise abatement back to that part of the public which utilizes air services.
- Public acceptance of such increases will depend upon a number of factors, the most important of which is the availability of substitutes for air travel.

One nontechnical approach which has been suggested would involve the adjusting of flight schedules to reduce noise generation at certain times of the day. Scheduling would have to be based on subjective criteria, however, and as demand for air travel increases, schedules will become too crowded to permit such adjustments.

Local Noise: Path

The number of people affected by aircraft noise depends upon the take-off and landing profiles. Research is being conducted to develop improved operational techniques which will permit take-off and approach paths to be adjusted so as to allow safe operation of aircraft with minimum noise footprints. The introduction of V/STOL aircraft will permit the use of a steeper access path, thereby reducing perceived noise on the ground. Selection of directions for approach and take-off with the goal of minimizing the noise effect upon communities (such as the Potomac River flight path for Washington National Airport) will continue to be useful where the topography allows.

Local Noise: Receiver

A noise problem can be alleviated without altering the noise source or noise path by introducing changes which modify the effects of noise on people. Technical solutions in this connection involve the insulation

of affected parties from the noise. Ground-level noise within the airport area can be contained through the use of acoustic wall or buffer zones of trees surrounding runways, and through the use of portable noise suppressors during engine run-up testing. Ground noise constitutes a relatively small part of the noise generated by aircraft, however, and its containment represents only a partial solution. Sound insulation of buildings in the vulnerable areas surrounding airports would be beneficial to the extent that the affected parties remain indoors.

One of the most promising approaches to the aircraft noise problem involves the application of land-use planning and control to maintain compatibility between the airport and its neighbors. For maximum flexibility, all of the land within the area of impact surrounding the airport should be acquired outright, as was done at the Dallas-Fort Worth International Airport. Purchase of adjacent land is likely to be prohibitively expensive in developed areas, however, unless some form of redevelopment-recoupment is employed. Serious relocation problems will be associated with the acquisition of residential land, and it is likely that ownership of parcels in intensely developed areas will be severely fragmented, leading to long delays in the process of negotiation for purchase. Sites in lightly developed fringe areas would obviously be preferable from the standpoint of land acquisition.

As an alternative to outright purchase, easements might be obtained which allow flights over the land in question. Easements would not solve the noise problem, but would eliminate some of the complaints.

Regulation of land use can be employed to ensure compatibility in those cases in which the land is not acquired. The major advantage of regulation over acquisition is that, as long as the regulation is applied in the interest of the public health, safety, and welfare, no compensation need be paid to the property owners affected. Zoning of the noise impact area for industrial use only will ensure that all future land use will be compatible with the noise resulting from airport operation. However, in those cases in which residential or other "non-conforming" uses already exist within the area of concern, an extensive period of use amortization (10-15 years) must be provided. During this time the airport is responsible to the property owner and must not operate the facility in such a way as to unreasonably restrict the use of the property. Where an airport is already in operation (or soon to be in operation), the existence of such incompatible uses can be a major impediment to efficient operation. If an airport is planned for some future time, prior rezoning may allow the amortization of "non-conforming" uses before the airport becomes operational. It is also an attractive alternative when incompatible uses of developed land are nonexistent or small in number (such as in industrial areas, railroad yards, etc.). Zoning and rezoning are essentially political processes and often end up being resolved in the courts. Therefore, practically speaking, zoning

may not be a permanent means of maintaining compatible land use, since it is subject to administrative adjustments.

If acquisition or regulation is not employed in land-use control, various inducements can be used to ensure compatible land use without compulsion. The control of taxing and spending, capital improvements, and bonus provisions may be coupled with the selective granting or withholding of loans and guarantees to promote the development of compatible land uses. Such policy is most effective in marginal areas where noise impact is minor.

Since the area affected by airport operations rarely lies within a single jurisdiction, comprehensive land-use planning may require new institutional organization (e.g., intergovernmental units to ensure integrated planning). The federal government may be able to provide assistance in this regard by setting stringent criteria for federally supported development in the vicinity of airports. FHA mortgage insurance, HUD's 701 program, regional development grants, and the Model Cities programs, as well as the administration of the Surplus Property Act, the Federal Property and Administrative Services Act, the Federal Military Facilities Act, the Public Airport Leasing Acts, and the Airport and Airways Development Act Trust Fund, can be used to promote and compel compatible land use near airports.

En Route Noise: Source

Two distinct types of en route noise may become highly significant in the not too distant future: the "sonic boom" created by high-flying

supersonic aircraft, and propulsive noise attendant to very-low-flying short-range aircraft such as STOL and VTOL.

The sonic boom has been the subject of much concern. Technical possibilities exist for lessening the problem, but complete elimination of the boom does not appear to be feasible except for transonic cruise speeds only a trifle above Mach 1.

It is not certain that noise from low-flying aircraft will prove to be a significant problem, since the noise reaching the ground from an aircraft flying at several thousand feet with a "cruise" power setting cannot fail to be a great deal less than that of the same aircraft close to the ground with maximum power. The engine modifications discussed earlier should reduce perceived en route noise to an even lower level. However, frequent overflights in rural areas might be irritating to residents unaccustomed to such intrusions, despite the relatively low noise level. It would be unsafe, therefore, not to give serious attention to possible en route noise problems relative to new short-range STOL and VTOL civil aviation systems.

En Route Noise: Path

The lack of technical solutions to the sonic boom problem has led to various proposals for nontechnical solutions, the prime example of which is the Federal regulation that supersonic flights will be restricted to paths over water. For short-range, low-altitude operations, however, changes in flight path would probably have little effect in reducing the total number of people exposed to a given noise level.

En Route Noise: Receiver

The problem of en route noise does not appear to be amenable to solution by any approach which attempts to reduce the impact of aircraft noise on the receiver:

- Sound treatment of residences along the flight path would be impracticable or of dubious usefulness.
- Since numerous jurisdictions are involved, no meaningful land-use planning appears possible at the local level.
- Nationwide modification of land-use patterns to accommodate air travel corridor patterns is unreasonable.
- The compensation of affected individuals for noise damage along thousands of miles of air routes would, in all probability, be prohibitively expensive.
- The only viable nontechnical solution to the problem of noise from low-flying aircraft would be to ban flights over populated areas. To the extent that STOL vehicles were to be used for short-range operation in relatively high-density areas, this approach would in effect preclude the use of such vehicles.

Policy Implications and Alternatives

There is no single solution to the noise problem, but rather an array of partial solutions of varying impact. The critical nature of noise as a problem makes it imperative that policy in this area be directed toward achieving the mix of solutions which most effectively deals with the problem. Current solutions may become inadequate as social values and tolerance of intrusions such as noise change with time.

Possible approaches to the aircraft noise problem are outlined in Table 10. The quiet engine and nacelle treatment programs are of vital importance. If significant noise reduction can be achieved at the source, path adjustments and alteration of the effect of the noise will require less comprehensive (and less expensive) efforts. Federal noise standards are an absolute necessity to compel the application of new noise reduction technologies. Research in other technical aspects of noise abatement can minimize the need for highly complex and extensive nontechnical solutions. Noise minimization by adjustment of flight profiles, methods of ground-level noise containment, and building insulation techniques are useful and necessary elements in a proper mix of solutions.

No technical solution or combination of technical solutions appear to be capable of completely eliminating the noise problem. Therefore:

- It will be essential that nontechnical approaches accompany the technical advances. The need for such a coordinated effort was pointed out in the 1966 report of the Jet Aircraft Noise Panel of the Office of Science and Technology.[86]
- The task will not be easy. Current practice places responsibility for some of the solutions in the hands of the federal government, while local governments, airport operators, aircraft manufacturers, or airlines are responsible for others. The federal government can set noise standards, for example, but does not establish building codes or land-use patterns near airports.

- Because of the highly fragmented responsibility for the implementation of abatement techniques, it would appear that, unless the federal government takes the lead in coordinating the noise abatement effort, only partial or ineffective solutions will result.

TABLE 10: NOISE

PROBLEM AREA	SOLUTION AREA	POSSIBLE SOLUTION	TECH-NICAL	NON-TECH-NICAL	RELEVANT R&D AREAS (EXAMPLES)
LOCAL NOISE (Airport vicinity)	SOURCE	1. REDUCTION OF NOISE GENERATION	X		REDUCTION/MODIFICATION OF PROPULSIVE NOISE PRODUCTION --Aerodynamics of noise production --Alteration of noise spectrum --Tradeoff studies of propulsor performance vs. noise
		2. ACOUSTICAL TREATMENT OF ENGINES	X		ACOUSTICAL TREATMENT OF ENGINE NACELLES
		3. ALTERNATION OF FLIGHT SCHEDULES		X	
	PATH	4. MODIFICATION OF TAKEOFF AND LANDING PATH	X	X	NOISE MINIMIZATION FLIGHT PROFILE STUDIES --Airport related measures such as runway orientation, non-linear approach paths, etc. --Vehicle/propulsion performance studies - role of V/STOL
	RECEIVER	5. CONTAINMENT OF NOISE IN AIRPORT	X		METHODS OF GROUND-LEVEL NOISE CONTAINMENT --Acoustic walls, noise buffers
		6. SOUNDPROOFING OF SURROUNDING BUILDINGS	X		METHODS OF BUILDING INSULATION
		7. LAND USE CONTROL - ACQUISITION - REGULATION - INCENTIVES		X	METHODS OF LAND USE CONTROL --Cost and effectiveness of various methods --Relation of noise measurement and noise standards

TABLE 10: NOISE (Cont'd)

PROBLEM AREA	SOLUTION AREA	POSSIBLE SOLUTION	TECH-NICAL	NON-TECH-NICAL	RELEVANT R&D AREAS (EXAMPLES)
EN ROUTE NOISE	SOURCE	8. REDUCTION OF NOISE GENERATION	X		SONIC BOOM REDUCTION (HIGH ALTITUDE SUPERSONIC) --Airframe aerodynamics --Boom attenuation techniques ENGINE NOISE REDUCTION (LOW ALTITUDE SUBSONIC) --Determination of overall airframe/propulsion design constraints
	PATH	9. RESTRICTION OF FLIGHT TO NON-POPULOUS AREAS		X	INVESTIGATION OF SENSITIVITY LEVELS OF NON-URBAN RESIDENTS
		10. AVOIDANCE OF LOW ALTITUDE FLIGHT PATHS	X	X	ANALYSIS OF DESIRABILITY OF LOW ALTITUDE MISSION PROFILE
	RECEIVER	NO PRACTICAL SOLUTIONS IDENTIFIED			

8. BEHAVIORAL AND SOCIOLOGICAL FACTORS

SUMMARY: An analysis is presented of various attitudinal factors which influence decisions to travel by air or to use other means of transportation. The effects of attitude changes on demand for air travel are noted. Behavioral factors that will influence the development of private general aviation are outlined. The benefits of commercial aviation are considered in relation to the psychological and sociological costs, and behavioral measurement tools are discussed which can aid the decision-maker in designing civil aviation policies to achieve maximum social benefit.

Introduction

The discussion below focuses upon the following specific question: What behavioral, psychological, and sociological factors need to be taken into account in planning future civil aviation systems?

Effective travel demand is a function of the interaction of at least three general variables: the desire or need to travel, the technological capability for safely reaching a destination in an acceptable period of time and with reasonable convenience and comfort, and the ability to pay for such transportation. Thus, aviation, in satisfying important travel needs by providing exceptional technological capabilities at competitive prices, has succeeded in capturing an ever-increasing share of the total passenger travel market.

It has been estimated that air travel will reach a level of over one-half million passesnger-trips per year in the United States and over one billion passenger-trips world-wide by 1980.[87] Such predictions are based on projections of increasing income, travel opportunities, leisure time, dispersal of families and business activity, and information about remote places.

Improvement of the attitude toward flying among even a small portion of the eligible population will result in an increased demand for air travel and will improve the economic viability of civil aviation. Although comfort and perceived utility of aviation are likely to increase with flying experience, this self-enhancing process will probably require improved service (scheduling, comfort, speed) and well-planned and comprehensive educational programs, both formal and informal.

