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SUMMARY & RECOMMENDATIONS NASA/MIT WORKSHOP ON SHORT HAUL AIR TRANSPORT

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SUMMARY AND RECOMMENDATIONS FOR THE NASA/MIT WORKSHOP ON SHORT HAUL AIR TRANSPORT
WATERVILLE VALLEY, NEW HAMPSHIRE, AUGUST 1971

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Editor

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Executive Summary

1.0 A review is given of the material covered by the MIT/NASA Waterville Valley workshop which dealt with the institutional, socio-economic, operational, and technological problems associated with introducing new forms of short haul domestic air transportation.

2.0 It was found that future air systems hold great potential in satisfying society's needs for a low noise, low landspace, high access, high speed, large network system for public travel over distances between 5 and 500 miles. In comparing future air and ground systems, it was found that:

2.1 Air systems use much less land and cause less noise sterilization than ground systems offering a similar service.

2.2 Air systems do not require a large, high risk, initial public investment like all ground systems.

2.3 Air systems are far more flexible than ground systems in adding new vehicles, new routes and new terminals to match a changing form of urban development.

2.4 Air systems offer better travel service to the passenger since access times and trip times will be shorter for the average passenger.

2.5 Air systems have a large, unexploited technology base whereas considerable effort is needed for advanced ground systems.

2.6 Air systems possess good export potential since the major investment is in vehicles saleable in the world market.

2.7 Both air and ground systems have community acceptance problems in acquiring land for ground facilities.

3.0 A review of technological programs related to short haul air transport revealed three surprising developments:

3.1 Very quiet propulsion now appears possible by using turbine engines which drive variable pitch, geared fans of bypass ratios up to 35. Takeoff and landing noise footprint sizes are reduced to one twentieth or less of present sizes by this form of propulsion which offers high takeoff thrust, and reasonable cruise efficiencies up to 500 mph.

3.2 The military programs to quiet the helicopter have had remarkable results. Two 50 passenger, 180 mph transport helicopters exist which can meet a criterion of 95 PNdb at 500 feet in hover, and future designs promise levels around 85 PNdb with relatively little change in operating cost.

3.3 Automatic ride control systems have demonstrated very good ride smoothing for all airplanes operating in rough air, but are of particular importance for low wing loading vehicles of the RTOL and STOL classes. These systems use inertial sensors to control wing flaps during cruise, and are the airplane equivalent of active suspension systems proposed for high speed ground transport vehicles.

Technology recommendations supported further development in each of the above areas because of their importance to future short haul air systems. A recommendation was made for developing improved guidance and control systems for STOL and VTOL vehicles, and for a review of research and development needs in non-vehicle areas such as air traffic control, and metroport operations.

4.0 The crucial issue for introducing new forms of short haul air transport was identified by the workshop as community acceptance of new airport/metroport ground facilities. An environmental statement and hearing are now required for federal investment in such facilities. It was concluded that quiet air systems were necessary (but not sufficient) for obtaining community approval. The following recommendations were made:

4.1 An extremely high priority must be assigned to the development of quiet aircraft for future short haul air systems, such that the environmental impact hearings can show net benefits to the community from introducing the system.

4.2 Studies of community acceptance factors should be undertaken to develop information and strategies for working with the community in the process of site selection and approval.

4.3 A national method of measuring community noise around airports and metroports should be developed. Local communities should be able to select standards for community noise using the methodology and have a non-aviation agency monitor and ensure compliance.

4.4 In order to provide economic incentives for operators to buy quiet short haul aircraft, a landing noise charge should be established which gives credit for reductions in noise footprint size for takeoff and landing operations.

4.5 All aircraft proposed for use in short haul demonstration projects should be significantly quieter than present day jet transports even if their operation is at busy airports, or small airports with no noise problem.

There were a number of findings related to other problems and issues concerning short haul air transportation:

4.6 Demonstration Projects for short haul air services pointed at obtaining market research data should be carried out under the leadership of the Department of Transportation.

4.7 The possibility of accommodating a busy short haul air system operating at metroports, peripheral airports, and at busy major airports should be given full consideration in the planning for both upgraded third and fourth generation ATC systems.

4.8 There is a need for DOT to establish a long term, consultative, participatory transportation planning process which should provide a policy statement on the future of short haul air transportation.

5.0 Because of the uncertainties in factors such as market acceptance, system performance, operating costs, environmental costs, etc. associated with planning for new forms of transportation, it is advisable to demonstrate new systems on a small scale over a few years time before committing the nation to a risky, long term major development. The primary objective of these Demonstration Projects should be market research to determine the relative importance of fare, frequency, trip time, accessibility comfort and ride quality to the passenger.

The Bi-Centennial Celebration in Philadelphia in 1976 was suggested by the workshop as an arena for demonstrating the value of a quiet short haul air system to a large number of the nation's travellers. Not only would the proposed three sites be connected by helicopter service, but short haul services would be operated into these sites by suitably quiet RTOL, STOL or VTOL vehicles from airports at New York, Philadelphia, Baltimore,and Washington as well as other sites in the Northeast Corridor. After the celebration, the New York to Washington corridor could be used to demonstrate passenger acceptance in competition with other forms of transportation.

6.0 A "QTOL" Program was developed by the workshop as a suggested national plan for quietening the takeoff and landing operations at major airports, providing capacity for long haul growth, and at the same time building a greatly improved short haul air transportation system. It is an alternative to other currently proposed aviation programs such as the Nacelle Retrofit Program, or Re-engine Program, and other concepts such as construction of remote or offshore jetports, extensive land acquisition around existing jetports or buying avigation noise easements in the noise impact areas.

Its key is the use of the new quiet propulsion to construct quiet aircraft called "Q-PLANES" of the RTOL, STOL, and VTOL class suitable for short haul travel. By diverting a sizeable fraction of the short haul passengers to "Q-PLANES" operating from new shorter runways called "Q-WAYS" constructed at major jetports, a significant reduction in the noise environment can be provided for the surrounding communities. At the same time, runway capacity can be released for longer haul air transports which themselves will be quieter with the introduction of the jumbo jets like the DC-10, L-1011, and B-747. The QTOL program also envisages the introduction of short haul air services from a number of new sites in the city center and suburban areas. These are "Q-PORTS" where the noise levels are strictly guaranteed to the community, and monitored and enforced by local non-aviation authorities. Only Q-PLANES would operate from Q-PORTS, providing service to Q-WAYS, at major jetports, and to other Q-PORTS.

The "QTOL" program provides a framework for establishing a national policy for short haul air transportation. The detailed planning of its development requires the concurrence of the aviation industry which should play a consultative role as the program is carried out.

1.0 Introduction

This report summarizes the results of a summer workshop on short haul air transportation held at Waterville Valley, N.H. August 2-27, 1971. The workshop was sponsored by the Flight Transportation Laboratory, Department of Aeronautics and Astronautics, MIT, and sponsored by the Office of Advanced Research and Technology, NASA. Over 100 experts from government and industry of three countries, U.S.A., U.K., and Canada attended the workshop to make presentations, or participated in workshop activities. Participants and presentations are listed in Appendices A and B.

The primary goal of the workshop was described as: "to develop a rational evolutionary plan for the development of a national short haul air transportation system."

A set of sub-goals was described as:

1) to review the past and present activities of the various government agencies, the manufacturers, the operators, and local authorities, and to outline a set of alternative paths of development which can be placed before transportation planners and policy makers.

2) to identify and describe critical issues in determining a national policy, and to determine the requirements for resolving these issues.

3) to provide guidance to various governmental R & D programs by ranking the importance of research tasks, identifying new areas for research, and describing more precisely the tasks to be performed in various operational testing and development programs already initiated.

While it is impossible to achieve the primary goal through the mechanism of an isolated workshop, it is believed that the sub-goals have been achieved. It is hoped that this report will lead to better understanding by transportation planners of the technological developments for future short haul air transportation which are occurring both domestically and internationally, while helping technical planners in understanding the non-technological factors encountered when introducing new systems of transportation into our society. This interchange between planning disciplines should lead to a rational integrated plan for better short haul air systems.

The short haul air transportation system is defined as servicing intercity and urban trips by passengers and cargo over distances of 5 to 500 miles. The present domestic airline system has been developed for intercity travel at longer hauls, and does not carry any significant traffic presently at distances less than 100 miles, yet roughly 50% of domestic passengers, and 80% of domestic scheduled flights are travelling less than 500 miles. Figure 1.1 shows the stage distribution of passenger trips for 1969 from CAB data. These values indicate the substantial demand for short haul air transportation; this should be a major consideration in planning for both future ground and air transport systems. Thus the importance of having a coherent national policy and plan for the development of the role of short haul V/STOL air transport systems as part of the overall national air transportation system seems clear.

This need has been recognized by a variety of governmental agencies, and the workshop operated in the context of an abundance of prior studies, planning documents, and ongoing activities. An attempt was made to review these activities, and to have participation by all concerned organizations. At the federal level, the following agencies were identified as being actively interested in planning which affects future short haul air transportation:

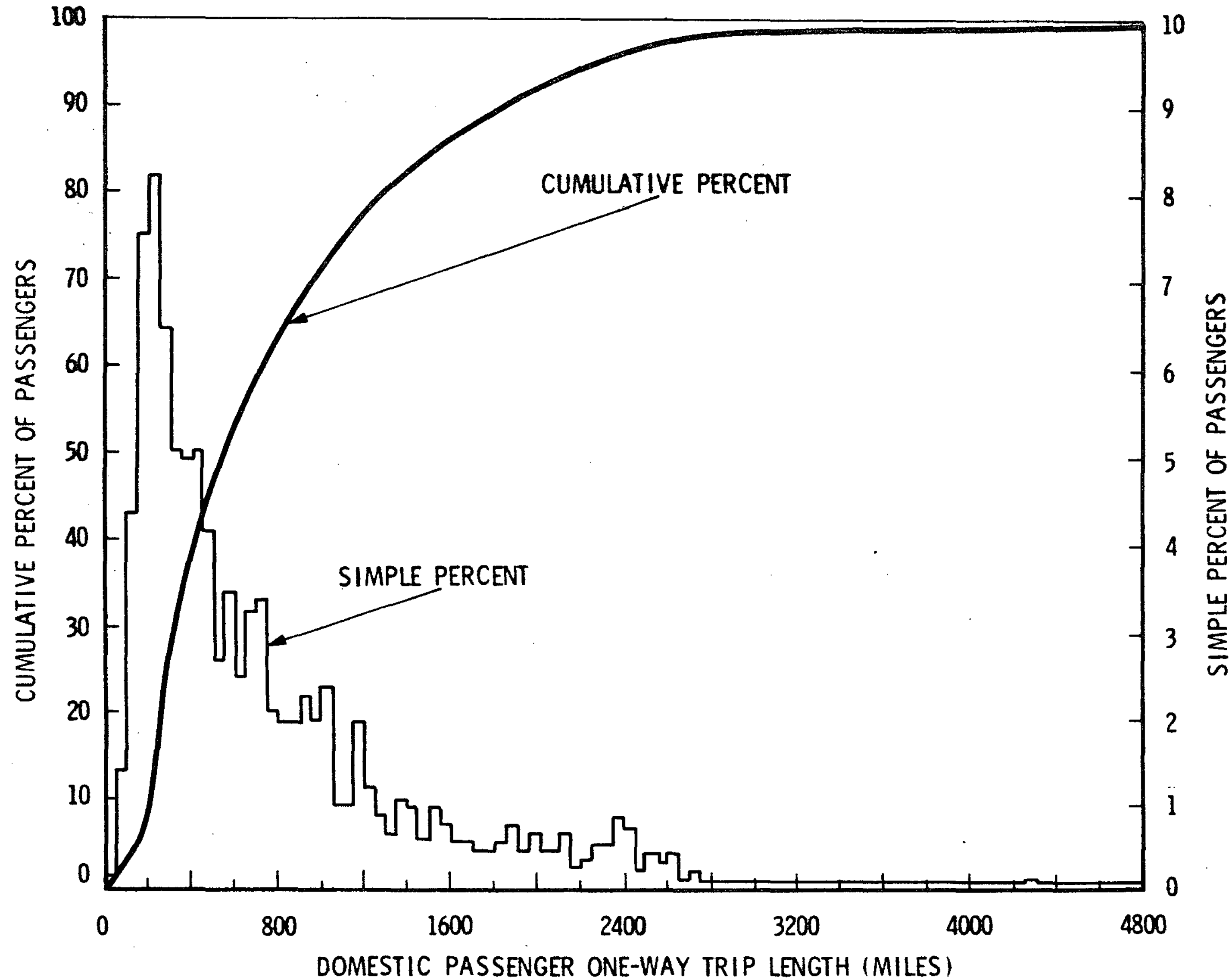


Fig. 1.1 Distribution of Passenger One-way Trips

Civil Aeronautics Board	-	Northeast Corridor Hearings (Trunk Airlines) Commuter Airline Hearings (Air Taxi Airlines)
National Aeronautics and Space Council	-	V/STOL R & D planning
Department of Defense	-	Military V/STOL R & D
Aviation Advisory Commission	-	Future Aviation Planning
DOT/TPI	-	Transportation Policy Statement, NECTP Recommendations
DOT/TST	-	CARD study, and follow on studies for R & D planning
NASA	-	CARD study, V/STOL R & D program
DOT/FAA	-	V/STOL Special Special Projects Office (SPO)

The creation of the V/STOL SPO within the FAA provides a central focal point to coordinate at least the activities of the federal agencies involved: DOT, DOD and NASA.

As well as these national activities, the workshop had to operate in the context of governmental activities and planning for short haul air transport occurring at an international level. European countries such as Great Britain, France, and Germany have similar sets of agencies interested in the development of short haul V/STOL aircraft and air transport systems. Canada, in particular, has established a national STOL air systems development plan, and is planning three STOL demonstration projects which were described to the workshop. All of these countries expect a sizeable US market for selling VTOL and STOL transport aircraft as part of their program.

The operation of the workshop followed well established practice. Some 56 presentations by government and industry were made during the first three weeks on a wide variety of topics, and a full discussion of presentations was allowed. The workshop participants organized themselves into panels to work on the workshop report.

A final briefing before some 33 invited guests was held on Friday, August 27. Various other briefings on the workshop have been subsequently presented in Washington to groups in NASA, DOT, FAA, and the Aviation Advisory Commission.

2.0 Why Short Haul Transportation by Air?

2.1 The Potential of Short Haul Aviation

In the total transportation system, the stagelength 50-500 miles, - which may be taken as defining the intercity short haul sector, is of exceptional importance. Both in the USA and in many other developed regions of the world the major high traffic-flow intercity routes lie in this range, creating the most intense competition between road, rail and air, and between operators within a common mode. It is in this sector that the conflict is most intense between society's need for "instant transportation" and society's rejection of the resultant damage to the environment, - by noise, pollution, land sterilization and unsightliness. This market may be served by all the major modes of transportation, but each mode is afflicted with operational, economic and environmental problems.

A rational transportation planning strategy must determine the relative merits of the various short haul modes and how they may be combined to provide the most benefit and economy. It must also consider how best to interrelate the resultant short haul system with the ultra-short haul and intra-urban system (5-50 miles) on the one hand, and the medium range, transcontinental and transoceanic systems on the other.

A survey of the progress of aviation (as itemized in the CARD study) reveals remarkable advances in air traffic growth, in reduced fare levels, in time saved, in improved safety, in numerous benefits to society through the stimulation of commerce and exploitation of natural wealth, and in benefits to the nation in technological leadership and international trade. A future strategy should take into account the investment represented by this past progress without underestimating the impact of present negative factors such as noise, pollution, and congestion. But it must also recognize the true potential of short haul aviation, not what it is now but what it can be, without overestimating future possibilities in the technical, social, regulatory or political fields.

The potential of short haul aviation derives primarily from the flexibility of the vehicle; despite the sophisticated and complex infrastructure which is part of the modern air system, air transport has always been and will continue to be dominated by the innate qualities of the vehicle. It is worth summarizing these and contrasting them with the characteristics of short haul surface systems.

First the aircraft is a fast vehicle. The average cruise speed of the modern jet is ten times faster than the automobile and six times faster than present day high speed trains. In all probability even the high speed train, running on good conventional track and with improved propulsion and suspension systems can only reduce this factor within a decade to around four, still leaving the aircraft with a substantial speed advantage.

Secondly the aircraft needs no track or guideway and every route is substantially free from all constraints of geography and from most constraints of weather. It is true that, along a single high density traffic corridor, a 500 mile rail "spine" might involve a capital investment, traffic control and infrastructure running costs similar to that required for a new airport/ATC chain of the same throughput capacity. But in practice an effective transport system must progress from the spinal to the network pattern, and eventually to the area coverage situation exemplified in the marine context by the "freedom of the seas". It is doubtful whether, against a history of intensive use of road and rail, but of a relatively sparse exploitation of the immense volume of the airspace, the true future potential of this quality of the air system has yet been grasped. It has been argued that the acceptance of the automobile in place of rail has been primarily due to the provision of a more widespread and more closely knitted road netowrk, the logical outcome of which is the "concrete sea" which threatens to engulf Los Angeles.

Air transport is only at the beginning of such a comprehensive stage of network development; even so it long ago passed the stage at which its network mileage could conceivably be approached within an acceptable capital budget, by any high speed surface transportation system. The elimination of all track costs (right of way and land acquisition, cutting, bridging, tunnelling, grading and general track construction and maintenance) has contributed to the success of aviation not only in the densely populated high land value corridors of North America, Europe and Japan but also in developing areas of low population.

At both extremes of the traffic density spectrum aircraft operate with minimum damage and disfigurement of the environment. Over most of their flight distance aircraft create hardly any discernible pollution or noise upon the surface over which they operate; the scarred land, the smog and haze upon which the air traveller looks down is not of his doing. Over most of its flight aircraft are detected only by sight, not sound. All these qualities result from the elimination of the constraints of the surface. As urbanization and surface congestion grow, the achievement of speed and the resulting productivity, economy and demand, become steadily more difficult and costly on the surface. The 3-dimensional aviation system remains perhaps the only one capable of economy-through-speed and incidentally economy-through-scale. Short haul aviation thus exhibits a combination of characteristics which has already made it the major transportation mode in the short haul sector and which potentially fits it for an expanding role in the foreseeable future.

And yet in the most highly developed short-haul markets of the world centered on New York, Los Angeles and Chicago, both block speeds and traveller's average trip speeds are falling. Failure to exploit 3-dimensional flexibility causes increasing congestion, and public concern over aviation noise and pollution in the vicinity of the airport is reaching an intensity which threatens the progress and possibly the very existence of many short haul aviation services.

All this represents a failure not of the aircraft/airport environment interfaces. But it does raise the question for the transportation strategist as to whether the potential of the airplane in its element can be realized, or whether it is limited by the constraints of the surface and near surface elements of the aviation system.

Taking a broad view, it would seem that the environmental problems of aviation spring mainly from one source, the high-velocity turbojet or turbofan propulsion unit. This unit, originally developed for high performance military aircraft, requires high jet velocity to produce high power in a compact form. Total engine noise is determined more by jet velocity than by any other factor, including size. It follows that the public reaction against aircraft noise, which has prevented the expansion of airports, or the opening or reopening of additional airports (which has in its turn increased congestion and reduced accessibility) is essentially a reaction against high jet velocity.

It is logical then to attempt to reduce the jet velocities of these engines. This is already underway. The engines on the Boeing 747, DC-10 and L1011 have achieved a 40-50% reduction from previous velocity levels. As a result these aircraft seem four times further away from a listener as a DC-8 or 707 at the same distance. Further reductions are not only possible but are being achieved steadily and progressively under the pressure of political demand. The noise problem has started to recede acoustically as if the whole airport/aircraft complex were being slowly withdrawn from the neighborhood of the community.

Separation in real distance of the aircraft and the community is of course also an option which is open to aviation as a flexible transportation system, in contrast to a fixed base railroad which cannot be readily repositioned in response to environmental complaints. The use of existing smaller peripheral airports not only removes noise from thickly populated areas, but also satisfies the demand for increased capacity and decreased air terminal congestion, both on the air side and land side.

Thus short haul aviation has sufficient operational and technical flexibility to solve the noise problem by a combination of source silencing and separation. For the present the separation requirement will preclude downtown city center operations except by the quiet helicopter. However, progressive demonstrable noise reduction could lead to the utilization of more conveniently located smaller airports by quiet short field CTOL (Conventional Takeoff and Landing) aircraft.

The pattern that emerges for the development of short haul aviation within the time frame 1975 - 1980 is the use of the flexible response inherent in aviation to reduce community annoyance while providing better service to the traveller.

The technology required to make these improvements is quite modest and within the state of the art: quieter, but not very quiet engines: lift wings, but not powered lift: use of existing smaller airports, but not new metroports: improved terminal guidance and area navigation. These are available measures which could at least maintain the position of aviation during the 1970's in the total short haul transportation spectrum, while making useful improvements in accessibility, reliability, and community noise.

The long range role that short haul aviation can and should play in a national transportation strategy will not, however, be determined by its ability to adapt to the conditions of the '70's, vital as that may be to the national welfare. Technological lead times are now so extended, both for air and surface transport modes, that a view must be formed now of future probabilities, and sufficient experimentation for advanced short haul systems must be carried out during the next five years to enable a firm transport strategy to be decided upon somewhere around 1975-6,which will determine the salient feature of short haul transportation for the '80's and possibly the '90's. Technical, social and political developments are now accelerating at such a rate that it is quite conceivable that by the 1980's the present environmental concerns will have come to dominate political thinking even more fundamentally. What might be called the mechanical structure of society, of which air transport is an important component, may have to adapt itself to achieving the increasing efficiency and economy demanded by a sophisticated society within heretofore unprecendented constraints imposed by conservationist democracy. In brief the product must from its inceptior be sold commercially <u>and</u> socially <u>and</u> politically.

To win the general approval of society, aviation must have the ability to react adequately to the criticism of **society-as-spectator**, which it has failed to do in the past, while offering society-as-user a quality of service in advance of demand (in which so far it has succeeded). This dual requirement can be met by technological changes within the air vehicle itself. Aviation's problem may at first sight appear to be associated with the airport, just as the automobile's is a problem of road-space and the railroad's a problem of track cost and flexibility. But the airport at present is not a <u>fundamental</u> of aviation in the way that the road and the rail-track are fundamentals of surface systems. Airport land usage and localized noise are products of the particular runway requirements and noise characteristics of transport aircraft at this particular stage in its development, a stage which, from the vantage point of the 80's and 90's may well appear rudimentary.

Society as a user of aircraft has demanded lower fares, requiring aircraft that are most economical to operate, at the expense of an excessive demand for landing space, and excessive noise level at low altitude and speed, and the consequent separation of airports from demand centers. A differently motivated non-user society could conceivably have presented technology with quite different requirements and this could equally have been satisfied.

At present there are no aircraft that are quiet, require a small landing area, and operate at the same comparative cost levels as CTOL aircraft. But with the advantage of technology, the realization that the solution to the problem of meeting these requirements is within vehicle design, indeed primarily within powerplant design, ensures that these requirements will be met. By the 1980's quiet, low landspace vehicles will be operating (and with them a more convenient location of metropolitan access points), not without economic penalty, but at a cost which, in the environment of the day, will be acceptable.

Past experience suggests that a technical challenge which can be focused upon a tangible object, such as an aircraft, generates more technical skill and energy (and frequently arouses more public sympathy and identification) than more diffused multi-element systems. Furthermore this is a proper field for competitive enterprise in research, production and operation, which still appears to be the major stimulant of progress.

In summary short haul aviation is potentially the fastest, cleanest and quietest short haul transport system which technology has so far evolved. Its fundamental qualities derive from its use of airspace, which is vast, compared with landspace which is congested and obstructed both by man and nature. By definition it is flexible, and its potential for expansion both in terms of vehicle size and network size does not appear to be constrained. The present environmental crisis is the outcome not of a fundamental characteristic of aviation, but of a particular course of development of the transport airplane over the last twenty years in response to user demand, not total social demand.

With the change in the balance of requirements, aviation technology has been re-directed, and progress towards the low-noise low-landscape vehicle is unlikely to be inhibited by any fundamental limits of technology. The transportation strategy for the 80's and 90's may well be determined in the middle of this present decade. It is suggested that in a society which is steadily upgrading its value of both time and the quality of life, the low-noise, low-landspace, high access, high speed, large network short haul air transport system offers the greatest potential for acceptance.