Shortened Perceived Distances and Time

A major incentive of air travel is its capacity to shorten perceived distances and time. Most individuals have "temporal budgets" which establish his limits on acceptable travel time. Acceptable commuting time, for example, may range from 15 minutes to one hour, but is seldom longer.[88]

Acceptance of Flying

Despite the tremendous growth of civil aviation since World War II, a relatively small portion of the U.S. population makes use of aviation on a truly regular basis. Of the 20 percent of the total population which has flown during the past 12 months, 2 percent have made 24 or more flights, 44 percent 3-24 flights, and 54 percent one or two flights.[89]

Key elements affecting the consumer's choice of transportation mode include safety, reliability, time savings, cost, convenience, and comfort.[90]

Safety

Safety is a basic factor in the choice of transportation mode,

although few people mention this unless asked. A market research study on both air travelers and non-air travelers for major airlines indicates that fear is a widespread psychological deterrent, danger being the second most frequent of all impediments cited by air travelers.[91] Fear of flight decreases, however, with flying experience. Since studies also indicate that 84 percent of teenagers have positive feelings toward flying (as compared to 66 percent of the adult population), a self-generating increase in flying would appear likely in the future.[92]

Consumer evaluation of air travel safety is quite subjective. Statistics establish conclusively that air travel is safer on a passenger-mile basis than the automobile, but the dramatic visibility of aviation accidents more than offsets this fact for many people. At the present fatality rates, 5,250 passengers will lose their lives in air accidents during the period 1970-1980, while 650,000 lives will be lost in the United States in motor vehicle accidents for the same 10-year period.[93] The latter statistic, appalling as it is, will make little practical impression on most automobile riders--yet the publicity surrounding a single air crash is sufficient to deter many people from ever boarding a plane.

Perceived safety can be influenced by such reassuring factors as the pilot's confident, businesslike tone in talking to passengers and the presence of human stewardesses rather than vending machines.[94] Awareness of protection from criminal acts or antisocial behavior is also important.

Reliability, Time-Savings, and Convenience

Since most airline passengers have access to auto travel, expectations for air service tend to be set according to the standards for private auto travel. Tolerance for poor reliability, delays, or transfers is quite low. The consumer naturally views a trip involving air travel as the total sequence of events which start and end at his front door. If he discovers that the inconvenience of the ground segments of the trip outweighs the time saved in flight, he will seek some other form of travel.

Costs

Costs and perceived costs are essential items if a major portion of the population is to have real access to the air transportation system. In a recent study, 20 percent of the air travelers sampled listed expense as the major disadvantage of flying. The image of the air transportation system may need some alteration to attract some potential consumer groups which may have falsely believed air travel to be beyond their means.

Behavioral Factors in the Development of Private General Aviation

In 1969 the Federal Aviation Administration reported approximately 130,00 private aircraft and 550,000 licensed pilots in the United States. Projections indicate 200,000 aircraft and 850,000 polots by 1979, and an increase for general aviation from 24.1 million hours in 1968 to 40.9 million hours in 1979.[95] FAA data also show that pleasure flying accounted for the greatest number of flying hours in private planes in 1967 and 1968,[96] which indicates among other things that the private

plane is serving human needs which are by no means rooted completely in economic considerations.

Private transportation is held in higher esteem than public transportation by most people since it provides greater mobility, privacy, and personal control for the traveler. These are very important factors in the present-day dominance of auto transportation, and they are certain to be of great importance in the future growth of general aviation.

A significant increase in private general aviation seems likely during the 1985-1995 time period. A number of educational, licensing, and control measures may be required to prevent increasing collision and crash rates, including:

- Air safety education.
- Vocational training in private craft maintenance and air traffic control.
- Pilot pre-flight training for older adolescents and adults.
- Continuing re-education programs for private pilots and support crews.

Critics of private aviation consider the present regulation and control practices clearly unsatisfactory. Improvements are needed at all levels of the system to ensure safe operation.[97] These should include:

- More stringent licensing requirements.
- Screening to detect operators with physical or psychological defects.[98]

- Inspection systems to monitor private pilots and craft prior to take-off.
- Improved air traffic control systems for small planes.
- Equitable allocation of airport facilities to accomodate small craft without infringing on the operation of commercial craft.
- Adequate supply of support personnel.
- Improved collision-avoidance systems for small aircraft.
- Higher standards for rescue services and firefighting equipment at small airports.

Psychological and Sociological Benefits and Costs of Aviation Systems

Since airports and new kinds of aircraft are highly visible, civil aviation can easily become a core around which social discontents of many kinds can accumulate and multiply. Indeed:

- Civil aviation, as an advanced, tangible, highly visible technological activity, tends to exhibit a "lightening rod" effect, drawing more than its share of societal protest and anger.

Factors which may either moderate or reinforce this effect include:

- The degree to which unwanted side-effects are balanced by benefits.
- The extent to which interested groups are consulted prior to implementation, and whether or not they perceive their participation as having any real effect on new systems.
- The extent to which press coverage makes the aviation issue salient and presents a balanced view of results and alternatives.

A favorable balance between perceived utility and personal stress is essential for acceptance of any given system. In the absence of such a balance, affected individuals will voice strong opposition to changes in existing systems or the introduction of new systems, frequently with some degree of success.

Public participation in the decision-making process can be a powerful factor in support of, or in opposition to, the development of new or expanded civil aviation systems. In general, a facility such as an airport which has been directly approved by the community will tend to cause less annoyance than one constructed in opposition to the desires of significant groups of the population. Similarly, employee morale can be affected positively if decisions concerning a facility in which people work are based on processes in which these people have participated. The absence of participation may also be a factor in increasing crime and vandalism at a new airport on the part of those whose lack of involvement in the original decision leads them to resent its presence.

Psychological Effects of Noise

Noise is a particularly significant element in public opposition to civil aviation systems, especially among those who live in close proximity to airports:

> The often-used term aircraft noise is seldom defined, but essentially it refers to complaints. If anything has been learned from the exhaustive studies made of noise complaints it is that--no matter how much the noise level is reduced--there will remain an ineradicable hard-core group of complainants. Both British and American studies indicate that this constant hard-core group of complainants constitutes about 30 percent of the population near airports.[99]

Any substantial variation from the established level or character of

background sound attracts attention and becomes perceived noise. Strong community reactions can be triggered, particularly when the noise level is sufficient to cause physical discomfort or persistent annoyance.

No single "tolerable" noise level can be identified in isolation from the conditions under which the noise is heard. To define reasonable or acceptable noise, four kinds of factors must be considered:

- Noise characteristics (absolute decibel level, intensity, frequency, duration, and intermittence).
- Conditions under which the noise is dispersed (temperature, humidity, physical environment, type of source).
- Individual background of those affected (experience with noise of a particular type, sensory adaptation to noise).
- Utility or disutility of the noise source to the hearer (e.g., source of employment versus perceived safety threat), and social conditions (such as control over the intrusion of noise and background social tensions).

The variables employed in a large proportion of the noise research to date deal with absolute limits, either physiological damage or estimates of intolerable PNdB (perceived noise in decibels) levels. For instance, a pure tone of 85 decibels for several hours a day over a long period is known to produce hearing loss; the same is true of mixed tones. In other words, there is a critical frequency range within which exposure of 85 db under the same time conditions produces irreversible physiological damage.[100] To protect a worker from hearing loss during an 8-hour working day, the American Standards Association has suggested an 85-db limit for any frequency above 700 cycles per second.[101]

Perceived noise, however, involves psychological reactions which operate throughout the audible sound spectrum and at all amplitude levels. From a practical standpoint, many of these "noise" reactions are more significant in ranges will below extreme physical or sensory tolerance levels (e.g., those associated with permanent hearing loss).

Since the general perceived-noise environment varies considerably from community to community, evaluations of tolerance for noise are difficult to generalize. Tolerance levels differ not only with location (e.g., central city vs. suburban) but also with social conditions. Indications of this fact were clear in the 1960's. A 5-point community reaction scale has been developed and is currently in use by the Air Force, based on the following critical variables: a) level of loudness and frequency, b) intermittence, c) day vs. night noise, d) socioeconomic level (measured by income), and e) experience with noise. The index correlates with the overt complainers in the community. It has been found, furthermore, that complainers tend to form groups in which three characteristics are critical: leadership, knowledge about how to complain effectively, and expectations of effectiveness in influencing decision-making.[102]

Population Distribution: Residence and Work Options

Although good transportation is not a sufficient condition for the development of new towns (and therefore for population redistribution), it is a necessary one:

> Technological development does change life-styles. People travel much more than they used to. Many now need to fly:

> invention becomes the mother of necessity. Transportation technology made possible heavy concentrated urbanization; changing technology made suburban dispersal possible.[103]

Just under two-thirds of the U.S. population now lives within Standard Metropolitan Statistical Areas.[104] This concentration in large cities is one of the most serious causes of deterioration in the quality of American life. The recently released White House National Goals Research Staff report indicates, in fact, that "the crisis of population growth lies more in the distribution of people than in sheer numbers..."[105]

The automobile and the airplane have made this intense urbanization possible, but the process is complex and includes the interaction of behavioral and socioeconomic factors such as territorial needs and demand for goods and services. Particularly since World War II, territorial needs have been impelling metropolitan residents outward from urbanized areas, while expanding demands for goods and services have kept people from going too far away from the facilities available only in the city. During this same period, employment opportunities and desire for the goods and services available in metropolitan areas have attracted rural residents toward the city. The result has been continual metropolitan growth, but within limits set by relatively fixed acceptable limits for commuting time and distance.

In planning for optimum population distribution, it is impossible to determine from which specific congested communities people will leave. What <u>can</u> be planned are new focal points for development which will be attractive enough to draw people. The most significant motivating factors appear to be attractive employment opportunities relative to living costs, environments which can satisfy territorial needs, availability of a wide

range of goods and services, and access to a large metropolitan area. Therefore:

- A well-developed short-haul aviation system connecting small and new towns with each other and with major cities would be highly beneficial in creating such an environment.
- Such a system would also benefit the city dweller by allowing him to leave the city for recreational purposes without being exposed to the frustrations associated with congested highways.
- New short-haul interurban systems could thus provide increased degrees of freedom for both the public (in mobility options) and policy-makers (for population distribution).

Manpower and Training Considerations

Aviation is one of the outstanding industries in providing well-paying, high-status blue-collar jobs. Although at the present time the major airlines are not experiencing difficulty in recruiting ground crews and pilots, continually increasing manpower demands have been projected for the next decades. Civil aviation may tend to drain the most intelligent and responsible blue-collar workers, who will be attracted by the high financial rewards for zero-error maintenance increasingly demanded by aviation, even to the point of creating possible shortages in other industries.

Although many aviation functions may be automated by the 1985-1995 period (ranging from air traffic control for some STOL systems to airport food services), the need for sharply increased numbers of pilots and ground crews is likely to persist. Social and political pressures may mount for making the desirable blue-collar jobs in aviation available

to large numbers of semi-skilled workers, who are likely to need considerable training. However, aviation-related subjects will be firmly embedded in secondary school vocational curricula by 1985, raising expectations of employment among those who do not anticipate a college education.[106]

Policy Implications

Whether one considers user benefits, the effects on non-users, manpower and training requirements, or such macroscopic factors as regional development and national population distribution, one finds important social behavioral forces at work as regards the social impacts of civil aviation. Both the benefits--e.g. time savings and generally improved mobility--and the disbenefits--e.g., aircraft noise--which are associated with aviation are dependent to a considerable degree on human perceptions, attitudes, and many other psychological factors, rather than being rigidly determined by cut-and-dried physical and economic relationships. The failure to consider such factors adequately can thus thwart research, development, and planning which may otherwise be seemingly well-conceived; conversely, the careful inclusion of these factors may afford additional degrees of freedom which could enable the solving of developmental problems which may otherwise seem insurmountable.

9. INTERNATIONAL ASPECTS OF CIVIL AVIATION

SUMMARY: Developments and possible trends in the world-wide aircraft and air transport industries are reviewed for the period 1970-1995, and the problems and opportunities which will face the United States in maintaining its international status in these industries are analyzed. It is concluded that, given the need for reciprocity between nations in regard to landing privileges, and given the propensity of American citizens to travel abroad, there is little that the United States can do to strengthen further its already commanding position as a supplier of air transport services. However, the role of the United States as a producer of civilian aircraft for world markets may be enlarged through the development of aircraft capable of providing the quality of service needed, but not currently available in the United States and abroad. Short-haul technology has experienced few of the gains that have come to long- and medium-haul traffic, and thus represents a principal area for desirable change. Short-haul service should be improved to meet standards of comfort and confidence equivalent to those for large jets.

Introduction

The discussion of international considerations focuses upon the following specific question: What problems and opportunities may the United States expect in maintaining its place in the world aircraft and air transport industries, and how should these problems and opportunities influence R&D priorities?