2.2 A Fundamental Comparison of Air and Ground Systems

This section of the report will emphasize some of the fundamental differences between new air and ground systems for short haul travel, particularly VTOL (Vertical Takeoff and Landing) and STOL (Short Takeoff and Landing) air systems and high speed ground systems. Transport systems consist of physical elements called vehicles, terminals, and guideways. While both air and ground systems designed for similar service will have similar vehicles and passenger terminals, with roughly similar investment costs, any form of new ground system will have a large expensive fixed guideway element to be compared with the runways of the air system. The problems of obtaining right of way, and financing the construction of the guideway networks required for widespread public service, now foreclose any future development of this anachronistic type of public transport system. The following sub-sections make very basic comparisons between air and ground systems on various important and fundamental characteristics.

2.2.1 Air Systems Use a Small Percentage of Land and Noise Areas for Ground Systems

A comparison of both land areas, and noise areas for present air and rail systems is shown in figure 2.1. It plots land area and the noise area within a 90 PNdb contour against track length on logarithmic scales. For the air systems runway length is used for track length, although one runway may be used to service aircraft from many terminal points. The CTOL aircraft is a present day short haul jet transport like a DC-9. The STOL is a propeller STOL like the DHC-7, and the VTOL is a large present day helicopter. The rail system is similar to the Metroliner or Turbotrain.

Figure 2.1 indicates that the land usage for a CTOL airport with 7000 foot runways equals 100 miles of tracklength, and the noise

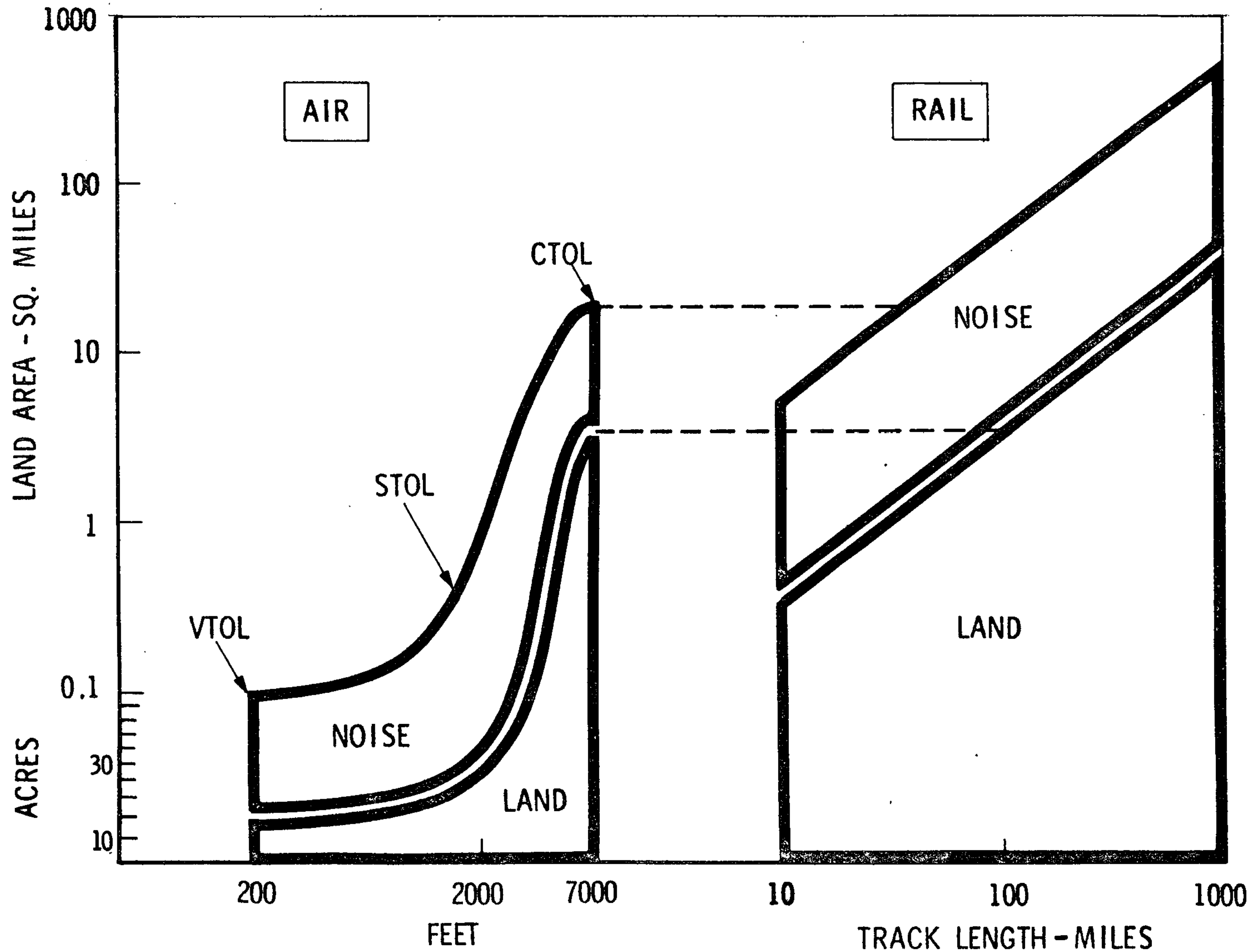


Fig. 2.1 Land and 90 PNdb Noise Areas-- 1960-70 Technology

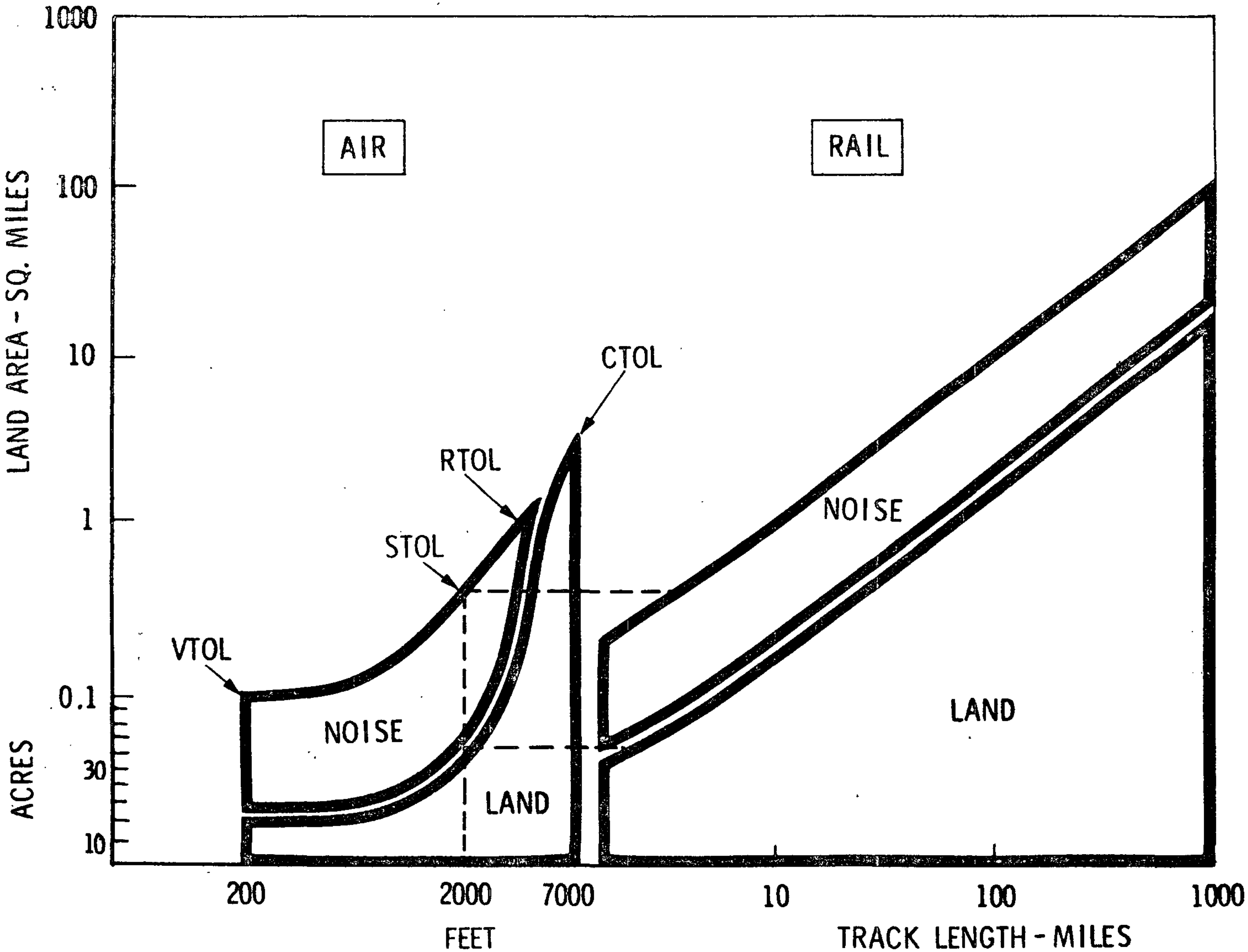


Fig. 2.2 Land and 90 PNdb Noise Areas -- 1980 Technology

sterilization area is equal to 50 miles of track. For STOL or VTOL systems, the track lengths must be under 10 miles to gain equivalent land usage. If one considers connecting 10 or more city pairs using the same airport or metroport and its runways, it becomes clear that both the land and noise sterilization areas of a present air system are a small percentage of that required for a present ground system.

Figure 2.2 shows a similar plot using improved technology appropriate for 1980 when quieter propulsion systems can be expected. This shows that a 2000 foot runway STOL system will have smaller land usage than improved high speed rail systems unless their track lengths are less than two miles, and the STOL noise area will be smaller unless rail tracks lengths are less than four miles. In this case, even if the train were absolutely silent, the land usage alone would exceed the land usage and noise area of the STOL system for any track lengths above 20 miles. Again, the possibility of connecting 10 or more city pairs makes the land usage of future air systems a very small percentage of any future ground systems.

2.2.2 New Ground Systems Require a Large, High Risk, Initial Public Investment

Because of the large programs for land acquisition and construction of guideway links, there is a large initial investment for ground systems which must be made over a period of several years ahead of the start of public service. Also, because of the uncertainty in forecasting public acceptance several years ahead of initial service, and in the face of probable development of competitive forms of short haul air service in that time scale (perhaps initiated by international programs), this large initial investment carries a high degree of risk as to the successful outcome of a viable high speed ground transport system. These factors prohibit the injection of private capital into the development.

As shown in figure 2.3, the investment per route mile for air systems is proportional to traffic volume along a route since vehicles are added as the system proves its need. For low volume routes (less than 100,000 passengers/year), there is an investment ratio of roughly 100:1, and it is not until there are 10 million passengers/year on a route that the investment/mile in the air system equals that of the ground system. Conversely, for low volume routes, the same investment would provide about 100 times the route mileage for the system. It is not surprising to notice that when governments wish to provide transportation to open up new areas of their country (as in Canada, Australia, Africa, or Russia) they no longer invest in rail systems.