The 1960's were a period of very rapid growth in air transportation. worldwide passenger miles in scheduled flights increased at an annual rate of 14 percent between 1960 and 1969, the number of passengers by 12 percent, and the average trip length by about 20 percent. Passengers per aircraft increased from an average of 35 in 1960 to 53 in 1969, and average flight speed rose from 224 to 351 miles per hour. Sixty-five percent of the absolute increase was accounted for by American carriers, three quarters of the

U. S. increase being in domestic travel. The data exclude the U.S.S.R. and mainland China, since no historical data are available for these countries. Clearly, however, the U.S.S.R. is now second only to the United States in air transportation: Aeroflot reported carrying 60.8 million passengers in 1968 and estimates 75 million for 1970.[107] For comparison, scheduled U.S. airlines carried 150 million passengers in 1968 and the airlines of all of the European International Civil Aviation Organization member countries carried 52 million passengers.

The growth patterns established during the 1960's will persist for a few years, although at a decelerating pace. New equipment delivered to the airlines of the developed countries will displace some older equipment, which will be sold to the less developed countries in what has become a classic pattern. Worldwide capacity will continue to increase and may be excessive for a short period, although passenger traffic will undoubtedly rise. However, an indefinite continuation of the 14 percent annual increase in passenger traffic is clearly a virtual impossibility, and the rate of growth will therefore decrease eventually. A continuation of rapid growth in air traffic will therefore rest upon the provision of air services--principally short-haul domestic--which have not grown rapidly in recent years and which will require equipment not now available.

The 1960's witnessed a substantial diversion of travel from other modes to long-range jets and a considerable upsurge in business and leisure travel, reflecting increased international contacts and generally

higher levels of economic activity accompanied by growing disposable income. Further growth of air travel will occur as larger-capacity, low-operating-cost aircraft become available and as more modern equipment replaces obsolescent aircraft operating domestically in many areas. The availability of such equipment will be an important factor in determining increases in air transportation over this period.

American International Travel and the U.S. Balance of Payments

American citizens constitute the world's largest group of international air travelers. Excluding land travel to Canada and Mexico, approximately 98 percent of travel between the United States and foreign countries is by air.

Entry of American flag carriers into foreign countries is controlled by agreements of the governments involved. Eleven American flag carriers have some international ports, although four account for most of the traffic. The United States has bilateral landing agreements with 67 countries, and unilateral grants of operating authority with others. Such reciprocity agreements permit 19 foreign flag carriers to compete with American operators in international traffic from the United States, most of them on the important North Atlantic route.[108]

Despite such competition, the share of the world's international passenger traffic carried by American scheduled airlines moved from a low of 37 percent in 1961 to a high of 42.8 percent in 1969. Preliminary estimates indicate that in 1969, Americans traveling abroad by air paid $860 million for passage on American carriers, but they also suggest

why the United States has experienced an increasingly unfavorable balance between receipts and payments for international air transportation (from a deficit of $150 million in 1960 to one of $272 million in 1968). Given the propensity and freedom of Americans to travel abroad, the deficit would have been much larger had American carriers competed less successfully for the overseas traveler's business (See Table 11).

American Aircraft in Foreign Markets

Overseas markets are of critical importance to the nation's aircraft industry. Foreign purchases of new civilian aircraft contribute substantially to the nation's international trade. A deterioration of that contribution would have a serious impact on the nation's balance of payments position.

With the introduction of the DC-3 in 1936, American-made aircraft established a firm position in world markets. That position was greatly strengthened by the large quantity of DC-3's produced for use during World War II. More DC-3's have been utilized by airlines in the United States and abroad than any other single type of aircraft. The DC-4 met with similar success, although on a lesser scale. Some DC-3's and DC-4's remained in use in the United States in 1968, and they still constitute more than 10 percent of the world's commercial aircraft fleets.

In 1958, 83 percent of the aircraft in operation on world civil airlines -- (excluding the Soviet bloc and China) were of American manufacture. That proportion has subsequently declined but, owing to

TABLE 11

UNITED STATES RECEIPTS AND PAYMENTS FOR INTERNATIONAL AIR TRANSPORTATION, 1947 TO 1969

(IN MILLIONS OF DOLLARS)

ITEM	1947	1950	1955	1960	1964	1965	1966	1967	1968	1969
Receipts										
Air transportation	85	108	183	358	484	572	653	820	907	1058
Export freight earnings	12	17	33	55	63	91	112	126	127	160
Passenger fares	63	68	97	156	231	262	307	363	405	441
Port expenditures	10	23	53	147	190	219	234	331	375	457
Payments										
Air transportation	70	106	183	504	651	775	896	1020	1136	1384
Import freight earnings	1	2	7	22	26	40	47	58	78	127
Passenger fares	9	26	68	301	430	510	555	635	695	850
Port expenditures	60	78	108	181	195	225	294	327	367	407
Net Payments	-15	-2	0	146	167	260	314	203	305	477

Sources: Statistical Abstract, 1969, p. 574.
Survey of Current Business, July 1970, p. 55.

the worldwide popularity of American-made jets, has remained at about 73 percent since 1963.

Foreign purchases of the civilian products of the United States aerospace industry -- aircraft, engines, parts, and accessories -- accounted for 37.6 percent of that industry's sales over the period 1958-1969 (Table 12).

Indications are that this distribution between domestic and foreign sales will continue over the next few years. Large commercial jet transports have accounted for nearly 90 percent of foreign aircraft sales in recent years (Table 13), even though sales of general aviation aircraft have been growing in number and in value.

Sales for export have been a vital factor in the economics of the U.S. civilian aircraft industry. Export opportunities are of particular importance in relation to a new aircraft intended for a use for which the demand appears to be limited, at least in the early stages. In the case of a new aircraft, it is essential that the producing firms have sufficient orders so that the price quoted to a buyer may reflect the amortization of development and start-up costs over a substantial number of aircraft. Offering potential buyers the most attractive possible prices can be accomplished only by accepting orders predicated on an aggregate closely approximating the volume of production on which price quotations were based (excluding the possibility of government subsidies).

TABLE 12

AEROSPACE INDUSTRY----TOTAL SALES AND EXPORTS OF CIVILIAN PRODUCTS

(IN MILLIONS OF DOLLARS)

Exports of Civilian Products	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Total Nongovernmental Sales	1372	1841	2208	1876	1772	1485	2020	2816	3663	4632	6763	5064
Total Civilian Exports	603.2	502.4	1088.7	878.0	909.8	731.9	763.8	854.5	1035.1	1380.5	2228.8	1948.2
Percent Civilian Exports of Total Nongovernmental Sales	44.0	27.3	49.3	46.8	51.3	49.3	37.8	30.3	28.2	29.8	33.0	38.5
Complete Aircraft	204.7	152.8	537.1	334.5	327.8	244.1	287.1	477.2	552.4	789.3	1405.4	1236.3
Transports	147.2	107.6	480.1	262.5	259.2	190.9	211.1	352.8	420.8	611.4	1200.2	939.9
Other	57.5	45.2	57.0	72.0	68.6	53.2	76.0	124.4	131.6	177.9	205.2	296.4
Engines, New and Used	48.3	43.7	70.7	75.3	63.0	45.1	46.7	56.2	77.0	101.2	115.7	101.8
Parts, Accessories, and Equipment	350.6	205.9	480.9	467.9	519.0	442.7	430.0	321.1	405.7	490.0	707.7	610.1

Source: Aerospace Industries Association of America, Inc., 1969 Aerospace Facts and Figures, (Fallbrook, California, 1970), pp. 9, 70.

TABLE 13
U.S. CIVILIAN AIRCRAFT EXPORTS BY TYPE

(VALUE IN MILLIONS OF DOLLARS)

	Commercial Transports				General Aviation Aircraft*	
	33,000 Pounds and Over Frame Weight		33,000 Pounds and Under Frame Weight			
	Number	Value	Number	Value	Number	Value
1958	83	$ 138	45	$91	986	$ 12
1959	39	104	26	40	1,033	13
1960	92	464	67	16	1,528	24
1961	51	251	68	11	1,646	27
1962	50	245	122	14	1,458	23
1963	30	179	151	18	1,583	27
1964	32	182	193	29	1,834	33
1965	60	347	16	5	2,457	69
1966	76	421	6	**	2,985	89
1967	121	607	13	4	3,125	91
1968	221	1,190	19	10	2,879	101

Source: Aerospace Industries Association of America, Aerospace Facts and Figures, (1969), pp. 72,73.

* 1965-68 -- All airframe weights. Prior to 1965 includes only airframe weights of less than 3,000 pounds.

** Less than $100,000.

The Contribution of American Aircraft to the U.S. Balance of Payments

Since 1958, American-made civilian aircraft, parts, and accessories have made up from three to more than six percent of total exports of U.S. merchandise (Table 14). In 1968 such exports were approximately equal in value to exports of electrical apparatus (including computers) and more than twice the value of wheat exports. Imports of aircraft and parts have averaged about 10 percent of exports since 1960. The aerospace industry has thus been contributing over $1.5 billion annually toward a favorable trade balance. This contribution should continue for some years, depending upon the success of other countries in meeting the needs of the world's airlines for aircraft and the point at which the demand for jet transports becomes saturated. At such a time, the demand for American-made general aircraft and for replacement parts of current types of commercial aircraft would provide exports that might stabilize for some years at 20 to 30 percent of present levels.

Aircraft Needs in the Near Future

Two particularly acute questions are currently before the aircraft industry: 1) What will be the nature of the principal types of aircraft that will be needed by the airlines in the foreseeable future? and 2) Who will build them?

The organization that acts upon its interpretation of the types of aircraft desired by the world's airlines faces a risk: its decision is verifiable only after it has placed its product on the market. It may find that its product, though generally suitable, is inferior to another product built somewhat later and with the knowledge gained from the pioneer's efforts.

TABLE 14
TOTAL U.S. EXPORTS AND EXPORTS OF CIVILIAN PRODUCTS OF U.S. AEROSPACE INDUSTRY

(In Millions of Dollars)

	Total Exports of U.S. Merchandise	Civil Aerospace Merchandise Exports	Percent Civil Aerospace of Total U.S. Merchandise Exports
1958	17,745	685	3.9
1959	17,461	538	3.1
1960	20,383	1,089	5.3
1961	20,754	878	4.2
1962	20,431	910	4.4
1963	23,062	732	3.2
1964	26,156	764	2.9
1965	27,135	854	3.1
1966	29,884	1,035	3.5
1967	31,142	1,380	4.4
1968	34,199	2,229	6.5
1969	37,444	1,948	5.2

Source: Aerospace Industry Associates of American, Inc., 1969 Aerospace Facts and Figures, (Fallbrook, California, 1970), p. 17.

The principal sources of competition faced by American aircraft manufacturers are the countries of Western Europe. It is possible, however, that the Soviet Union will enter the international markets with certain types of aircraft. Canada, Japan, and Israel are producing specialized types of aircraft that might increase in importance.

Firms in the Western European aircraft industry have been handicapped by a scattering of resources in units too small to deal with many of the technological problems of the industry and with internal markets too small to support economic efforts. Some mergers have occurred in recent years, particularly the formation of the Society National Industrielle Aerospatiale and Zentral Gesellschaft VFW-Fokker (which also controls Belgium's SABCA). The British aircraft industry has also experienced some consolidations. Although the British industry is the largest in Europe and has important technological capabilities, it has been plagued with misfortunes and the mergers have been insufficient to provide needed resources and assured markets. In their civilian aircraft efforts, the British firms are now wholly involved in collaborative projects such as that with the French in the development of the Concorde. A variety of other bilateral and multilateral agreements exist outside the European Community's sponsorship and are intended to respond to the challenge of the American industry as effectively as possible.

Such collaborative efforts by different European countries have been essential for access to an adequate market and the pooling of

resources, but they have been economically inefficient. One estimate is that collaboration increases the costs of development by a third, an increase not fully offset by the broader market. Sir George Edwards, managing director of British Overseas Airways Corporation, is quoted as saying:

> In a collaboration the cost is one and a third that of unilateral production. Against that disadvantage, there is a savings of 20 percent on unit cost through doubling the market and so securing big-scale production. Although this may strengthen the manufacturer's position in overseas sales, it does not wholly overcome the economic penalty of joint development. In any case there still remains the question of unequal technological contributions and their possible consequences.[109]

The slow but clear development of the European Community is of special significance to the American aircraft industry, particularly if the United Kingdom becomes a member as seems highly probable. In its official organ, the European community recently pointed out:

> More than 76 percent of aircraft belonging to Community members have been produced in the United States, a sign of industrial weakness that the Commission's industrial policy is intended to rectify.[110]

Competition between Europe and the United States has been most sharply joined in the Anglo-French Concorde and the American SST. The Concorde and, in particular, the American SST represent efforts to develop commercial aircraft to their technological limits. However, it should be recognized that, in application, virtually all technologies are utilized short of their feasible engineering limits because of economic considerations. Aircraft are not exempt from this principle and are subject to user concepts of trade-offs between what is techno-

logically feasible and what is economically desirable.

Interest in STOL aircraft in the United States and Europe, as well as the general interest in more comfortable short-and medium-range aircraft, indicates at least a vague recognition that demand for large capacity, high performance aircraft is approaching saturation.[111] The continuing growth of air transport will depend upon the availability of aircraft that can fulfill requirements for short-distance travel with a high degree of comfort and convenience--aircraft that are not now available. For a few years after 1970, the U.S. balance of payments could be unfavorably affected by purchases of the Concorde, although European purchases of wide-body, airbus-type aircraft from the United States would offset this trend somewhat. Much will depend upon the economic and technological characteristics of the Franco-German A-300B airbus as compared with those of U.S. models; British European Airways has already expressed a preference for the American product. If and when the American SST becomes operational, the United States should remedy some of its unfavorable international position.

Whatever the success of the SST, there are other objectives toward which U.S. technological efforts should be directed. The federal government has left to private enterprise the task of supplying new models to provide improved service of the type supplied by the many older, intermediate-sized aircraft now in use.

The desirability of more modern short-range aircraft than are currently available has long been recognized. Some years ago the FAA

issued a Request for Proposal for a replacement of the DC-3 but later cancelled the project.[112] Some American aircraft manufacturers have sought to fill this need, but none has had outstanding appeal. A Japanese firm is offering the YS11, a plane sufficiently attractive to induce an American regional airline to purchase a significant number. Canada's DeHavilland is promoting its Twin Otter and Israel Aircraft Industries its Arova, with modest success. The U.S.S.R. is reported to be planning to build large numbers of a new aircraft of this general type, and some European firms are also developing such aircraft.

There seems to be relatively little enthusiasm for any of these efforts, although some of them may enjoy a degree of success. The reasons for airline disinterest may be economic, technological, or even social, and require careful and detailed examination.

It has become clear in recent years that the position of the U.S. economy in international trade is dependent in large measure upon comparative advantages in productivity. These advantages follow specifically from the utilization of superior technology, whether in product or in production. In the case of aircraft, the United States maintained and built upon the favorable position acquired during World War II, reacting to technological developments which, though not always prompt, have succeeded in providing a superior product. The current American superiority in jet-powered civilian aircraft is, for example, based in part upon developments in engine technology that originated abroad. The present U.S. lead rests upon quicker and

more effective application of such engines to operational aircraft. It should be noted that the British aircraft industry continues to maintain a very high level of competence in jet engine development and production.

The advantages of national technological superiority have in recent decades tended to erode at an accelerating rate. That is to say, as more countries have become industrialized, technology transfer tends to take place more quickly and the advantage to the originating country declines correspondingly. Technological advancement is maintained by a constant search for markets to which the technology can be applied, as well as by adapting new technological objectives to recognize the potential for foreign markets.

Technological superiority, is, however, as much economics as engineering. The problem is that of marrying what can be accomplished technologically with what is wanted by the user, with due consideration to what is acceptable to the society as a whole. It is clear from the debate over the Concorde and the American SST that these aircraft presently stand very near the margin of economic and social acceptability.

Gaps exist between actual and potential uses of civilian aviation. STOL aircraft may fill such gaps, but could prove not to be the aircraft that potential world users are looking for.

Policy Implications

The vigor of the nation's aviation industry, which has a considerable impact on the nation's balance of payments, is at root dependent

upon the technological superiority of American civil transport aircraft and upon the managerial and marketing expertise required both to service aircraft sold to foreign airlines and to enable American airlines to compete effectively in international markets. Should the United States allow itself to fall behind its competitors in this area, one price would necessarily be a drain on our balance of payments.

Conversely, the international status of the American aviation industry partially determines how able the industry is to move ahead with developments which will maintain its competitiveness. There is, in other words, a sort of snowball effect in the international arena wherein success facilitates further success, and overcoming a less-than-fully-competitive position is most difficult.

Therefore, it is important that not only the domestic markets for new civil aviation systems be considered, but also emerging foreign markets which may differ from those of today. Such trends as have been examined in the present study suggest that the dominance of the large jet transport as the market leader may have reached a peak, and may begin to be replaced in the near future by short-haul--including STOL--aircraft, where the U.S. faces international competition which promises to be severe. Brisk developments abroad, which are ahead of those in the U.S. in this area, are already leading to inroads of foreign aircraft into domestic American applications, and suggest the possibility that the U.S. could a few years hence find itself in a "come from behind" position in the international short-haul market.

PART II

MAJOR SOCIAL IMPACT FINDINGS AND THEIR IMPLICATIONS FOR FEDERAL ACTION

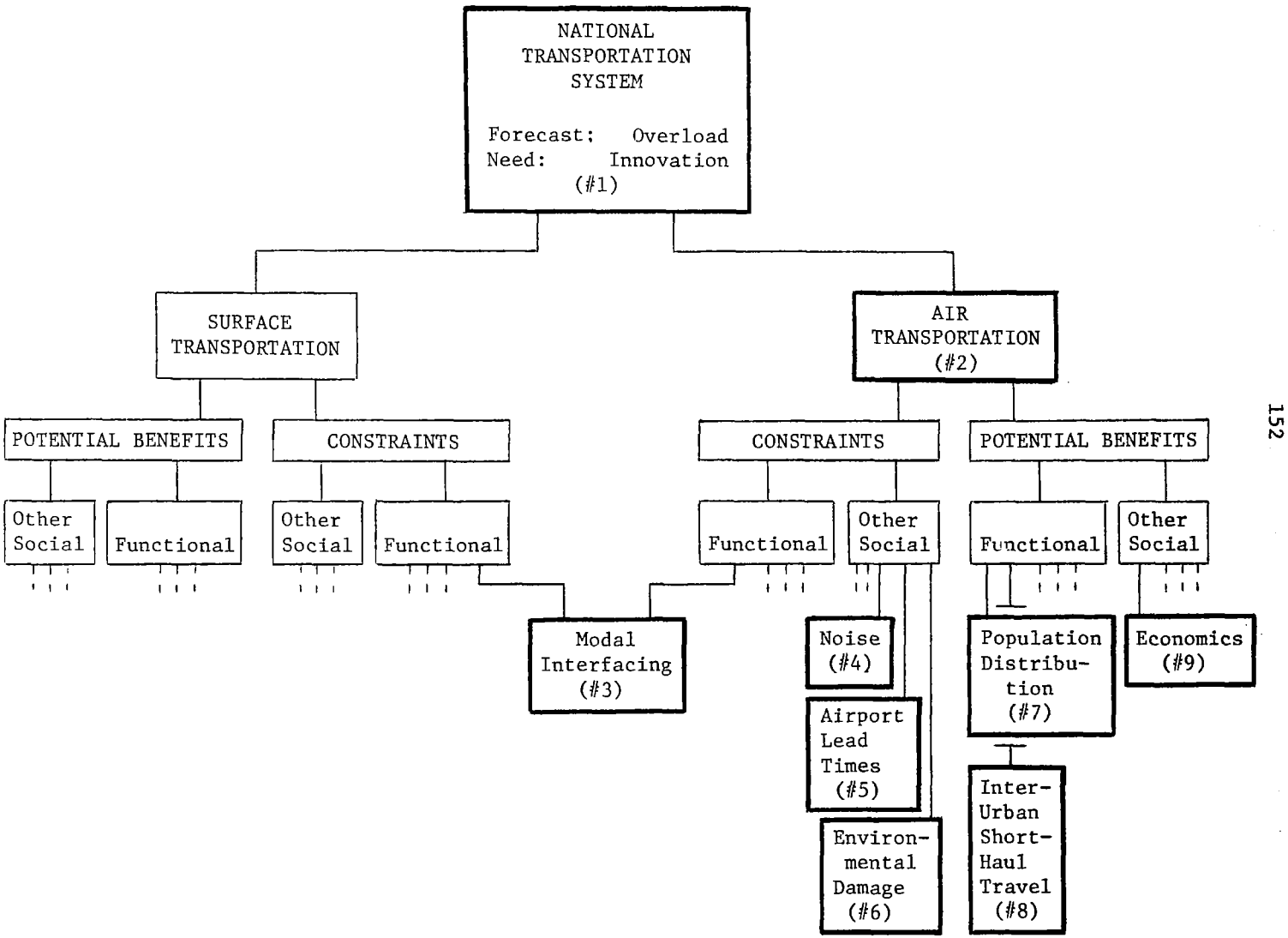
PART II. MAJOR SOCIAL IMPACT FINDINGS AND THEIR IMPLICATIONS FOR FEDERAL ACTION

INTRODUCTORY COMMENTS

Figure 5 summarizes in visual form the framework around which the Findings of this Study crystallized. Since aviation exists to serve the societal function of transportation, it must be viewed in this context in order for any social-impact analysis to be meaningful; therefore, the role of air transportation as one major component of the national transportation network is indicated, surface transportation being the other portion. Within each transportation sector, there are potential social benefits to be realized as well as constraints to social usefulness to be removed. Some of the potential benefits and constraints are functional in nature--that is, they derive primarily from the manner in which the system itself functions or the purposes it can serve--while others do not spring directly from functional requirements but are socially relevant nevertheless.

The blocks with heavy borders in Figure 5 correspond to areas in which major Findings have been arrived at in the GWU/CARD Study, the number in each block referring to the relevant Finding as it is discussed in the present report. Vertical dashlines are shown in many places, signifying areas which undoubtedly exist

FIGURE 5: HIERARCHY OF FINDINGS



and are important but which could not be given detailed attention in the present study. The formulation of a rational, comprehensive, and effective national policy for transportation in general--and civil aviation in particular--depends not only upon the very significant social impact considerations already explored, but also upon these as-yet unexamined areas.

The Findings are discussed in an order which follows directly from Figure 5. The first Finding deals with the anticipated future of U.S. transportation in general, given continuation of current trends, and sets the stage for the rest of the Findings. This Finding predicts an unacceptable overload in transportation on a national scale which will be critical by 1985--perhaps well before that--if appropriate governmental action is not taken to prevent it. The second Finding then focuses attention upon the significance this has for civil aviation in particular, pointing out both the threats and the promises which lie in store. The next four Findings deal with important constraints upon the utility and social acceptability of civil aviation systems and facilities, while the last three discuss important social benefits which could be obtained by exploiting civil aviation potentials should government so elect.

Several general observations can be made on the basis of this analysis:

- The use of anticipatory instead of remedial measures will be increasingly crucial, and indeed indispensible in some cases: witness the need for advance planning to prevent irreversible ecological disturbances; to guide population distribution patterns in their formative stages (versus urban renewal); and to fend off noise problems before they happen.

There is a strong interdependence among the various social impact Findings and the needed actions which they imply. For example, one could conceive of a remotely located major airport which could cause negligible environmental damage--and simultaneously eliminate the burdensome problem of aircraft take-off and landing noise--if adequate airport access were provided via fast-transit link which brought the passenger to an accessible, efficient terminal in an urban location (which in turn would have to satisfy certain political and economic criteria).

- The sheer number and importance of social impact considerations, which will not be static over time, implies that a continuing effort will be required to seek them out if rational and effective research and development is to be pursued.

It will be noticed that references to documentation are absent in this section of the report. This is because the statements and discussions of Findings draw upon the material developed in Part I, with a view to weaving together the major threads running through the various Policy Issues.

The Findings are examined in the present section to indicate the guidance obtainable from them with respect to concrete policies, and a number of "Candidate Basic Federal Undertakings" are derived. Each Undertaking represents a potential area which might merit governmental action. These broad Basic Undertakings provide a basic structure which can be subdivided into progressively more specific and detailed definitions of areas for federal endeavor. A logical hierarchy can thus be

generated, of which the first two levels are treated in the present report, which began with general considerations and progress to ever more specific levels:

1. Findings.
2. Basic Undertakings--pertaining to each Finding.
3. Alternative Courses of Action--for implementation of each Undertaking.
4. Programs--major action routes involved in each Course of Action chosen.
5. Projects--identifiable, large packages of work needed to carry out the various aims of each Program.
6. Tasks--specific work units involved in each Project.