Figure 2.3 also shows that if traffic volumes above 10 million passengers/year can be expected along a route, the investment per mile for the ground system would be less than for the air system. The proper strategy for construction of a rail system then is to build a "spinal" configuration where large adjacent areas are required to feed their traffic to and from the spine. The air system's strategy could be to add connecting service directly between the adjacent areas as the demand justifies adding this service. Because the ground system cannot afford to construct such connecting links, it is vulnerable to such later improved service offered by an air system. Figure 2.4 shows forecasts for the Northeast Corridor, with a simple splitting of traffic occurring in the year 1978 for the highest volume route. This effect inhibits the ground system from

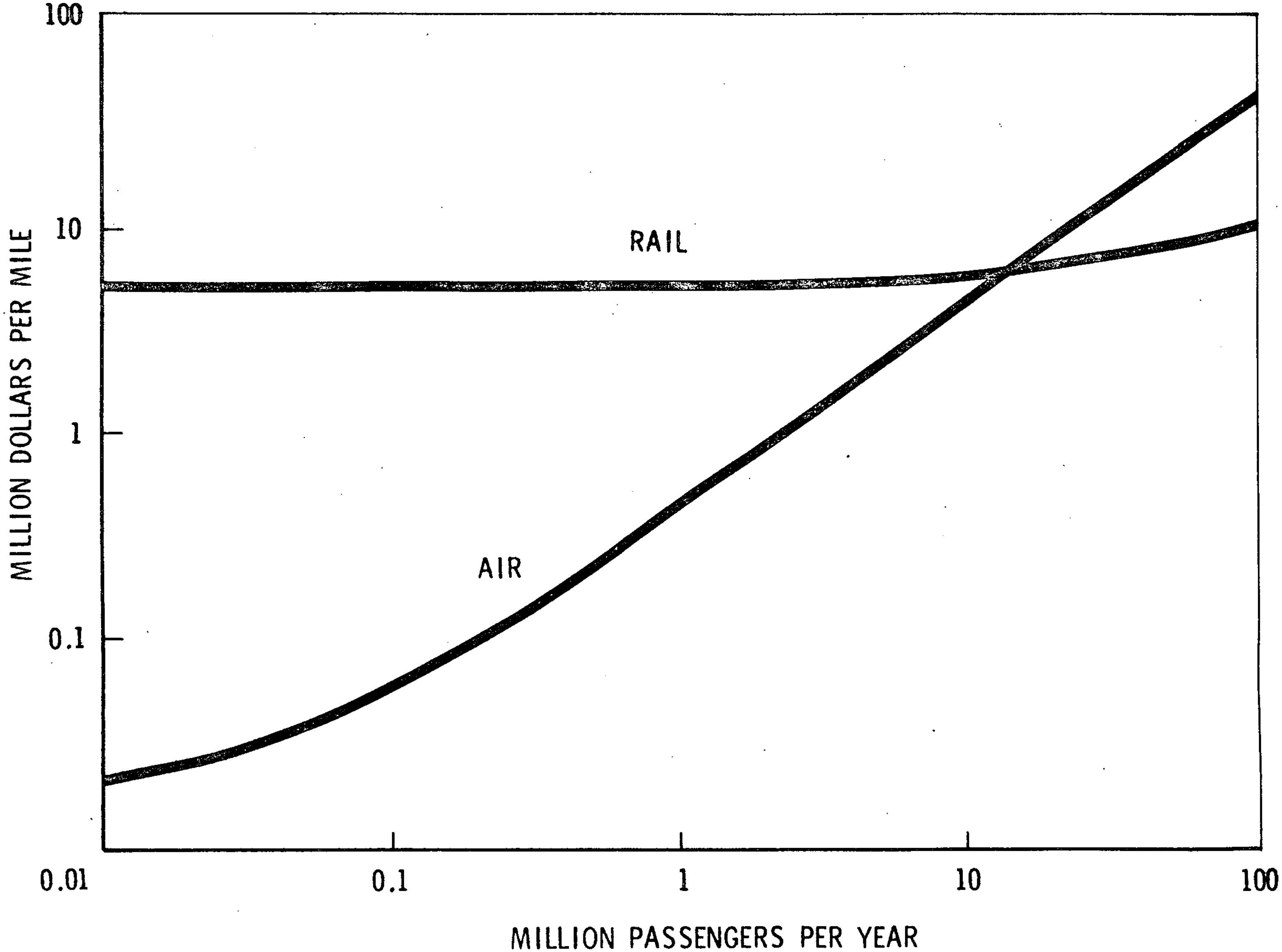


Fig. 2.3 Investment per Mile -- Rail and Air Systems

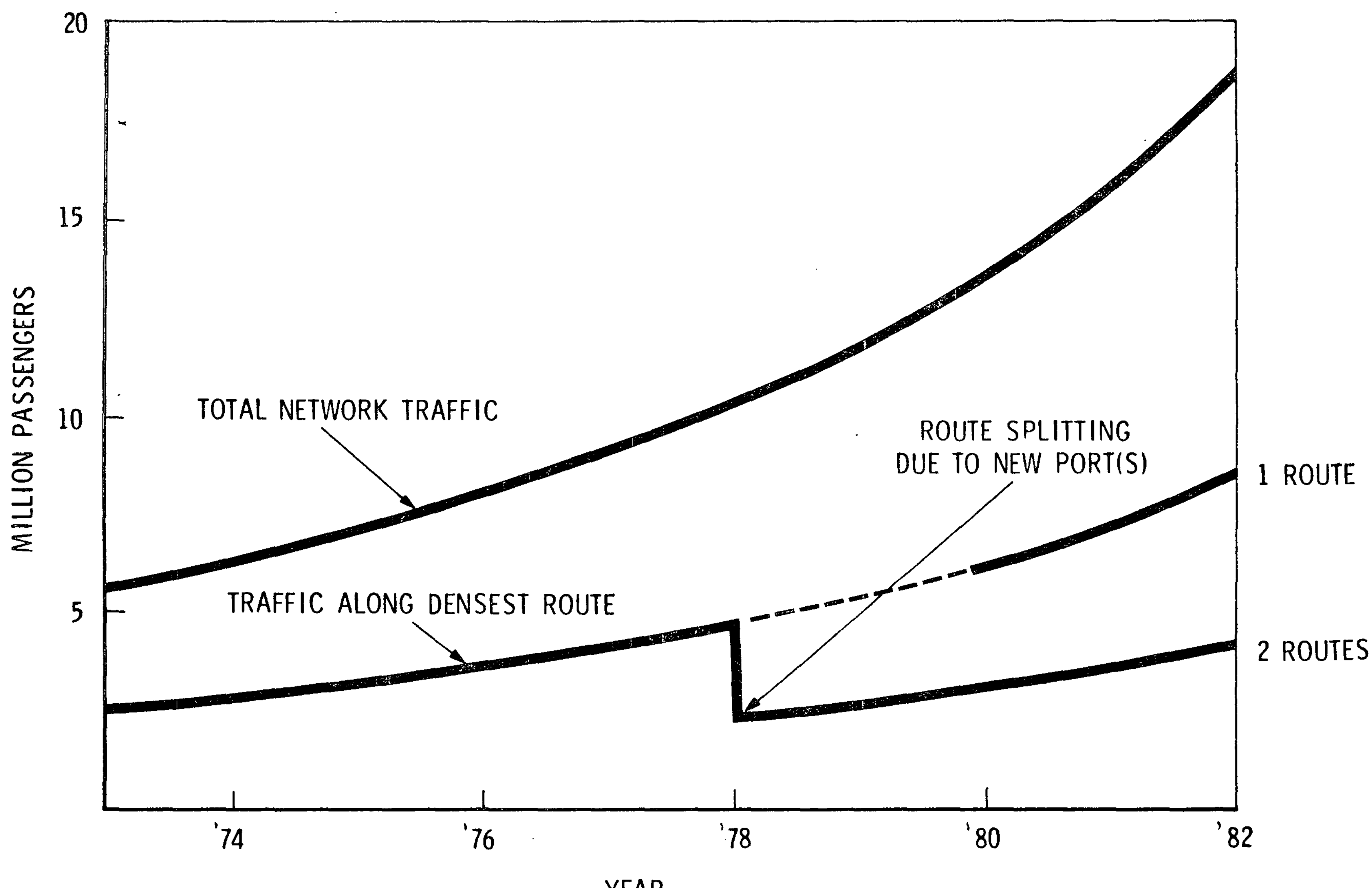


Fig. 2.4 Typical Projection -- Potential Air Traffic 1973-82

ever achieving the high traffic volumes required to improve the investment ratio.

2.2.3 The Air Systems are Far More Flexible than Ground Systems

Air systems consist of a set of terminals (airports or metroports) and vehicles which can fly from one terminal to any other terminal. The network of services can be flexibly changed as land usage, population shifts, etc. adjust over a long timescale. Also, the size of the air vehicles, and their frequency of service are easily varied. For STOL and VTOL in particular, there is a relatively low investment in initiating new terminals and entering new short haul travel markets to obtain traveller response. If the market response is not good, or declines after some time, there is only a small loss in leaving the market.

Ground systems cannot add routes very easily or adapt themselves to demands unseen at the time of construction of the system. They tend to fix the urban form for as long a period as they are in use. The introduction of a successful spinal system to an area like the Northeast Corridor would have a prime impact on land usage and travel patterns over a long period of time such as to develop high density urban areas along the spine, particularly at terminal locations. In these times, the changes which 10 or 15 years bring in the form of new technology for both air and ground transportation systems, in changing life styles, in new patterns of land development would mean that any inflexible system would be bypassed, and become obsolescent.

The potential short-haul domestic market under 500 miles identified from 1969 CAB traffic statistics are shown in figure 2.5. As can be seen, these routes exist throughout the country, and can

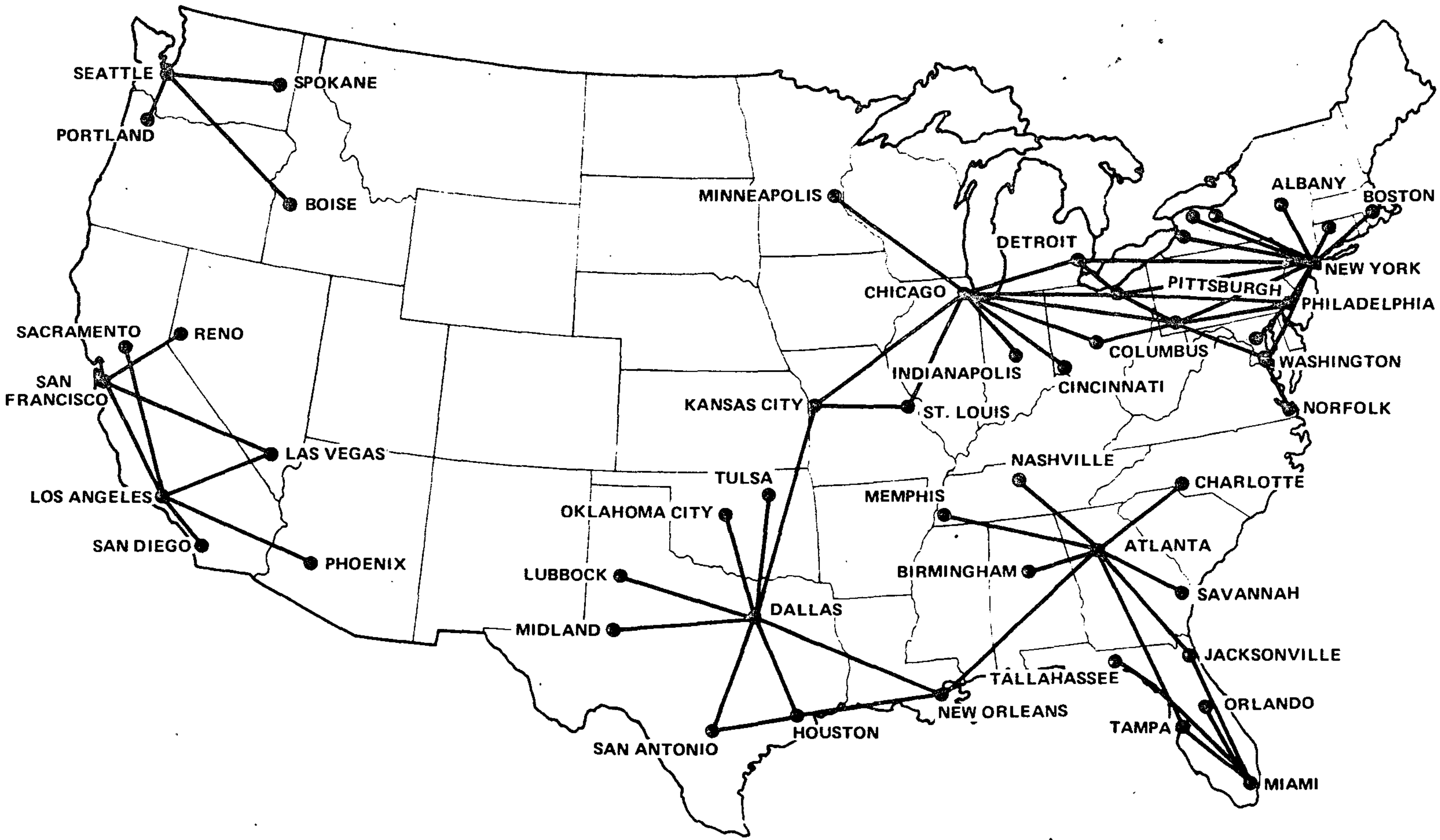


Fig.2.5 Potential short-haul market regions.

only be served by a short haul air system because of its low investment costs and flexibility in marketing its service to this wide variety of markets.

2.2.4 Air Systems Offer Better Travel Service to the Passenger

One of the major selling-points of any transport system is the convenience that is offered in terms of reduction of total trip time. Figure 2.6 shows average total trip times for city center to city center for different modes of travel in 1975 and 1985. The rail system is expected to have a block speed of 100 mph in 1975. Even so, a CTOL system offers a reduced trip time for distances of about 140 miles and more. A suburban STOL with a block speed of 250 mph offers an advantage over distances of 50 to 350 miles, and a metropolitan helicopter, operating at 185 mph, offers a further small advantage. It appears that current technology for air systems offer advantages over advanced but otherwise conventional rail systems at any range. For 1985 technology, using TACV with a 250 mph block speed as datum a comparison may be made with both a suburban STOL and a metropolitan V/STOL system, both with a cruise Mach number of 0.8. The reductions in total trip time are still evident.

Although it is difficult to quote actual operating costs especially for 1985 technology, some comparisons can be made on the value of time savings for various air systems compared with rail, as shown in figure 2.7. For 1975, time is valued at somewhat less than the $12/hour the CARD study suggests, but the savings in cents per mile are self-evident. For 1985 time is valued at $20/hour as in the CARD study, and the value of time saved when travelling on a metropolitan V/STOL system as compared with TACV is also shown.

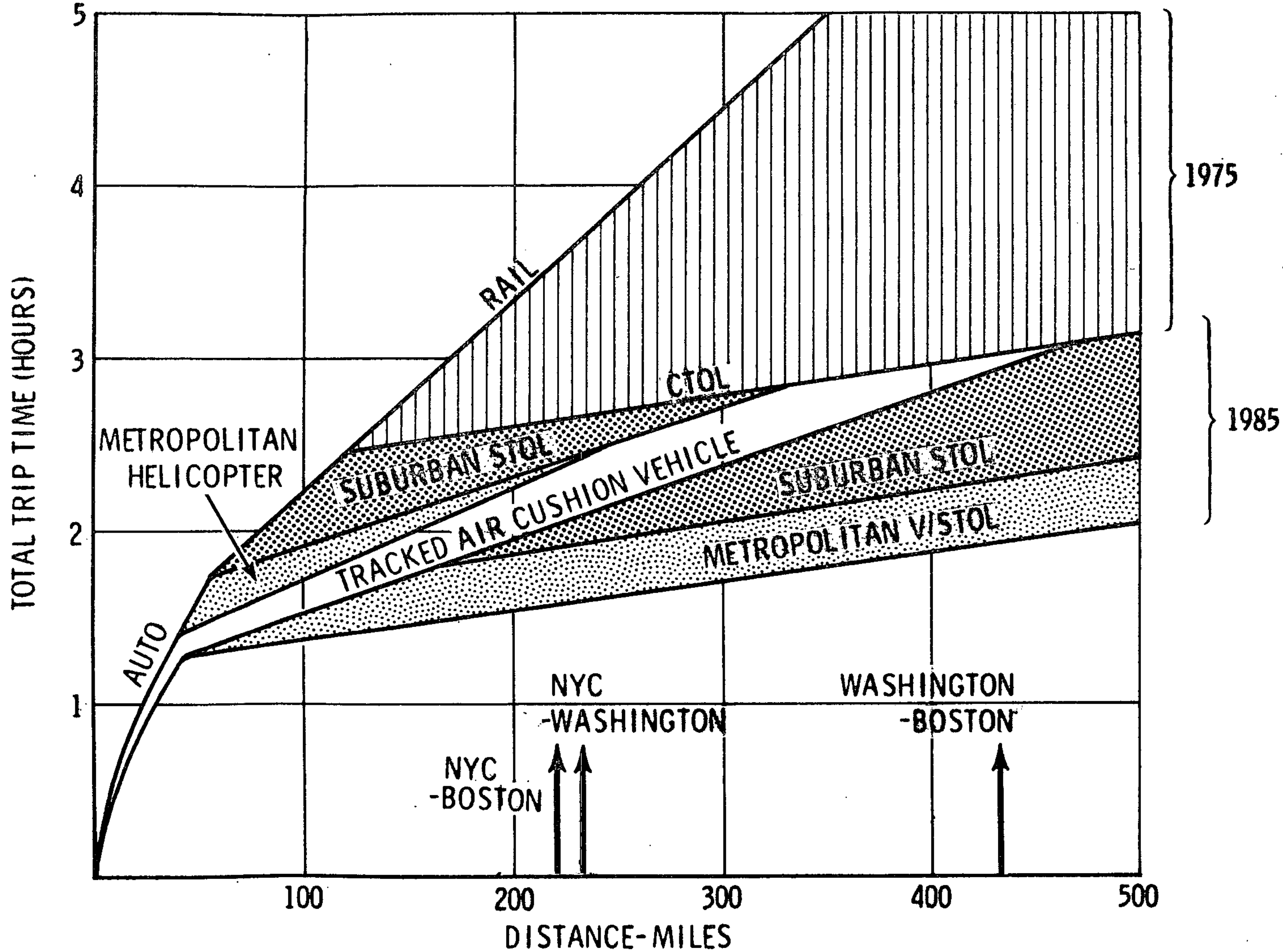


Fig. 2.6 Average Total Trip Times: NEC 1975 and 1985

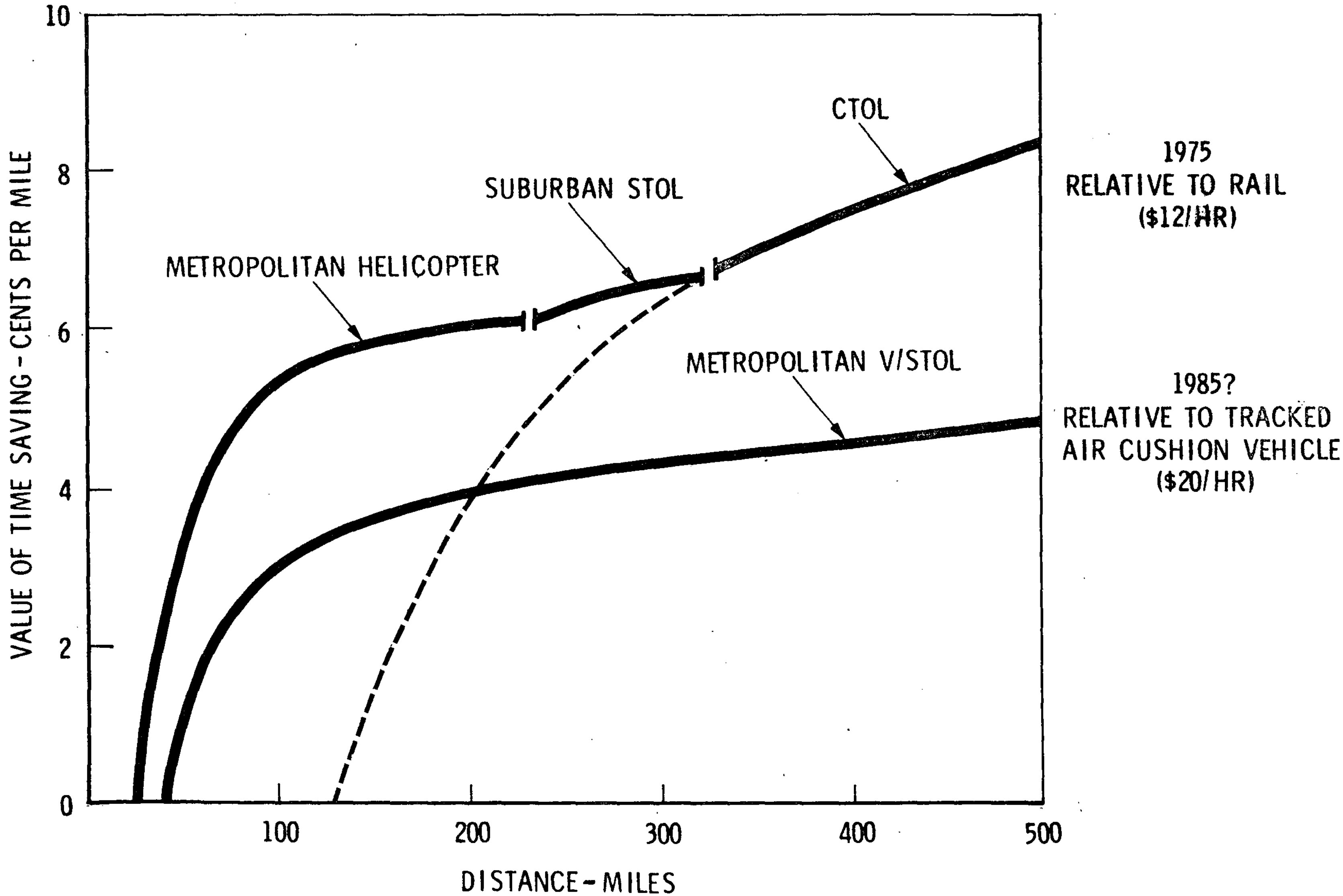


Fig. 2.7 Typical Values of Time Savings for Air: 1973 and 1985

As well as reduced travel time, the short haul traveller will benefit from the flexibility of the air system. The introduction of new direct point to point services, and the construction of more terminals throughout the travel area for a given level of traffic will reduce both the access time and total trip time of the traveller.

2.2.5 Air Systems Already Have a Large, Unexploited Technology Base

Military R & D spending in the area of technology for VTOL and STOL aircraft over the past fifteen years is estimated to be over 650 million dollars. Some 42 prototype vehicles have been designed and tested in that period, and yet no commercial exploitation has yet been made of this R & D investment. Civil R & D spending in this area is continuing as NASA turns its attentions to civil aeronautical problems.

On the other hand, sizeable R & D funding is required to design, construct, and test a number of possible vehicle and propulsion systems for high speed ground systems simply to bring the technology base up to a state comparable to the present air systems.

2.2.6 Air Systems Possess Good Export Potential

Since the federal investment in new air systems is made in vehicle development, and these vehicles have application to a wide variety of transportation problems on a world wide scale, an export market exists in sales of the air system's vehicles. In ground systems the major federal investment is in guideways which cannot readily be exported.

2.2.7 Both Air and Ground Systems have Community Acceptance Problems

The problem of gaining local community acceptance for new terminals sited at points accessible to the short haul traveller is a major one for both air and ground systems. Approval for construction of a busy public facility with its changes in urban activity and land usage is not easily obtained in today's society. For the short haul air system, the noise impact must be eliminated, as discussed elsewhere in this report. For the ground system the acquisition of new rights of way, or construction of elevated trackage into and from urban sites will cause battles for community acceptance with a larger number of local authorities. The community problem with a ground system may be partially solved by resorting to underground access at high investment cost. The acceptance of terminals and their associated activity patterns remains.

2.3 Solutions for the Problems of Short Haul Air Systems

The problems commonly associated with new short haul air systems are concerned with noise, air traffic control, air pollution, and ride quality. As discussed elsewhere in this report, these problems have been recognized, and are being worked on with quite promising solutions in evidence. It is pertinent to summarize briefly these solutions to ensure that transportation planners recognize future technological advances when assessing short haul air systems.

2.3.1 Noise

Existing turbofan propulsion will give new short haul aircraft a takeoff and landing noise size which is about 5% of the noise footprint of current transports like the DC-9. The footprint is likely to be even smaller for STOL and VTOL vehicles because of their steeper takeoff and landing profiles. Also, developments in new forms of propulsion such as the prop-fan seem to promise even further reductions in engine noise. Helicopters of 50 passengers, 180 mph, and 200 mile range which are presently flying are quiet enough now for city center operation, and studies indicate that the noise levels of future versions of these helicopters can be below normal daytime ambient city center noise levels. These technological developments in quiet propulsion and quiet helicopters were the highlights of the summer workshop, and hold great implications to planning of future short haul systems.

2.3.2 Air Traffic Control

The congestion and delays of the CTOL air traffic control system are being alleviated by improvements now being implemented, and further reductions are expected from subsequent developments of an upgraded third generation ATC system. The long term relief from delays in the total air system lies in providing additional facilities at existing airports, or new airports and metroports. A short haul air system which provides these new runways and terminals solves the congestion problem by relieving present procedures and facilities, and using new airspace. There are no reasons to expect any degradation from the present safety levels with the improved aircraft guidance, improved surveillance, and improved controller automation of the new ATC system.