Finally, it is worth noting that the wording of each Basic Undertaking reflects a civil aviation perspective. Each Undertaking may be thought of as responding to the question: "Considering the potentials of civil aviation specifically, what types of federal action appear to merit attention on the basis of social impact considerations?" This perspective could in a sense be attacked on the basis that some other perspective--e.g., total transportation needs--may appear more appropriate. However, the CARD Study grew out of a Congressional concerns specifically with civil aviation, and it therefore seems appropriate to address these concerns as directly as possible.

1. NEED FOR INCREASED FEDERAL ACTION IN TRANSPORTATION

Statement of Finding

Federal action, including a more active role in transportation development and innovation, will be required to avert a nationwide transportation overload of serious proportions by 1985.

Implications for Governmental Role

This is the broadest and most fundamental finding produced by the GWU/CARD Study, in terms of the guidance it offers for future federal policy relative to civil aviation. It defines an impending problem area of unavoidable and vital concern in transportation, in which civil aviation is an inextricable, major factor. It then states that, due to this problem area, increased federal activity in transportation will become not merely desirable, but essential and inevitable.

The prediction of a growing congestive crisis spans the entire national transportation scene, including civil aviation. The automobile has grown in the past two decades to a position of dominance for short-and medium-range intercity travel, with air travel assuming ever-increasing significance for longer-range trips. Accompanying these trends--and to a considerable degree, caused by them--there has been an opposite trend in public intercity ground transportation, consisting of trains and buses. These services have experienced a steady decline, to the point that public ground transportation no longer possesses the ability to satisfy more than a very small percentage of the nation's intercity travel needs.

Unfortunately, the demand for intercity travel is now accelerating at such a rate that the facilities and routes for both of the now dominant

modes--auto and air--are headed for insuperable problems of saturation if their present development trends continue. Already, the capacity of highways in heavily traveled corridors is being severely taxed. And in aviation, the failure of airport and airway developments to keep pace with the growth of traffic, and in some cases with the characteristics of new aircraft, is now producing system-saturation headaches the vanguard of which are already upon us.

Since continued evolution along present lines cannot be expected to lead to satisfaction of emerging new levels and types of transportation needs, it is clear that innovation is a necessity:

- The requirement for good, fast, high-capacity public ground transportation, particularly in high-density corridors, is not being met so far by an effective revival of such transportation systems.
- Many promising solutions to the ground transportation problem appear possible, but all require further research and development and coordinated planning for their implementation.
- The technical possibility also exists for more effective utilization of the civil aviation system, but here again such progress is dependent upon substantial innovation--both technologically and in non-technological areas.

Because of the magnitude and complexity of the problem combined with its increasing urgency, the federal government must soon assume a more active and effective role in transportation development than it has so far chosen to take. This role must be more "active" both with regard to level of effort and in terms of taking a greater initiative to support develop-

ment in certain areas. The latter aspect is particularly important in some areas in which the federal government currently acts almost solely to regulate passively the products and efforts of the private sector. Because innovative developments in future transportation must be introduced at an advanced level of technical sophistication, they will entail high risks which may be unacceptable to private industry; this factor, combined with the presence of large potential social benefits and costs, suggests the need for some commitment of public assistance. Areas where such assistance should be considered include:

- Subsidies for selected research and development efforts.
- Support for interface technologies, including system access.
- All types of assistance in solving anticipated social problems such as, noise, ecological disruption, etc.
- Study, analysis, and monitoring programs to anticipate problem areas.

To a considerable extent, the options for federal assistance in preventing a transportation crisis will decrease as time goes by, with delays in governmental action tending generally to narrow the range of options as some are foreclosed. Thus, for example, the opportunity still exists now to carry out a considerable amount of basic and exploratory research and testing, in order to determine what technological and non-technological innovations can best promote transportation developments which will minimize the anticipated overload while maximizing social benefits. As time goes on without definitive action, however, continued evolution in present directions will tend to make problems more and more acute, with less and less room to consider alternative policies or long

range programs. Eventually--certainly before 1985, and perhaps long before--economic and social pressures will compel government action in an atmosphere of crisis, if appropriate measures have not been initiated in a more constructive manner. By that time, the only mechanisms available to the government will be short term "fixes" and/or legislative actions such as to restrict travel. A beginning can of course be made even then to work toward real improvements; but at that late hour, truly massive efforts of several years duration will be required before achievement of net improvement in what will be a further deteriorating situation.

Candidate Basic Federal Undertakings

This Finding suggests that, if a transportation overload is to be avoided, the following basic undertaking will be required on the part of the federal government:

1.1 Augment the federal role in the support of innovative developments for U.S. transportation systems, not only as necessary to prevent an overload of these systems, but also to insure that they will develop in such a way as to maximize their social benefits and minimize adverse social impacts.

2. NECESSITY FOR INNOVATIVE IMPROVEMENTS IN CIVIL AVIATION

Statement of Finding

Innovative improvements in civil aviation, including more rapid and systematic airport/airway system development, will be a necessity if the approaching national transportation overload is to be avoided.

Implications for Governmental Role

A safe, adequate, and efficient civil air transportation system is an essential ingredient of the present-day American way of life. It has become one of the two dominant modes of intercity passenger travel (the other being the automobile), and its share of this market is still growing rapidly. Aviation, an important factor in national security, is also a major thread binding much of the fabric of the United States economy, to such an extent that its deterioration to any great degree could cause a considerable portion of the economic fabric to begin unraveling. Thus, if the federal government should allow any major degradation in civil aviation safety or service, it will do so at the peril of incurring serious economic and political consequences.

The need for innovation in aviation is evident from the increasing extent to which aviation is encountering serious constraints upon its continued viability. Existing airports are limited in capacity to levels which are already being reached--even exceeded in some cases--and major improvements cannot be made without new or modified runways; improved landing and traffic control aids; and vastly improved terminal-area layouts with better passenger services and intermodal/interface arrangements. Airways are likewise reaching the limits of their present capabilities in heavy

traffic corridors, due to air traffic control techniques and equipment which are overdue for modernization. New airports, which would be of considerable help in some areas, are being blocked by societal obstacles which make it clear that the relatively narrow considerations used in the past to plan airports will be even less successful in the future. New criteria and planning techniques are needed, along with technological options which will make these techniques viable.

The law of supply and demand cannot be expected to lead unassisted to the needed developments in aviation, because there are many factors involved beyond the control of the private sector. There are also social impact factors associated with transportation--all transportation, including aviation and automobile travel--which prevent pure marketplace pressures from producing optimal transportation capabilities. The viability of civil aviation--both commercial and general--is linked inextricably to public-financed airport and airway facilities, just as the private automobile depends upon the availability of highways and other roadways which could neither be planned in a coordinated manner nor implemented by the private sector.

- Thus, the marketplace response has been, and will continue to be, perturbed and constrained by factors outside the control of the civil aviation industry and of its clients, the traveling public.
- These factors include constraints on land use and acquisition for airports; shortcomings in airport location combined with inadequate airport-access capabilities; resistance to civil air operations by political and social elements whose interests are adversely affected;

and other, similar factors.

In light of these facts, combined with the need for rapid and systematic improvements, the need for governmental action is clear. Government assistance need not be used to induce civil air carriers to expand their services to meet increased demand, but rather to remove constraints to their expansion in realms which are beyond their control, wherever such expansion is seen to be in the national public interest.

Candidate Basic Federal Undertakings

This Finding suggests that, as a part of the effort to prevent a national congestive crisis in transportation, several basic undertakings will be needed on the part of the federal government. These include, though probably are not limited to, the following:

2.1 Support those innovative developments in civil air vehicle technology that can be justified as essential to overcome constraints to such growth of civil aviation as is required to satisfy air travel needs through 1985.

2.2 Insure that airport development, including building, modification, and expansion, can and will take place as necessary to allow for such increases in civil air services as are required in light of overall national transportation needs.

2.3 Continue to provide those supporting services which are deemed necessary to the safe and efficient operation of the civil aviation system, and which are accepted as proper governmental functions.

2.4 Pursue research and development in technical areas relating to more efficient airway and airport design and use.

(NOTE: Limitations upon civil air expansion and effectiveness which result from inadequate airport access systems, or from social, political, or ecological considerations are dealt with under separate Findings.)

3. IMPORTANCE OF AVIATION INTERFACING WITH GROUND TRANSPORTATION

Statement of Finding

Achievement of maximum utility with new and existing civil aviation systems will be increasingly contingent upon interfacing and coordination with improved ground transportation.

Implications for Governmental Role

Any federal program to improve civil aviation must explicitly recognize urban ground transportation to be an increasingly critical constraining factor. If the intention is to maximize the overall quality of transportation available to the traveling public, then it follows that aviation must be integrated and balanced with other modes. If, on the other hand, emphasis is to be placed upon aviation specifically, then it must be remembered that the traveler is interested in his overall trip, rather than just the airborne parts between airports. The usefulness of civil aviation is degraded whenever excessive amounts of time are consumed by travel to and from the airport or by delays and inconveniences within the airport itself. The latter difficulties, which are essentially problems of urban transportation and intermodal transfers, are no doubt at least partially responsible for the fact that the short-haul interurban market accounts for a dwindling share of total air transport activity.

In highly populated areas where there is heavy civil air traffic, improved forms of ground transportation are needed to connect the city both with existing airports and with any new airports which may be built. For example, rim-ports--STOLports located on the urban fringe--appear capable of substituting effectively for some proposed center-city STOLports, with

fewer political problems and perhaps at considerably lower cost if adequate airport access is provided by high speed ground systems.

- It is important to note that, in all probability, pure "airport access systems" are not likely to be a good solution in most cases. Rather, the airport must be linked in a rational way to a system which exists to provide a more general service for the metropolitan area.
- Even though the airport may provide an important incentive for the establishment of such a system, it is likely that in most cases a confluence of aviation interests with other community transportation needs will be necessary for the achievement of good airport access.

In new towns, or in small population centers with expansion potential, airports can be planned and built concurrently with high speed ground systems. Comprehensive, systematic plans potentially can be followed in which airport capacities are expanded and improved in a manner which is continually in concert with other urban developments, including those in transportation. In contrast to the metropolitan case, which is characterized by a pressing need for remedial measures, the growth-center situation offers a relatively "clean slate" to work with. However, this attractive potential for systematic, balanced development can be forfeited if farsighted, long-range planning is not instituted at an early stage; future growth must be provided for well in advance. This may involve, for example, setting aside land for airport expansion and for ground transportation rights-of-way, so that early random growth will not inadvertently choke off possible avenues for continued development.

Important relationships between ground transportation and aviation exist

not only in the city-to-airport arena, but also within the airport complex. For example, many large airports today have layouts which require passengers to walk distances on the order of a mile to make connections between flights. Efficient processing of large passenger surges produced by jumbo jets is still a dream. Movement between terminal and arrival area (i.e., parking lot) is usually awkward and time-consuming. This small-scale, intra-airport realm is far from being solved in practice and will require increasing attention.

At the other end of the distance scale, interurban high speed ground transportation (HSGT) may become more complementary than competitive to aviation as extremely long-range aircraft such as the supersonic transport (SST) come into use. This will be particularly true if federal initiatives are not taken to strengthen the aviation role in short-haul interurban travel, since in this case the trend toward ever-longer average stage lengths will probably continue, leaving a vacuum which only HSGT can satisfactorily fill.

Finally, while the above remarks have tacitly been directed primarily to commercial passenger travel, analogous--but not identical--interfacing considerations exist with regard to air freight operations and general aviation. The whole interfacing question becomes even more involved when the necessary interrelationships among the various sectors of aviation itself are introduced. The scope of this study did not allow more than cursory examination of these factors, but it is abundantly clear that all must be weighed carefully if the future course of American civil aviation is to be efficient, socially beneficial, and prosperous.

Candidate Basic Federal Undertakings

3.1 Promote improvements in ground transportation in metropolitan areas, wherever such improvements serve to improve airport access and thereby relieve constraints upon the utility of civil aviation.

3.2 Promote the implementation of effective regional plans for growth-center development which provide for modification and upgrading of airport access as needed to accommodate growth in air traffic.

3.3 Promote more rapid and efficient intermodal transfer of passengers, luggage, and freight within existing and new airport complexes.

3.4 Encourage future developments in high speed ground transportation which may be used to complement the civil air system.

4. URGENCY OF THE AIRCRAFT NOISE PROBLEM

Statement of Finding

Aircraft noise is presently the most urgent of all social-impact factors in civil aviation, and its alleviation is a necessary--though by no means sufficient--condition for continued civil aviation progress.