2.3.3 Air Pollution

The turbine engines used by aircraft are extremely clean engines compared with automotive engines, on a basis of pollutants emitted per passenger mile. For the local community around busy city center locations, the exhaust from landings and takeoffs, and from idling engines may cause local concentrations which could be objectionable. There is knowledge now available for further reducing turbine exhaust pollutants in these areas. With proper consideration during site selection, this local problem should not be a serious one for short haul air operations in the city center.

2.3.4 Ride Quality

The smooth ride associate with jet transports for long haul flights is mainly due to the lack of turbulence at cruising altitudes above 20,000 feet. A short haul air passenger will always travel at lower altitudes where turbulence on certain days may cause a less smooth ride. For CTOL and STOL aircraft, a promising new development to improve ride qualities is the automatic gust alleviation system which senses turbulence and actively controls the wing flaps in cruise. For rotary winged aircraft, cabin vibration levels have been greatly reduced due to improvements in rotor aerodynamics and design and the introduction of improvements like the bi-filar vibration absorber.

3.0 Status and Forecast of Technology for Short Haul Air Systems

3.1 Transport Aircraft Characteristics

We shall use takeoff and landing distance, and the form of propulsion as characteristics which classify present and future transport aircraft. This section is intended to describe capabilities of present and future aircraft designed for carrying about 100 passengers over a stage length less than 500 miles.

3.1.1 Turbofan Powered Aircraft

The standard transport aircraft at the present time may be classified as turbofan CTOL (Conventional Takeoff and Landing) which cruise at speeds greater than 500 mph., and use runways greater than 5000 feet. Long range transports are likely to continue to require runways of up to 12,000 feet, but for short range transports, it becomes feasible to design a turbofan transport to use shorter runways and smaller airports. Figure 3.1 illustrates the general trend of increasing vehicle complexity, cost and development effort for transport aircraft as runway length is reduced.

Initially, runway length can be reduced by simply increasing the takeoff thrust and wing area. Also, one can optimize the wing for maximum lift at takeoff and approach configurations rather than cruise conditions, by using less sweepback, greater thickness/chord ratio, more complex leading and trailing edge devices etc. This leads to a class of CTOL aircraft called "short field CTOL", or RTOL(Reduced Takeoff and Landing). Here runway lengths between 2500 and 4500 feet are assigned to this class of aircraft.

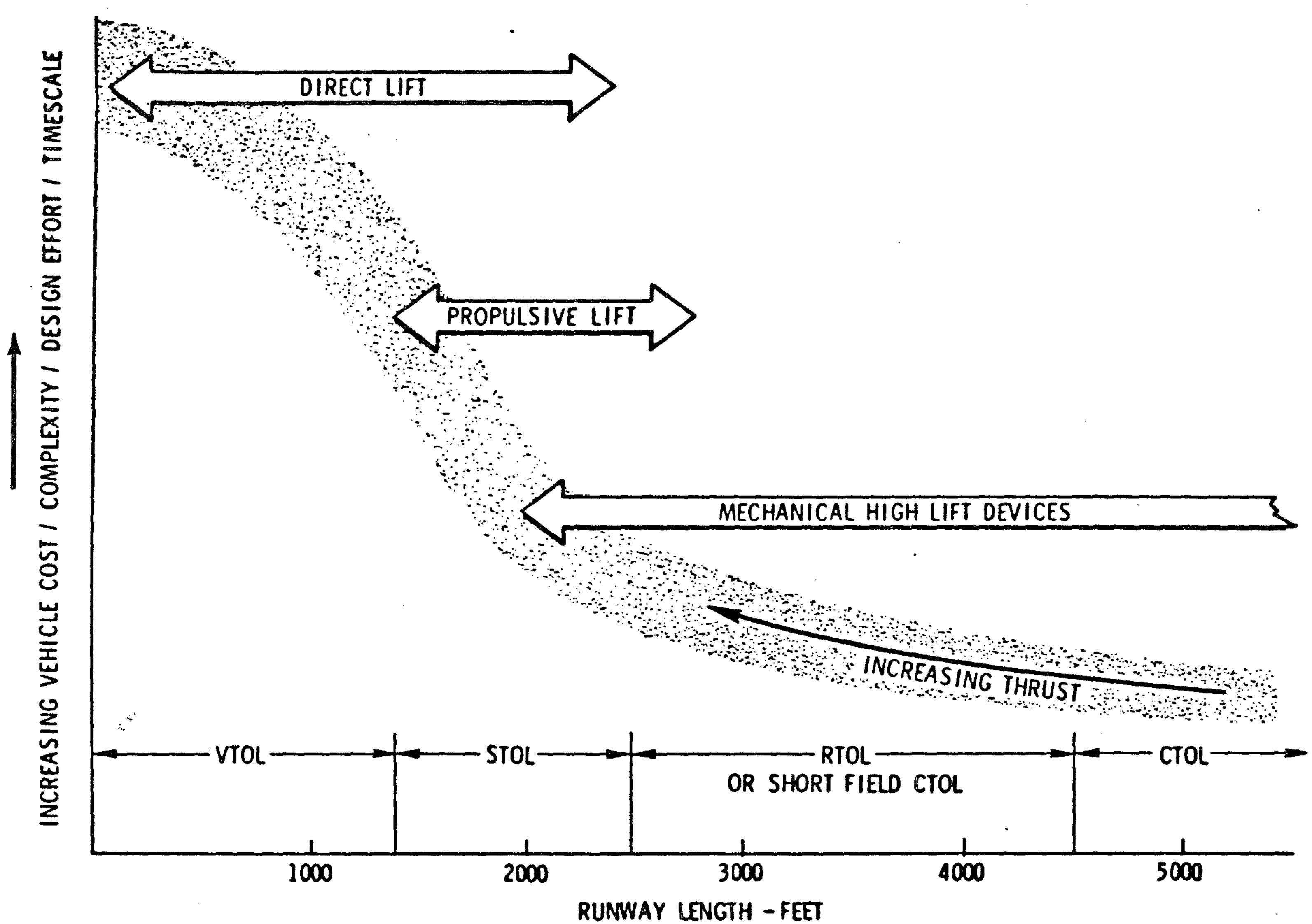


Fig. 3.1 Complexity vs Runway Length for Turbofan Aircraft.

As wing area is increased, (or wing loading is reduced) aircraft become more sensitive to gusts in cruise conditions and may become unacceptable for passenger comfort. A new development to help alleviate this problem is the ride smoothing system which senses gust loadings and automatically controls the wing flaps in cruise. These systems show a significant reduction in aircraft gust response for low wing loading transport aircraft, and indicate that acceptable RTOL transports can be designed with runway lengths as low as 2500 feet.

Runway lengths can then be further reduced to achieve STOL (Short Takeoff and Landing) performance by using some form of propulsive lift, i.e., the powerplant must be used to increase the lift by some means. There are various ways for achieving this, such as:- deflecting the thrust of the propulsion engines, adding light weight lift-engines, or by increasing the wing lift by using concepts such as the augmentor wing, the externally blown flap, the jet flap, etc. All will add cost and complexity to the aircraft to a varying extent. The higher lift generated will allow the wing area to be reduced for a given field length performance thereby improving cruise performance and costs to offset the extra cost of the powered lift system. At the present time it is impossible to forecast which of these propulsive lift systems is the best. The NASA experimental STOL transport aircraft program is pointed toward resolving some of these uncertainties since it will fly both the augmentor wing and the externally blown flap.

If still shorter runway lengths are required then these can be achieved by decreasing the wing loading and/or by increasing the powered lift. For runway lengths less than 1500 feet, low speed stability and control problems will become severe and non-aerodynamic controls will be required, e.g., reaction jets, thrust modulation and deflection, etc. This will further increase cost and complexity and will probably mean that VTOL (Vertical Takeoff and Landing) performance can be achieved with only a relatively small amount of additional cost and complexity.

Turbofan powered VTOL aircraft employ direct lift fan engines and/or deflected thrust from the propulsion engines. The gas generators for the lift fans can be integral or remote. The advantage of these concepts is that the wing and forward propulsion systems can be optimized for maximum cruise performance which allows cruise speed and range equivalent to current jet transports. The disadvantages are: high noise relative to rotary wing VTOL aircraft, and high fuel consumption in the terminal area, probably requiring an automatic takeoff and landing system.

Turbofan RTOL or transports seating 100 passengers with runway lengths around 2500 feet could be available by 1976 depending on the availability of new quiet propulsion engines. British Aircraft Corporation has proposed such a new aircraft (called the QSTOL) based on the Rolls Royce M45S engine with the Dowty-Rotol variable pitch, geared fan. It is possible that reengined, quiet RTOL versions of the B-737, or DC-9-10 could also be available before 1976 if needed for demonstration projects.

If a shorter runway length is required with an approach speed of around 75 knots, it seems unlikely that such a STOL transport could be in service before 1980. It would await flight test results of the NASA experimental STOL aircraft program. Similarly a turbofan direct lift VTOL transport seems unlikely to be available for service before 1980, and would require a major development program during the 70's.

3.1.2 Turboprop Powered Aircraft

The general trend of increasing complexity and/or decreasing wing loading with reduction in runway length that was discussed in the previous section also applies to turboprop aircraft. Because of the propeller, these aircraft are slower in cruise speed than the turbofan transports although this may not be significant at shorter stage lengths. With properly designed, low tip speed propellers the turboprop aircraft can be considerably less noisy than a similarly sized present turbofan aircraft.

In the past turboprop transports have had low wing loadings which gave less comfortable ride qualities than present jet transports. The application of ride smoothing systems which dynamically control the wing flaps in cruise so as to alleviate gust effects appears to be a promising development for these aircraft.

There are a number of turboprop transports currently in service such as the Electra, F-27, and Convair 540. By limited loading these aircraft could be classified as RTOL. The only turboprop STOL in scheduled service at present is the 19 passenger DHC-6 Twin Otter built by DeHavilland Canada. If a go-ahead decision on the DHC-7 is made by the end of 1971, a 48 passenger, 275 mph. quiet STOL transport would be available for short haul service by the end of 1974. Figure 3.2 shows a drawing of this aircraft in typical operations.

3.1.3 Prop-Fan Powered Vehicles

A new form of aircraft propulsion, well suited to short haul aircraft was presented to the workshop. Since it lies intermediate to propellers and current fans, it has been called the prop-fan, but is now named Q-Fan by its developer, Hamilton Standard. As seen in Figure 3.3 it is a variable pitch, geared fan with 13 blades, bypass ratios from 15 to 30 (ratio of cold air to hot air) and tip speeds from 600 to 800 fps. It does offer good propulsive efficiencies up to M = 0.75 or 0.80 (approximately 500 mph.) which is sufficient for short haul aircraft.

No prop-fan aircraft have been designed, but since this form of propulsion seems to offer an extremely quiet and efficient propulsion suitable for all short haul aircraft, it is important that R & D emphasis be placed on its development. Construction of testbed and flight test engines based on existing turboprop gas generators (such as the T-64 or T-55) is required and would take 18-24 months. Existing transport aircraft such as the B-737, or DC-9 might be reengined with the prop-fan to provide a Q-plane for short haul air demonstration projects. The time scale for introducing a new prop-fan transport is roughly 1977 if a major development program is initiated promptly.

3.2 Rotary Wing Transport Aircraft

At this point in time, rotary winged VTOL vehicles are well behind fixed wing aircraft in their technological development. Whereas the present subsonic jet transport represents

Fig. 3.2 Proposed DHC-7 quiet STOL airliner - De Havilland, Canada.

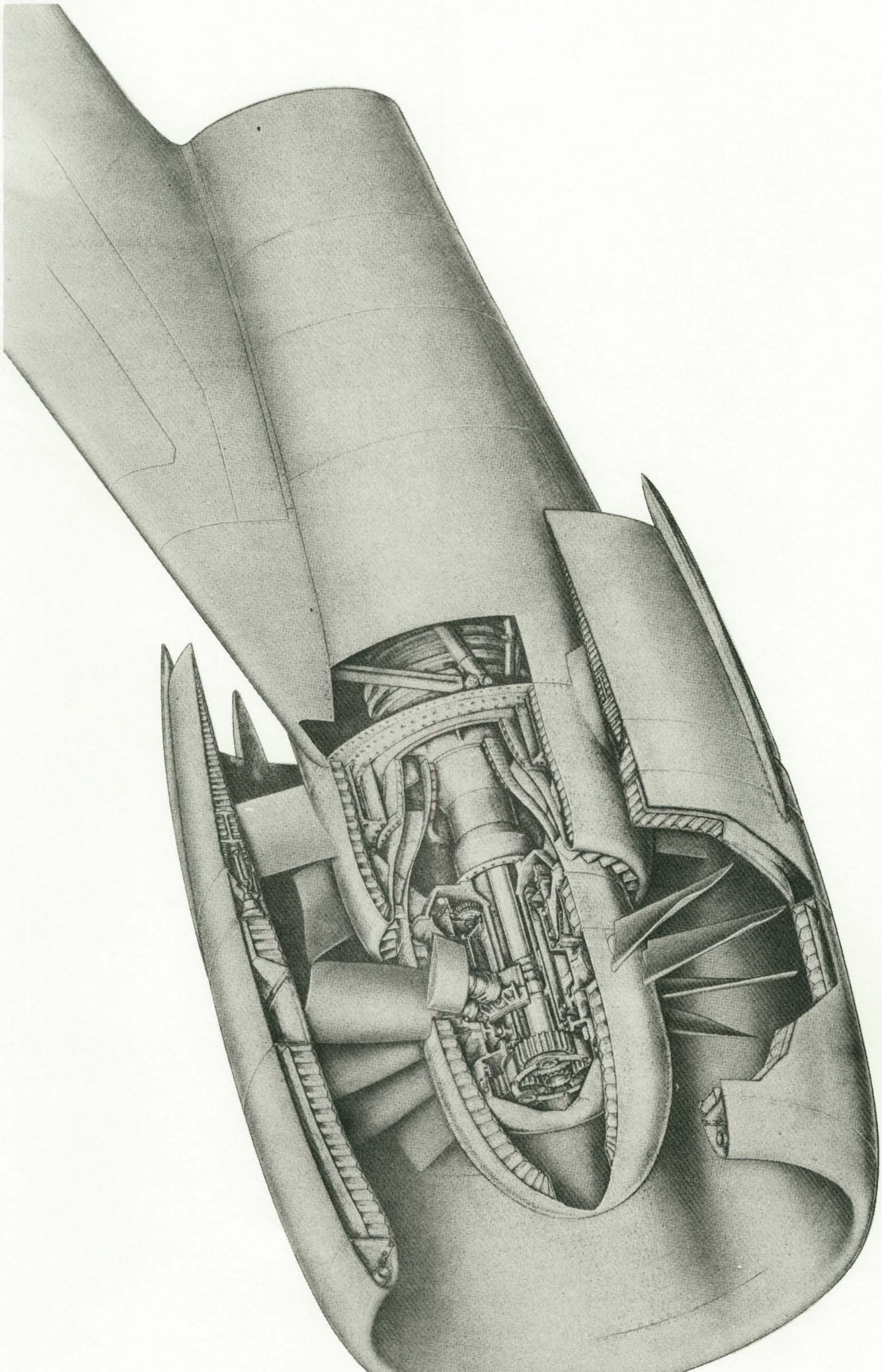


Fig. 3.3 Quiet propulsion prop-fan engine (courtesy of Hamilton Standard).

the maturity of 40 years of progress and development, rotary winged transports are still in their infancy where major developments are still occurring and substantial progress can still be expected. Since rotary wing VTOL transport offer substantial promise of quiet city center operations, they are worthy of future civil R & D effort.

Present helicopters have evolved from military developments over the past 30 years, and the relatively few helicopters in commercial service are civil derivatives of military models. Important advantages of helicopters include efficient hover capability, relatively low noise, low downwash velocities, and power off autorotation capability. On the other hand, present helicopter deficiencies include relatively slow speed, short range, high cabin vibration levels, and higher initial and direct operating costs.

The last military transport helicopter development was initiated in 1962 and to date there have been no large helicopters developed in this country or elsewhere specifically for commercial transport. However, relatively low levels of R & D funding from military and industry sources continue to identify many design improvements. For example, the problem of vibration has been substantially reduced by installing a bifilar vibration absorber on the main rotor head. Experience to date with the military and New York Airways indicates that the absorber provides a more comfortable ride and reduces maintenance costs. Other improvements in rotor aerodynamics, drag reduction, dynamic components, and turbine engines now offer the potential of increased speed, payload and range to the helicopter designer. In addition, the use of new materials, design features for reliability, and new test techniques should substantially reduce maintenance on future transport helicopters which are properly designed from the start for civil usage.

3.2.1 Advanced Helicopters

For the advanced helicopter, with cruise speeds over 220 mph, there are several concepts for rotor development such as the cantilever rotor, variable geometry rotor, jet flap rotor and a rigid coaxial rotor known as the ABC (Advancing Blade Concept). Some of these have been successful under initial tests, and are worthy of **further** research and development. The idea of a rotor test vehicle for purposes of flight testing these concepts seems a necessary part of future development.

There are two advanced helicopter military transports currently flying which could be developed for certificated civil usage in about two years time. The civil version of the Sikorsky CH-53 is called the S-65-40 (shown in Figure 3.4) and Boeing Vertol has a modified version of the Chinook called the BV-347 (shown in Figure 3.11). Both helicopters carry 50 passengers over 200 miles or more at speeds around 180 mph., and both are quiet enough to win city center acceptance at properly selected sites. With this time scale and performance, both of these helicopters are candidates for early intercity demonstration projects over distances of 200 miles or less.

3.2.2 Compound Helicopter

A compound helicopter, where a small wing and forward propulsion is added, can increase cruising speeds substantially. Several configurations have been flown, and one has exceeded

Fig. 3.4 Proposed Sikorsky S-65-40 advanced transport helicopter.

300 mph. The current technology base is adequate to build a 100 passenger compound transport helicopter with speeds over 250 mph. by 1975. The compound configuration is particularly suited for the advanced rotor concepts mentioned above.

3.2.3 Tilt Rotor Aircraft

Beyond the capabilities of the compound helicopter, the most promising design concept is the tilt rotor aircraft. With a disc loading nearly as low as the helicopter, the tilt rotor shares the same desirable characteristics in terminal operations: low noise, low downwash velocities, and autorotation capability. In cruise configuration the tilt rotor behaves much like a conventional turboprop aircraft, with cruise speeds up to 400 mph. The tilt rotor can have a high wing loading since the wing is not compromised for takeoff and landing. The conversion process is simple, can be stopped or reversed at any time, and the conversion corridor of airspeed vs. rotor angle is wide.

Flight experience with the tilt rotor is limited to one experimental aircraft, the XV-3, which suffered from serious aeroelastic problems. Promising solutions to these problems have been developed and tested by NASA in the full scale wind tunnel. However another experimental flight test vehicle is required before transport aircraft prototypes can be designed. Since the tilt rotor concept has great potential for both civil and military applications it seems reasonable to give high priority to this experimental flight test vehicle. If this is done expeditiously a tilt rotor transport could be in service in the early 1980's with a cruise speed around 350 mph. and a stage length of 400 miles.

3.3 Aircraft Noise

3.3.1 Turbofan Powered Aircraft

The CTOL jet transports which were developed and brought into service during the late 1950's and the early part of the 1960's (here referred to as of "1960" technology) were not compromised to any great extent by consideration of their noise impact upon the environment. The result has been that older aircraft in the current civil transport fleet exceed the noise levels now applied to new subsonic transports by Federal Air Regulations Part 36 by up to 10 to 15 EPNdb (Effective Perceived Noise in decibels).

Figure 3.5 shows the sideline noise of current turbofan transport aircraft during takeoff at a point 0.35 n.m. to the side of the runway. The 1960 technology aircraft are of both US and European origin. The "1970" technology points refer to the new large aircraft coming into service at this time - the Boeing 747, McDonnell Douglas DC-10 and Lockheed L-1011. The improvement over the "1960" technology models is about 10-15 EPNdb. A similar improvement applies to the flyover (or takeoff) case, but for the approach case the improvement is smaller - roughly 5-6 EPNdb for current CTOL landing techniques which use a 3 degree glide slope.

If the results for these new large medium-to-long range aircraft are now extrapolated to smaller aircraft sizes they suggest that a new short haul CTOL turbofan aircraft with 1970 technology would produce a sideline noise in the lower 90 EPNdb range at 0.35 n.m. as indicated in Figure 3.5. A similar improvement will apply to the flyover case. The approach noise

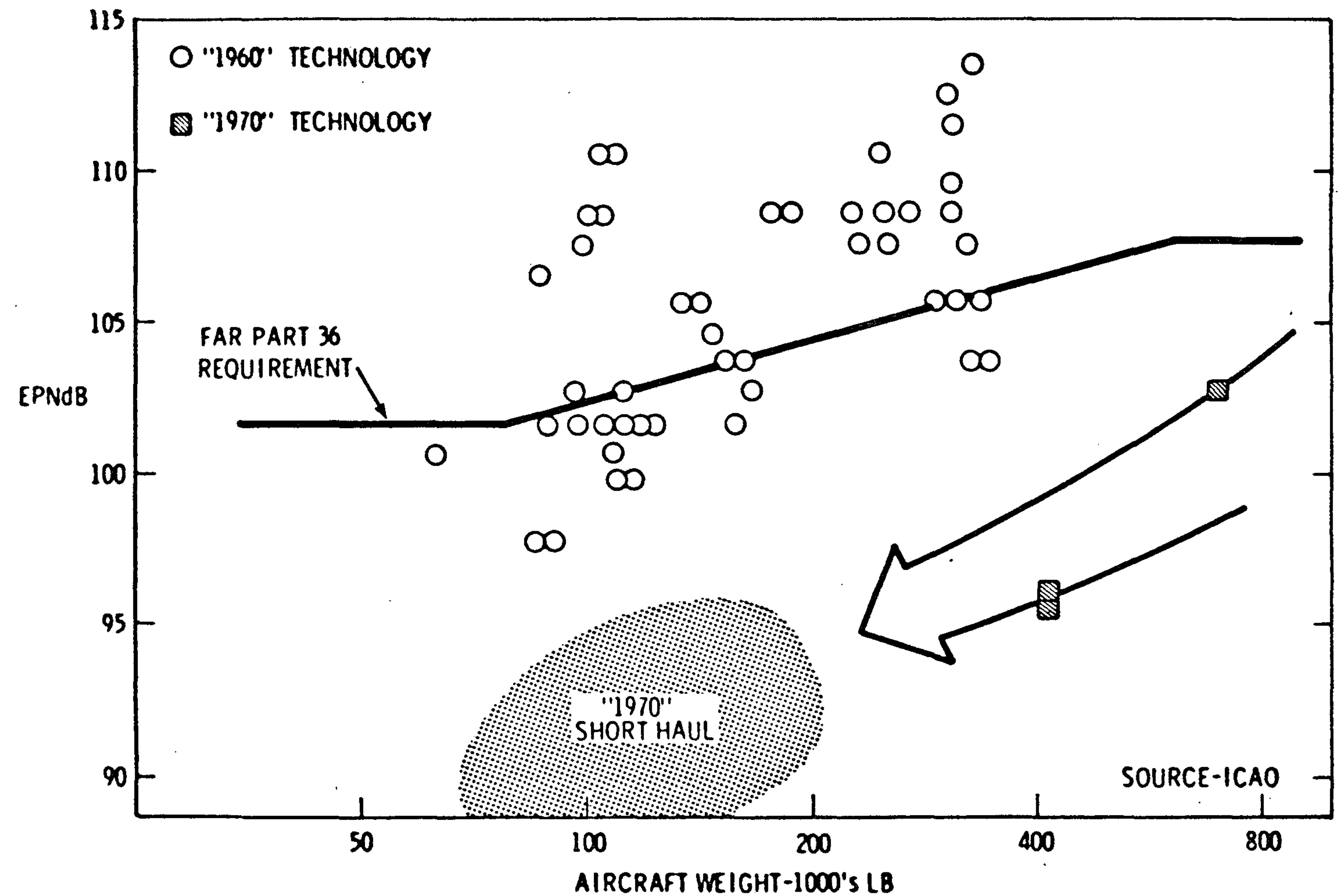


Fig. 3.5 Sideline Noise at Takeoff -- CTOL Transports

level will be in the range of 100 EPNdb, reduced from current levels around 110 EPNdb. However, if new transport have improved guidance systems, a steeper approach procedure can be used which then offers a 10-15 EPNdb reduction in approach noise.