Implications for Governmental Role

Increased federal activity to alleviate the problem of aircraft noise is needed, and will probably become unavoidable because of public pressures to produce a solution. Several overall observations can be cited in support of this statement:

- Noise improvements do not translate directly into revenue increase commensurate with their costs. The extremely high costs of significantly reducing the noise problem would, as a result, more than eliminate the profit margins of the aviation industry for the foreseeable future. Therefore unless the collapse of the nation's civil aviation system is to be accepted, some commitment of public resources will be necessary to solve the problem.
- Practical solutions to the overall noise problem will require a blend of technical and non-technical approaches on a scale, and with a degree of coordination possible only with federal participation.
- The necessity of federal action will be recognized more and more by citizens' groups and others seeking relief from noise incursions, and the result will be a steady buildup of pressure on the United States Government to "do something". Such pressure may take many forms, ranging from political activism and protest to noise-related lawsuits

directed at the federal government rather than at local municipalities.

Noise is singled out as the most urgent social-impact problem, but it should be noted carefully that this is not to say it is also the most important in a long-range sense. Its urgency stems not only from the very real social disbenefits produced by noise, but also from the fact that public exasperation over the noise problem is already at a dangerously high level and is still rising: thus, if real improvements are not brought about soon in this area, all the other gains produced by aviation are likely to be nullified in the public eye. The fact that noise is not necessarily the most important long-range consideration, however, can be deduced by simply bearing in mind the extremely important and long-range factors involved in Findings #3 and 5 through 9.

The great current social importance of noise, then, springs from the magnitude and immediacy of the problem and the resulting implications for civil aviation. Noise spills over far beyond the property owned by aviation interests. It is a highly noticeable by-product of aviation which adversely affects large numbers of people. This gives rise to everything from sporadic complaints to lawsuits, and causes a degradation of property values over large areas neighboring airports. The noise problem must be brought under control if aviation is not to encounter very large obstacles to further development. Aircraft have come to be associated with unacceptable noise in the minds of an increasing segment of the public, to the extent that most new airport proposals now encounter opposition right from the start. This problem must be overcome if government at all levels is to get the local cooperation necessary to accommodate the efficient

growth of air travel.

Community-borne social costs are reflected in, and lead to the necessity of, noise-abatement approach and takeoff procedures. These reduce effective airport capacity, may compromise safety to some degree, yet fall far short of truly satisfying community wishes. Some relief is already a technological possibility, but will be costly to airlines and hence to the traveling public unless subsidized by the government. Techniques which are more feasible economically still lie in the future, and there appear in any case to be physical limits to the amount of noise suppression possible at any price.

- The crux of this finding is that advanced technology measures cannot by themselves lead to a full, practical resolution of the noise problem.
- This implies a strong need for imaginative efforts in non-technological areas, particularly with regard to promotion of compatible land use in areas surrounding airports.
- It also suggests that research and development in noise-reduction techniques might prove most fruitful if the guiding philosophy were to use technical improvements as a tool to improve the viability of non-technical courses of action, since this would serve to help select the technical noise-reduction efforts which are most relevant.
- It is clear that coordination of technical programs with non-technical areas such as regulation, legislation, and federal-local cooperative planning is of great importance.

- In addition to searching for means of alleviating the noise problems which already beset aviation, the anti-noise effort should be expanded to include studies of possible noise hazards associated with distinctive new aviation systems as they come under consideration. The practical utility to be expected from some such systems might be altered drastically when viewed in this light, and critical aspects of vehicle design or operating profiles might be altered at an early stage so as to avoid or minimize problems in the operational phase.
- The possible ramifications of failing to perform this anticipatory study function could conceivably be profound, as exhibited by the fact that enroute noise--an entire new category in the social sense--could virtually burst upon the aviation scene a decade or so hence, and yet there has been little public recognition of the possibility that such a major new dimension to the noise problem might be in the offing.

The only enroute noise problem--as opposed to local noise, which exists only in the vicinity of airports--which has so far been identified is the SST sonic "boom", concern over which has led to banning of supersonic flights over populated areas. It is at least conceivable, however, that enroute noise could also turn out to have major adverse social impacts at the opposite end of the flight spectrum, with the introduction of V/STOL vehicles flying dense short-haul corridors at very low altitude and relatively low speeds. Indeed, had helicopters proved to be more attractive for short-haul mass transport, we would no doubt have this problem with us today. Such noise would impinge upon great numbers of people, many of whom would not necessarily exhibit the same levels of tolerance found near airports; and

since most of the non-technical solutions applicable in local noise do not appear usable in the enroute case, the alternative to proper advance attention to noise in designing aircraft and engines could devolve into abandonment of service.

The federal government already bears the responsibility for establishing civil aviation noise standards, and this responsibility will become more complex and crucial in the years ahead. With the benefit of well-conceived programs which encompass both technical and non-technical realms, and which anticipate future developments as well as attacking immediate problems, these standards can be rational, fair, and--of no small importance--enforced. Without such a foundation, however, standards will ultimately be arrived at in the haphazard arena of social protest and litigation, which can only work to the detriment of society as a whole and civil aviation in particular.

Candidate Basic Federal Undertakings

4.1 Promote comprehensive solutions to the aircraft noise problem through coordinated use of both technological and non-technological methods.

4.2 Anticipate and minimize noise problems associated with new aviation systems.

4.3 Establish and enforce valid aircraft noise standards which reflect, and protect, social values.

5. INCREASING LEAD TIMES IN AIRPORT DEVELOPMENT

Statement of Finding

Lead times for airport development are increasing and are likely to continue doing so, due to fragmentation of the local planning process and to uncertainties inherent in present forms of public participation in land-use decisions.

Implications for Governmental Role

Airports have become a major limiting factor in the continued development of the civil aviation system, overshadowing aircraft technology and even the air traffic control (ATC) problem. New airports are needed in some areas now, as are modifications of many existing airports to improve their efficiency, to boost capacities beyond current levels, and to alleviate noise problems. Despite these needs, airport building efforts are encountering increasingly knotty problems and resultant delays. The seriousness of this situation is clear. Without new airports, emerging needs in localities previously without service cannot be met. Without upgrading existing airports, little can be done to meet expanding needs in high demand areas. Our ability to avoid a national transportation overload by 1985 will depend to a considerable extent on our ability to solve these problems.

Moreover, solution of the lead-time problem is crucial if the potential usefulness of aviation with regard to national population distribution and regional development (see Finding #7) is to be realized. If this obstacle is removed, then the timely development and judicious location of new airports can serve as catalysts for the development of new suburban communities,

promote regional growth and economic development, and even contribute--if desired--to population shifts leading to the decongestion of urban centers. These capabilities are deemed particularly strong if effective inter-urban short-haul systems, preferably utilizing STOL aircraft, are used to link these various types of areas appropriately.

The inordinate difficulty in realizing new or improved airports do not stem primarily from the technical problems to be solved, but rather from non-technical obstacles. Important technical problems do exist with respect to airports, just as they do in aircraft technology and ATC, and these should not be neglected; but the crucial challenge lies in bringing about changes in decision-making institutions and processes which will enable planning, land acquisition and construction to proceed.

Two critical facets of this decision-making realm are:

- the local planning process
- public participation in land-use decisions.

A good example of local planning difficulties is that of inter-jurisdictional conflicts over siting of airports in metropolitan areas, where literally hundreds of municipalities and authorities may be affected by airport plans. The practical importance of this factor is evident from the experience of the Dallas-Fort Worth region: airport progress was precluded for years because of competitive feuding, whereas a shift to cooperative planning led to viable plans for what promises to become one of the world's more influential airport complexes. As for public participation, the totally negative example of the Everglades airport project in Florida provides insight into the magnitude of the problem and the general inadequacy of

present processes to deal with it. At the same time, there is a hint of the possible leverage for expediting airport development which would be afforded by positive, constructive techniques.

There would appear to be a virtual mandate for the federal government to take a hand in helping to resolve these problems, if the long-range public interest is to be served.

- Every airport open to civil aviation not only serves the host community but functions as a link in the nationwide air travel network, so that an element of the national good--not just local benefit-- is present in every case.
- Only the federal government has the financial, organizational, and political resources in general to coordinate the establishment of procedures designed to produce beneficial long-range results, rather than bowing exclusively to local interest and/or short-range pressures.
- If the federal government is going to invest sizeable sums in the development of new or more advanced civil air systems, such as STOL, V/STOL, and advanced long-range transports, it stands to reason that the government must be able to plan the introduction of these as a total "system." This inlcudes air traffic control and airport requirements as well as aircraft.
- Under the present division of responsibilities for airport development it is conceivable that a major federal investment in new civil air systems could be wasted by the lack of suitable airports to support it.

Candidate Basic Federal Undertakings

5.1 Encourage improvements in the local planning process as

necessary to permit orderly progress in civil aviation, so as to help forestall a congestive transportation crisis by 1985.

5.2 Encourage the development of improved techniques for introducing public participation into airport-related land-use decision-making, in order to lead more quickly to realizable development plans while simultaneously complying with recent legislation requiring such public participation.

6. NEED FOR ENVIRONMENTAL PLANNING IN AVIATION SYSTEM DESIGN

Statement of Finding

Aviation-spawned strains on the physical environment, which are growing in significance, can be adequately controlled if--and only if--environmental considerations are made a basic ingredient in future system planning and design.

Implications for Governmental Role

Governmental action will be required to prevent ecological side effects of aviation from producing undesirable social impacts and attendant constraints on civil aviation over the next several decades.

- The federal authority over airport design standards and certification confers both the ability to insure the inclusion of the environmental considerations in planning and a mandate to do so, since the future evolution of the nation-wide air transport system will inevitably have ecological ramifications.
- Additionally, if aviation is to be fostered by the federal government as a vital part of the U.S. transportation system, an important collateral concern should be to promote those air travel technologies which will not have unacceptable or undesirable environmental side effects.
- The definition of what is "unacceptable" must, in itself, be a federal function also, since no other body can command the resources which are likely to be needed in answering future environmental-impact questions relative to civil aviation in a comprehensive, public-interested way.
- Federal initiative is made more imperative by the fact that preserva-

tion of the environment must be pre-eminently anticipatory and preventive in nature; once disturbed seriously, the ecological balance which exists today both locally and globally may not be restorable.

Environmental side effects of civil aviation fall into two distinct categories: direct and indirect. Direct effects, consisting primarily of air pollution from aircraft engine emissions, are as yet relatively minor, but this could well change in the near future. It is noted that noise, another direct effect, does no lasting damage to the physical environment and generally has no detectable effect on ecological balance; it is therefore properly considered as a separate social impact area (see Finding #4). Indirect effects, which consist of perturbations wrought by land development patterns generated by airports, are of some importance presently and will grow worse if new superports are brought into being without due attention to their impact on the environment.

Indirect, airport-related environmental considerations can be cited at both the local and national levels. In the local vicinity of any airport, the problems are generated by the activities and developments which spring into being because of the airport's presence, and include altered water runoff patterns, sewage disposal headaches, elimination of oxygen-producing plant life, and all the other ecological distortions produced by any modern urbanization pattern. The seriousness of all these effects depends upon both the location and the characteristics of the airport; generally, an airport of conventional design will have more detrimental consequences if placed in a previously undeveloped area than if located within or adjacent to a developed, urban area.

- A part of the national perspective on environmental factors is thus the structuring of the air travel network so that transportation needs can be met without sacrificing areas which are particularly sensitive ecologically.
- Another point which is relevant to national network planning is that ecological damage is likely to be much less serious if built-up areas are relatively dense and separated by large amounts of open space than if it occurs in low-density, diffuse, megalopolitan "sprawl". This implies that the positioning and functional use of airports in the national air transport system can have long-range ecological ramifications of consequence, because the structure of the airport system can have a considerable influence upon nation-wide population distribution patterns. (See Finding #7.)
- In the past, airports have been developed almost exclusively around plans of local municipalities, with only passive regulation and guidance by the federal government. As a result, local indirect environmental effects have been generally unappreciated--even to the extent of precipitating the Everglades airport debacle--and there has been no structure whatever for systematic consideration of the ecological implications of the national airport distribution pattern.

The direct category of environmental perturbations has so far played a secondary role relative to the indirect category, with the unsurprising result that little has yet been done to set criteria which attack this problem, beyond requiring the elimination of engine smoke. However, aircraft air pollution is likely to become more salient in the near future, both

quantitatively and qualitatively. Considering the quantitative aspect:

- The quantitative significance of aviation in air pollution tends generally to be dismissed with the observation that aircraft produce only about 1-2% of the total in urban areas.
- However, at least two important factors are at work which will raise this percentage at an accelerating rate: the aviation share of the total transport market is increasing rapidly, and the major non-aviation polluters such as factories and the automobile are under increasing pressure to "clean up" quickly, so that their pollutant contributions will soon begin dropping off.
- Thus, unless preventive action is taken, the status of civil aviation could change over the next decade or so from the comfortable one of a negligible polluter to that of a rather major offender.

As for the qualitative aspect of aircraft air pollution, the point to be made is that aircraft distribute their pollutants in a unique way. Other sources of air contamination are all at ground level and are concentrated primarily within cities; aircraft, by contrast, inject their effluvia into the atmosphere along their entire flight paths and at cruising altitudes, with only a fraction of the total pollution per flight occurring in urban areas.

- At present, this may be more beneficial than detrimental, since it means that only a small part of the total pollution generated appears at low altitudes where it can endanger health, sicken vegetation, and so forth.
- In the future, however, the unique contaminant-distributing

> characteristics of aircraft may have detrimental environmental effects, and hence become a liability rather than an advantage for civil aviation. Concern over upper-atmospheric contamination by the SST may prove not to be unique in this regard; for example, very dense low-altitude interurban traffic could conceivably bring with it enroute pollution problems which are as yet unsuspected.

Regardless of the specific levels of aviation-produced air pollution at any given time, it must be remembered that aviation may be more vulnerable to criticism than other activities, and thus can ill afford to be lax. Civil aviation tends to act as a "lightening rod" for social protest due to its visibility and the uneven distribution of its social benefits and disbenefits. As a result, its negative side effects produce vigorous protest even when they are relatively minor: witness the vociferous--and effective--hue and cry for airlines to clean up their smoky engines, even though the smoke is a miniscule fraction of the total engine exhaust, which in turn adds up to the tiny 1-2% figure cited earlier. The "visibility" of an infraction, whether literally or in the more general social sense, leads relatively swiftly and surely to the culprit's being called to account, and in any case of unacceptable enroute pollution the identification of aviation as the responsible party would be exceptionally easy.

Candidate Basic Federal Undertakings

This Finding indicates that the continued encouragement of civil aviation as a major component of the nation's transportation system

may be accompanied by either favorable or unfavorable environmental consequences, depending upon whether or not effective anticipatory planning and regulation is employed by the federal governemnt. Basic undertakings which will be needed include:

6.1 Establish and enforce rational environmental criteria and standards, designed to assure that perturbations due to civil air systems will be contained within bounds which are acceptable both ecologically and socially.

6.2 Give preventive attention to potential ecological damage, both direct and indirect, in airport design, location, and operation.

6.3 Prevent an undue increase in air pollution--in absolute as well as relative terms--as a concomitant of increased air travel.

6.4 Anticipate new types of ecological damage hazards which may be posed by innovative forms of aviation, and prevent the occurrence of any which could have critical and irreversible consequences.

7. IMPORTANCE OF CIVIL AVIATION TO POPULATION DISTRIBUTION AND REGIONAL DEVELOPMENT

Statement of Finding

Civil air routing and airport system development can contribute significantly to regional development and, potentially, to implementation of national population distribution policies.

Implications for Governmental Role

The nation is increasingly concerned about population growth and distribution, which may point to the need for the formulation of policies which address this area specifically. This concern coalesces out of disparate questions concerning the future "quality of life" and socio-economic makeup of the United States. It should also take into account implications for such things as transportation demand and impact on the natural environment; some of these implications are considered in other Findings.

This Finding indicates that civil air routing and airport location can significantly influence national population distribution patterns, and can therefore serve as an instrument of policy implementation.

- The structuring of commercial air service corridors will tend to stimulate growth in favored areas and discourage growth in areas not served; thus, this structuring could gradually help bring about desirable national population patterns.
- It should be noted, however, that this is a two-edged sword; if commercial air service routing procedures are not linked to whatever population-distribution policies are chosen, they may easily

help thwart those policies.

- This is particularly true if population redistribution into patterns different from those of today is decided upon as being desirable, since commercial route patterns would need to begin branching out from established markets into new routes which would not be profitable at first.
- Thus, if aviation were to be used in this role of stimulation and alteration, it would imply a need for federal subsidization of the corresponding aviation activities.

Airports can also be of importance at the regional level, in helping to shape urban and regional development patterns. In relatively new, growing areas, where patterns are still fluid and subject to change, community development can be affected to a substantial degree by airports and their relationship to the community. Airport design and size characteristics, type of air service provided, location and number of airports, and airport access characteristics can all help to determine urban growth patterns as well as the prospects for industrial and economic growth. Airports alone can by no means dictate the entire character of these patterns, but they cannot fail to be an important ingredient.

The relationship between airports and civil air service and population distribution patterns will have relevance in any case, whether the government chooses to use aviation actively or passively to influence population distribution.

- If an active approach is taken, the government can directly influence economic growth and population patterns, provided the government

makes use of the relationships between these patterns and civil aviation.

- If instead the government does not elect to use civil aviation directly as a tool to coordinate regional and/or national growth patterns, it must still reckon with the fact that many American towns, cities and regions already recognize aviation implications for their growth potential but lack the resources to maximize this potential by providing the large airports necessary to accommodate service. Federal assistance and guidance is therefore needed by these communities, and the manner in which the government provides this assistance will tend either to reinforce or to nullify other federal actions directed more specifically toward control of population distribution.

Candidate Basic Federal Undertakings

If the full potential of civil aviation for the management of population trends and achievement of desired regional economic growth is to be realized, certain undertakings will be needed on the part of the federal government. The following are relevant in this regard:

7.1 Provide federal assistance in response to local governmental efforts to develop civil aviation services as part of their economic development plans, to the degree that this assistance does not conflict unduly with achievement of higher-level federal policies concerning desired trends in population distribution.

7.2 Utilize active national policies concerning civil aviation

routes, services, and airport development to help implement policies concerning rational population distribution and regional development.

8. USEFULNESS OF STOL SYSTEMS FOR INTERURBAN TRAVEL

Statement of Finding

Significant social benefits can be realized through improved short-haul interurban aviation (particularly STOL) systems utilizing airports in urban-fringe, "new town", and growth-center locations; however, center-city STOLports appear impracticable and of questionable utility in all but a few exceptional cases.

Implications for Governmental Role

The importance of short-haul interurban travel was disclosed by the 1967 Census of Transportation, which showed that about 40% of all person-miles traveled occurred in this sector. Heavy reliance for such transportation is now being placed upon a single mode of travel--the automobile--whose further growth in traffic capability is approaching foreseeable limits due to highway congestion, for which only limited relief can be obtained by increasing highway capacity with additional lanes. There is also increasing opposition to paving over ever-increasing amounts of valuable land with roadways, which already cover a third or more of the total land area in many cities.

While the overall importance of good air transportation to the U.S. way of life has been pointed out, some unique facets of this mode of travel must be recognized in the short-haul realm.

- Aviation systems depend upon terminal facilities (i.e., airports) which are much more sophisticated and complex than those typical of ground transportation.
- Air travel has the advantage over ground transportation of not

requiring prepared rights-of-way. Therefore, if the constraints upon airport development are removed, there is potentially more flexibility in setting and altering air routes than ground routes.

- The aerospace industry as it exists today possesses the capability for rapid near-term technological progress, given appropriate economic incentives, so that aeronautical developments could yield considerable improvements in service relatively quickly.
- If this were done, it could give the nation breathing time during the decade or more which may be needed to bring to bear widespread high-speed ground transportation systems for very high capacity service.

However, this aviation potential is far from being met by current trends. Short-haul air travel is growing in absolute terms, but not fast enough to materially affect the impending crisis in overall short-haul travel. Indeed, the current trend in aviation toward ever-longer average stage lengths suggests that the air share of the short-haul market might even begin to decline unless steps are taken to bolster it.

In areas of high and increasing travel density, the need is both for increased capacity and for reduced portal-to portal trip time. When political and social objections, land costs, and interfacing with urban surface transportation are all taken into account:

- It appears that in most cases the center-city STOLport concept very probably is not as desirable in meeting these requirements as urban-fringe STOLports (rim-ports) with good high-speed access to one another and to downtown areas.

- The few cities in which center-city STOLports do appear to have merit are those in which--generally by accident of geography--sufficient land is practically obtainable at a logical STOLport location, around which the land use happens to be reasonably compatible with aircraft operations.

To the extent that shifts in population distribution are to be fostered or allowed as through the development of new towns and the stimulation of existing small towns having growth potential, the emphasis must be on flexibility and frequence of service, as opposed to high capacity.

- The capability for growth in capacity must be present, since it is precisely this growth which would be of interest, but capacity is not the most crucial factor for operations during early phases of service.
- The constraints imposed upon the utility of civil aviation by airport access problems should be much less severe in the case of growth centers than in the case of developed metropoli; but this early advantage must not be exploited in such a way as to forfeit long-range benefits.
- A balance must be struck between those interurban short-haul aviation systems designed to serve established population centers and those oriented toward smaller growth centers. Sophisticated vehicles and airports will be required to serve high-capacity inter-metropolitan areas, whereas adequate and appropriate service to small growth centers can be provided by less sophisticated

equipment and terminal facilities.

Candidate Basic Federal Undertakings

This Finding indicates that socially rewarding roles can be played by appropriate civil aviation systems in the short-haul interurban travel sector, both in influencing population distribution patterns and in helping forestall the congestive crisis in transportation which presently appears likely by 1985. If aviation is in fact to perform these tasks, certain federal undertakings will be required, such as:

8.1 Promote improvements in the capability of civil aviation to serve high-density intercity travel demands in populous corridors, as needed to help prevent congestive breakdown of short-haul inter-metropolitan ground transportation prior to introduction of high-capacity, high-speed ground transportation systems.

8.2 Promote improvements in the capability of civil aviation to satisfy needs for low-density, moderately high-frequency travel to and from selected smaller growth centers.

8.3 Develop means for effectively integrating the systems provided for "populous corridor" and "growth center" service respectively, so as to optimize the overall contribution of aviation to interurban transportation service.

9. ECONOMIC IMPORTANCE OF CIVIL AVIATION

Statement of Finding

Civil aviation is a strong contributor to the national economy in terms of employment, productivity, technological advancement, and contribution to a favorable international balance of payments.

Implications for Governmental Role

Aviation offers the possibility of major benefits to society and to the nation's economy. It can materially affect employment and productivity as well as the U.S. balance of payments, while simultaneously contributing to advancement of the nation's technological base. The economic benefits considered here do not result primarily from the service provided by aviation in its fundamental transportation role, but rather are by-products of the technology and commerce which typify the aerospace and aviation industries.

The linkage between the balance of payments and civil aviation programs is strongest where aircraft exports are involved. The sale of aircraft to other countries also helps generate high employment and industrial productivity in the aerospace industry, which is one of the nation's largest employers. This benefit is quite prominent in the aircraft industry, because the characteristics of the product cause aerospace manufacturing to remain rather labor-intensive despite very high productivity.

There are at least three interrelated facets to the economic desirability of having American aircraft which can compete in the world markets:

- Any U.S. product sold abroad at a profit helps the balance of payments, and modern commercial aircraft are big-money items.
- In the absence of competitive American aircraft to serve a commercially valuable market, foreign products will tend to be imported by U.S. operators with a corresponding negative effect upon the U.S. balance of payments.
- The ability to sell American aircraft of a given type abroad introduces economies of scale which can enable relatively small, specialized domestic aviation markets to be served by American equipment even though these markets could not by themselves support the development of that equipment.

It is interesting to note that one of the warmer debates surrounding the American SST deals with precisely the balance of payments issue, in which all three of these facets can be discerned.

The technological advancements generated by the U.S. aerospace industry, while they are not readily quantifiable, constitute a valuable resource economically as well as in a national security sense. Thus, wherever a full analysis of the transportation and social benefits and disbenefits of a proposed new aviation research program or system does not lead to a definitive "go/no-go" decision, economic considerations including the expected stimulation of technology may become the determining criteria.

Candidate Basic Federal Undertakings

If the full potential of civil aviation to help achieve U.S. economic and world trade goals is to be realized, certain basic undertakings on

the part of the government will deserve consideration:

9.1 Support, through subsidies or by other appropriate means, those functionally and socially desirable civil air system developments which can contribute most to greater employment and technological advancement, but which cannot be supported by the private sector alone.

9.2 Support, through subsidies or by other appropriate means, those civil air system developments and research programs that offer the best prospects for increasing U.S. foreign sales, and/or preventing unacceptable growth in foreign sales to the U.S.

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APPENDIX A

SOCIAL IMPACT-RELATED AREAS NEEDING FURTHER STUDY

APPENDIX A. SOCIAL IMPACT-RELATED AREAS NEEDING FURTHER STUDY

During the course of the social impact assessment carried out by the GWU Program of Policy Studies for the CARD Study, many areas were encountered in which further study would clearly be needed in order to make the assessment more comprehensive. Some of these were areas in which needed source data was unavailable; some were areas which were beyond the scope of the present study in terms of time and resources; some were areas which of necessity could not be studied concurrently with those examined so far, because of logical sequencing of effort.

A number of these items are of such a nature that they could be addressed most effectively by an interdisciplinary research team; others are much more specific in nature as they stand, and could serve -- among other things -- as problem statements for basic technological research by DOT and NASA which would be readily justifiable on social grounds. Such "problem-definition" research could be of very great long-range social value, and would typically involve a degree of technical sophistication which is entirely appropriate to the missions of these agencies.

The following summary identifies areas needing further study, organized by general subject area but without additional elaboration:

Social Impact Assessment Methodology

1. Pursue "effects" analysis to fill in Standard Reference Effects Chart (GWU/CARD methodology).
2. Compare GWU/CARD methodology with others relevant for technology assessment studies (e.g., the Delphi approach).
3. Conduct a further inquiry into alternative means of identifying technological effects and selection of those warranting detailed examination (GWU/CARD methodology).

4. Conduct a further investigation of means of evaluating, measuring, and quantifying social impacts in order to give the decision-maker information he can work with effectively.
   a. Develop alternative techniques for presenting assessment outcomes.
   b. Construct a set of indicators and other measures of effect and social need, specific to transportation and civil aviation.

5. Perform a critical analysis of forecasting techniques to determine their respective strengths and weaknesses in planning transportation systems.

Natural Environment and Resources

1. Conduct a comparative study of modes (present and predictable future) of transportation in order to determine their potential for various types of pollution.

2. Conduct an investigation for the purpose of determining the combinations of land use and modes of transportation which will cause minimum damage to the natural environment.

3. Make a comparative study of aviation with other transportation modes with regard to exhaustion of world hydrocarbon and other natural resources.

4. Conduct an investigation to gather ecological data for other than large metropolitan areas.

5. Study the effects of high altitude emissions on meterology, including but not restricted to SST's potential for harm in this area.

6. Assemble data as to the amount of solid waste produced by airports.

7. Study the effects of pollution and other side effects of human activities on natural animal populations.

Political Factors

1. Conduct a study of controversies associated with various types of public construction in order to determine what conditions evoke a direct public response.
   a. Do case studies of airport development and controversies as they relate to urban renewal and public housing projects in general.
   b. Make a field survey of metropolitan Washington airport controversies.

2. Analyze the relation of special districts and/or airport authorities with other political institutions.

3. Conduct a study of the various means of public funding utilized in the building of airports.
   a. Investigate the implications of heavy capital investment in aircraft facilities for the financial well-being of individual local governments.
   b. Make an examination of airport related bond issues.

4. Conduct a study to determine which of the various forms of public participation in land use decisions will produce the most durable solutions and most successfully prevent disruptions.

5. Conduct studies to answer the following questions:
   a. At what point in the public hearing process do citizens feel they've participated or have been consulted? What conditions must exist before citizens perceive a response, even if their demands are not fully satisfied?
   b. How early in the planning process can community participation fruitfully be introduced?
   c. How well does the public hearing process represent community attitudes and desires?
   d. What will be the social/political impacts of the developing regionalism and interjurisdictional cooperation which will be encouraged by the requirements of a vigorous airport building program?
   e. What impact do public construction (airport building, urban renewal, highway building, etc.) and the associated controversies have on local political leadership, voting patterns, elite structures, etc.? Under what conditions do such controversies evoke direct action as violent protests, demonstrations, and confrontations?

6. Analyze the continued value of mass demonstrations as an effective political tool.

7. Conduct a study to develop a satisfactory means of conveying to the public information concerning the long-range costs/benefits of public works, and the land-use implications of such works.

8. Conduct a study to determine what the public sees as proper priorities for this nation in the foreseeable future.

Legal Factors

1. Conduct an examination of the interacting federal statutes relating to civil aviation, including a study of the potential conflict between the 1970 Airport/Airways Act and the 1969 Environmental Policy Act.

2. Investigate the possible simplification of complex state constitutions to enable them to deal more adequately with modern technological advances.

3. Study the possible liability of the federal government for noise-related damage from aircraft.

Land-Use Planning and Regional Development

1. Conduct a comprehensive investigation into the potential value of civil aviation as a tool for influencing population redistribution and regional development.
   a. Examine the relationship between air transportation and the socioeconomic needs of "New Towns."

2. Make a study of land development needs in major hub metropolitan areas.

3. Develop means of measuring community consensus on land use decisions.

4. Conduct a study to determine if STOLports will serve as catalysts for significant rejuvenation of their environs.
   a. Identify the total functions, both in regard to transportation in general and to the neighboring community, of a STOLport complex.

5. Conduct a study to determine in advance potential zoning and redistricting conflicts which might arise out of the imposition of a new or expanded airport in a given area.
   a. Study competing land-use claims in connection with the siting of an airport.
   b. Study a total land-development control system for airports and neighboring land, including advanced land acquisition, innovative compensatory techniques, joint development/redevelopment concepts, and the role of federal legislation.

6. Study improved techniques for interfacing rapid transit systems with air terminal facilities, and the effects which such techniques would have on urban and regional development.

Economic Factors

1. Investigate the "functional" economic effects of aviation on society, through aviation's role as part of the overall transportation system providing mobility for people and goods.

2. Conduct a study concerning the competitive environment within the civil aviation industry, and between the industry and others which by their nature compete with it.

3. Investigate the operation and maintenance costs of STOLports of various types for comparison with those of conventional (CTOL) facilities.

4. Carry out economic studies at the regional and local level, to complement the macroeconomic analysis which has been carried out for the nation as a whole.

5. Investigate the effects which anticipated decreases in foreign sales of U.S. jet transport aircraft in the international market may have on profits and risks facing American aircraft manufacturers, and the resulting projected needs for federal subsidization of development of new aircraft.

Psychological Factors

1. Conduct a study of the tranportation needs of the various civil aviation user groups from a psychological standpoint to determine what people perceive those needs to be.

2. Conduct a study to determine what psychological factors influence population movement.

3. Investigate human-factors implications of the anticipated mushrooming expansion of private general aviation, particularly as regards safety.

4. Conduct a study of the individual's reaction to traffic congestion and determine the manner in which congestion affects man's desire to travel.

Noise

1. Conduct further research into the effects of noise -- physiological psychological and otherwise -- on people.

2. Investigate possibilities for coordination among the technical and non-technical solutions to the noise problem.
   a. Conduct a social impact assessment of alternative approaches to noise abatement.

Telecommunications

1. Conduct an evaluation of the possible impact of telecommunication technology on civil aviation.

General

1. Extend the entire GWU/CARD Study analysis through 1995.
   a. Do a full analysis of all civil aviation systems (besides interurban short-haul) defined by CARD, including general aviation and air freight.

2. Conduct a study of the total NASA/DOT relationship to delineate specific areas of responsibility and control.

3. Investigate in greater depth the social and economic effects of civil aviation in terms of a total transportation system.
   a. Perform a full analysis of interfacing factors.
   b. Study traffic peaking effects, with attention to means of relieving the congestive problems they impose.

4. Investigate the potential uses of atomic energy in the civil aviation field, particularly with reference to possible relief of depletion of hydrocarbon resources, alleviating upper-atmosphere pollution effects, and so forth.

APPENDIX B

GWU/CARD STUDY PERSONNEL

APPENDIX B. GWU/CARD STUDY PERSONNEL

Staff and Consultants--The Program of Policy Studies in Science and Technology, The George Washington University

Key for "Task/Assignment" Column--

Social Impact Task Unit (SITU) #1: Transportation-Communications
" #2: Effective Public Decision-Making Process
" #3: Economic Resources & Systems
" #4: Knowledge and Skills
" #5: Regional Impacts and Interactions
" #6: Social Behavior Patterns
" #7: Environmental Quality: Social & Natural

Study Phase: I--Basic Study (April 1 to September 1, 1970)
II--Study Extension (September 1, 1970 to April 30, 1971)

NAME	DISCIPLINE	TASK/ASSIGNMENT
Amin-Arsala, Betsy	Community Development	II--Editorial Assistant and Special Studies on Regional Impacts
Beaconsfield, Marie	Journalism	II--Report Condensation
Blatt, Joseph	Civil Aviation R&D	I--General Aviation Forecasting
Brankey, George E.	Business Administration & Law	I--Report Assembly
Brown, James M.	Law and Land Use Management	I--SITU #5
Coates, Vary T.	Political Science	I--SITU #2 II--Special Studies on Regional Impacts
Danhof, Clarence H.	Economics	I--SITU #3 and 1970 Social Environment Integration
Doscher, Susan	Political Science	II--Editorial Assistant
Dublin, Kirk	Law	I--SITU #2

NAME	DISCIPLINE	TASK/ASSIGNMENT
Ericson, Richard F.	Management Cybernetics/ Communications	I--Transportation/Communication
Fischer, William	Economics	I--SITU #3
Foa, Joseph	High Speed Ground Transportation Systems	I--SITU #1
Graham, Philip A.	Aeronautical Engineering and Transportation	I--SITU #1 II--Policy Implications Analyst and Editor, Contractor Report
Greenberg, Stuart	Political Science	I--SITU #2
Hensley, Kathryn L.	Motivational Research, Behavioral Science	I--SITU #6 and SITU #7
Holman, Mary A.	Economics	I--Integrated Analysis: Inter-Urban/Short-haul Civil Aviation Sub-Systems
Houston, Dee Ann	Ecology	I--SITU #7
Kasper, Raphael G.	Nuclear Physics	I--SITU #1 & GWU/CARD Liaison
Lingenfelter, Steve	Law	I--Institutional & Social Environmental Aspects of Major Jetport Installations
Mahoney, James E.	Organization/ Management	I--GWU/CARD Workshop Director II--GWU/CARD Project Director
Margolin, Joseph B.	Psychology	I--SITU #6 and SITU #7
Mayo, Louis H.	Public Law	I and II--PRINCIPAL INVESTIGATOR I--SITU #4
Misch, Marion R.	Behavioral Science and Psychology	I--SITU #6 and SITU #7
Mohr, Frederick	Journalism	II--Editorial Consultant
McDonald, Phyllis	Behavioral Science and Special Education	I--SITU #6 and SITU #7

NAME	DISCIPLINE	TASK/ASSIGNMENT
Reese, Howard C.	Government	I--Report Organization
Richardson, R.C. III	Management	I--GWU/CARD Workshop and Study Critique II--Direction of Policy Implications Analysis
Ruffin, Jean	Sociology/ Political Science	I--SITU #4
Saltzmann, Stephen	Aeronautics	II--Study Critique and Report Condensation
Siegel, Irving	Economics & Manpower Policy	I--Study Critique
Smith, Michael	Economics	I--SITU #3
Solomon, Henry	Economics	I--SITU #4
Studholme, Edward D.	Urban and Regional Planning	I--SITU #5
Suranyi-Unger, Theodore	Economics	I--SITU #3 II--Special Studies on Regional Impacts
Tiller, Richard	Ecology	I--SITU #7
Wood, Frederick	Electrical Engineering & Business Administration	I--SITU #1

Supporting Staff

I--Linda Taylor, Penny Blum, Ruth Cooperman, Eva Maestas, Marian Sterling

II--Penny Blum, Jacquelyn Howard, Margaret Chan

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NAME	DISCIPLINE	TASK/ASSIGNMENT
Reese, Howard C.	Government	I--Report Organization
Richardson, R.C. III	Management	I--GWU/CARD Workshop and Study Critique II--Direction of Policy Implications Analysis
Ruffin, Jean	Sociology/ Political Science	I--SITU #4
Saltzmann, Stephen	Aeronautics	II--Study Critique and Report Condensation
Siegel, Irving	Economics & Manpower Policy	I--Study Critique
Smith, Michael	Economics	I--SITU #3
Solomon, Henry	Economics	I--SITU #4
Studholme, Edward D.	Urban and Regional Planning	I--SITU #5
Suranyi-Unger, Theodore	Economics	I--SITU #3 II--Special Studies on Regional Impacts
Tiller, Richard	Ecology	I--SITU #7
Wood, Frederick	Electrical Engineering & Business Administration	I--SITU #1

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