While these reductions are now in hand, there are a number of reasons to expect developments in turbofan technology that could further reduce the noise level by at least another 5-10 EPNdb by 1977, without incurring significant economic or engine performance penalties.

For the future, especially for V/STOL, the FAR Part 36 measuring points may have less relevance and increased attention has been paid to the area of swept noise contours - the noise "footprint". For one landing and take-off, a current 1960 technology 100 passenger turbofan transport typically subjects 30 sq. miles of land to noise levels above 90 PNdb. This is illustrated in Figure 3.6. The marked reduction in area to 3.2 sq. miles shown for 1970 and to 1.3 sq. miles for 1977 technology is surprising, but understandable when it is realized that this footprint area is halved for each 3-4 PNdb reduction in engine noise - see Figure 3.7. The use of footprint area as a measure of noise impact seems an attractive means of explaining the significance of noise level improvements to the layman.

Thus, the above forecast reduction of 15-20 PNdb by reduction in engine noise alone indicates that the 1977 footprint area for short haul CTOL turbofan aircraft can be reduced to less than 5% of the current value. This percentage is not affected by the value of the particular noise contour which is considered; i.e. whether one chooses the 90, or 95, or 80 PNdb contour is

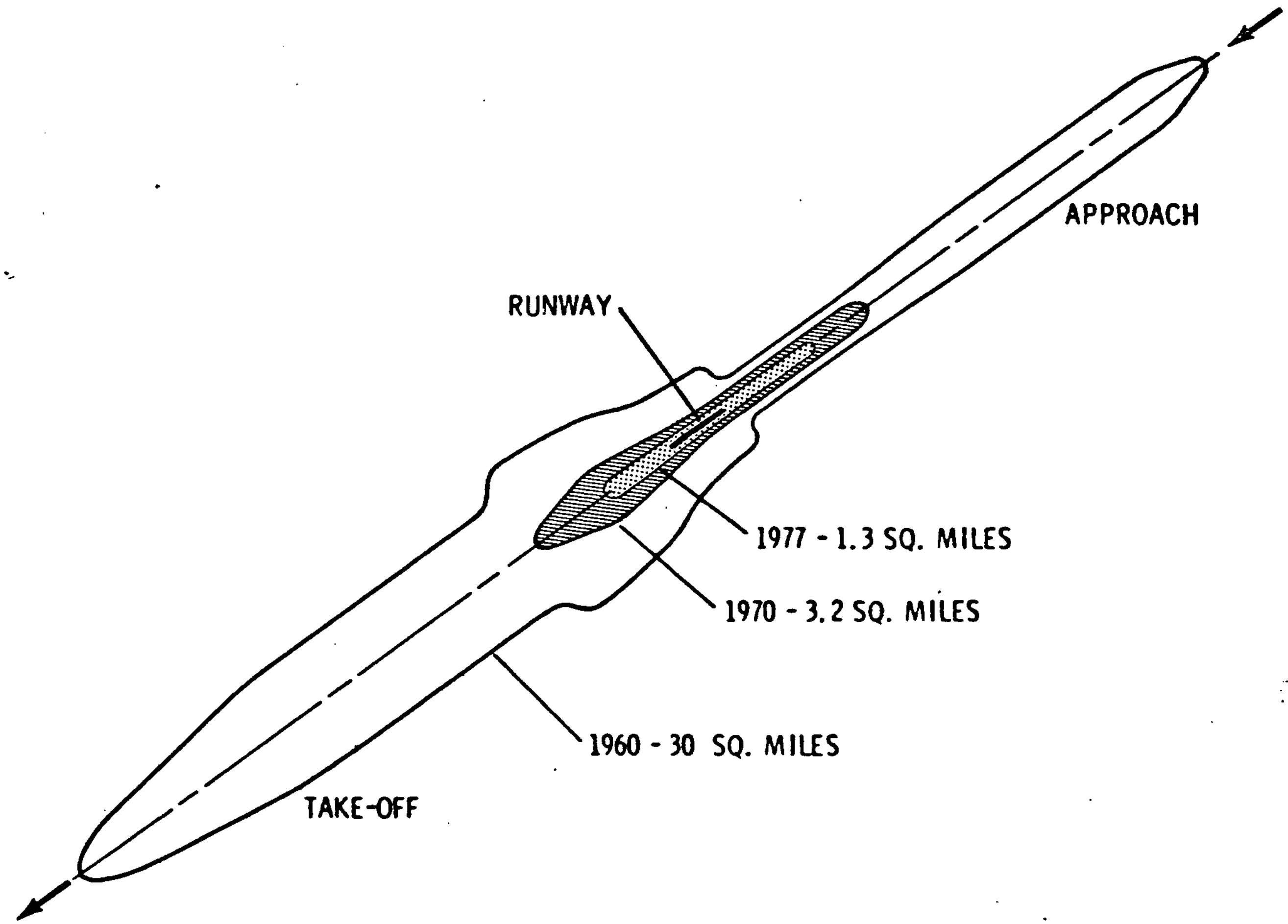


Fig. 3.6 90 PNdb Footprint - Turbofan CTOL Short Haul Transports

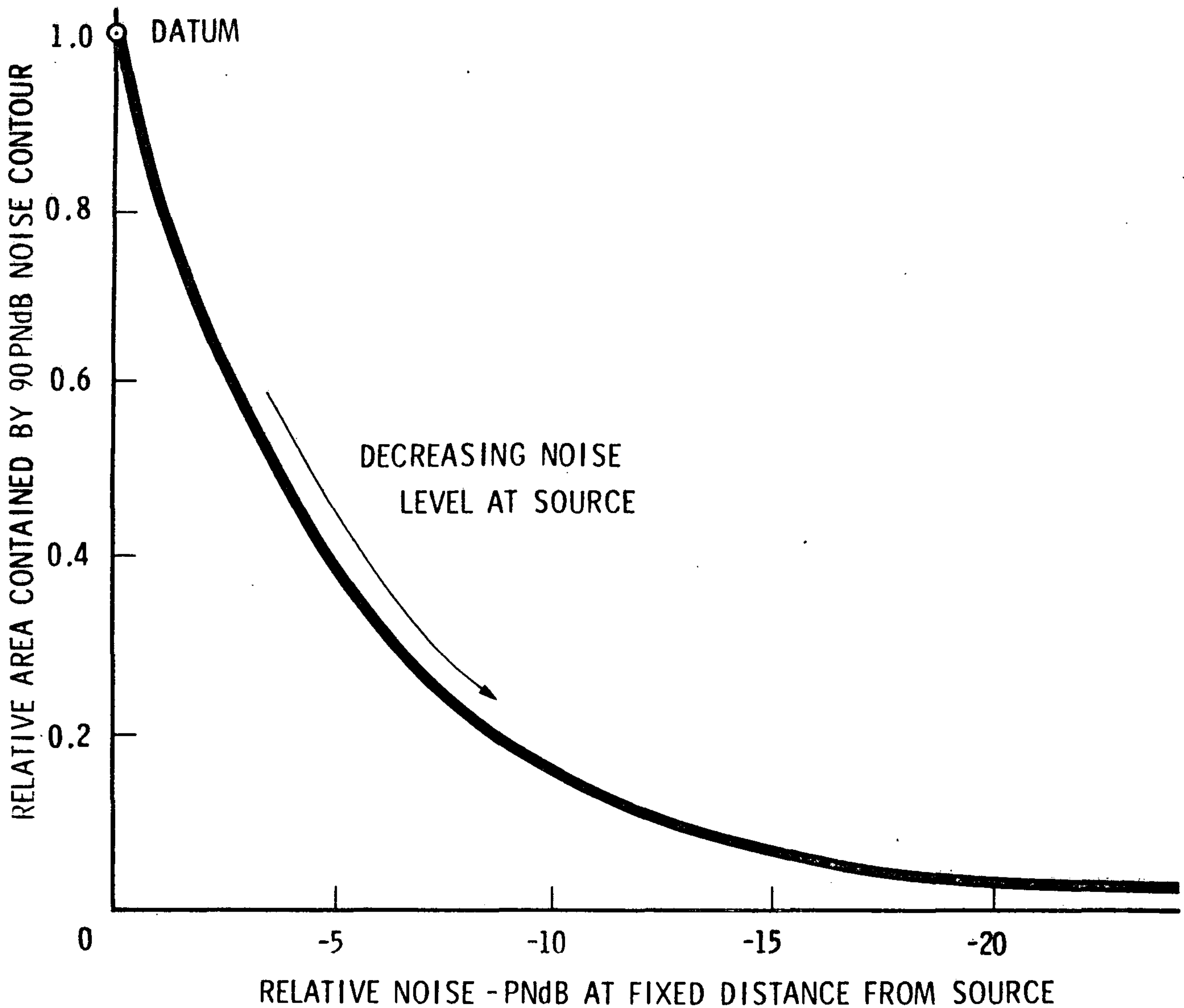


Fig. 3.7 Typical Variation of Footprint Area With Noise

is immaterial; the percentage remains constant.

THIS FORECAST OF A GREATLY REDUCED NOISE FOOTPRINT AREA DUE TO CURRENT AND FUTURE DEVELOPMENTS IN TURBOFAN PROPULSION TECHNOLOGY WAS ONE OF THE MOST SURPRISING FINDINGS OF THE WORKSHOP. IT HAS GREAT SIGNIFICANCE IN PLANNING THE FUTURE OF AIR TRANSPORT, AND IN PARTICULAR FOR THE DEVELOPMENT OF SHORT HAUL AIR TRANSPORT. THE MAJOR BARRIER TO THE FUTURE GROWTH AND DEVELOPMENT OF AIR TRANSPORT (AS DISCUSSED LATER) IS COMMUNITY ACCEPTANCE OF THE NOISE ENVIRONMENT IN THE AREAS ADJACENT TO AIRPORTS AND METROPORTS. THE PROMISE OFFERED BY THESE TECHNOLOGICAL DEVELOPMENTS IN QUIET PROPULSION ARE OF SUCH VITAL IMPORTANCE TO AIR TRANSPORT THAT IMMEDIATE AND FULL SCALE DEVELOPMENT OF SUCH TECHNOLOGY INTO FLIGHT TEST ENGINES IS MANDATORY IN ORDER TO VALIDATE THE FORECAST. MAJOR DECISIONS FACE THIS NATION CONCERNING RETROFITTING OF NACELLES, REENGINEING PRESENT FLEETS, RETIRING PRESENT FLEETS FOR NEWER, QUIETER TRANSPORTS, BUYING LAND AROUND AIRPORTS, ETC., AND THE DECISIONS WHEN MADE WILL BE A MAJOR DETERMINANT OF THE FUTURE DEVELOPMENT IN SHORT HAUL AIR TRANSPORTATION. THE EXISTENCE OF FLIGHT TEST ENGINES USING HIGH BYPASS RATIO FANS WILL BE A KEY FACTOR IN THE DECISION MAKING PROCESS.

V/STOL aircraft require more thrust than CTOL and therefore will generate more near-field noise for the same level of propulsion technology. However, the ability to perform steeper appraoch and climb-out flight paths will reduce the footprint size. The net effect of these opposing trends will depend on the V/STOL configuration, i.e., the method of generating lift at low speeds.

a) STOL Advanced Mechanical Flaps - it is estimated that the footprint should be reduced by one-third to one-half compared with a CTOL contemporary, e.g., from 1.3 to roughly 0.7 sq. miles in Figure 3.6 for 1977 technology. However, further research is required into noise reflection from these large wing flaps to validate this reduction.

b) STOL Externally Blown Flap - apart from possible reflection effects, preliminary NASA research has shown that a large amount of additional noise will be generated by impingement of the engine efflux on the flaps unless the efflux velocity is very low - far lower than the current turbofan range. This scrubbing effect requires further research, and may indicate that a lower velocity propulsor such as a prop-fan should be used with this configuration.

c) STOL Internally Blown Flap and augmentor wing - at the blowing air expansion ratios required, considerable noise is generated at the flaps and continuation of the research into acoustic treatments is indicated.

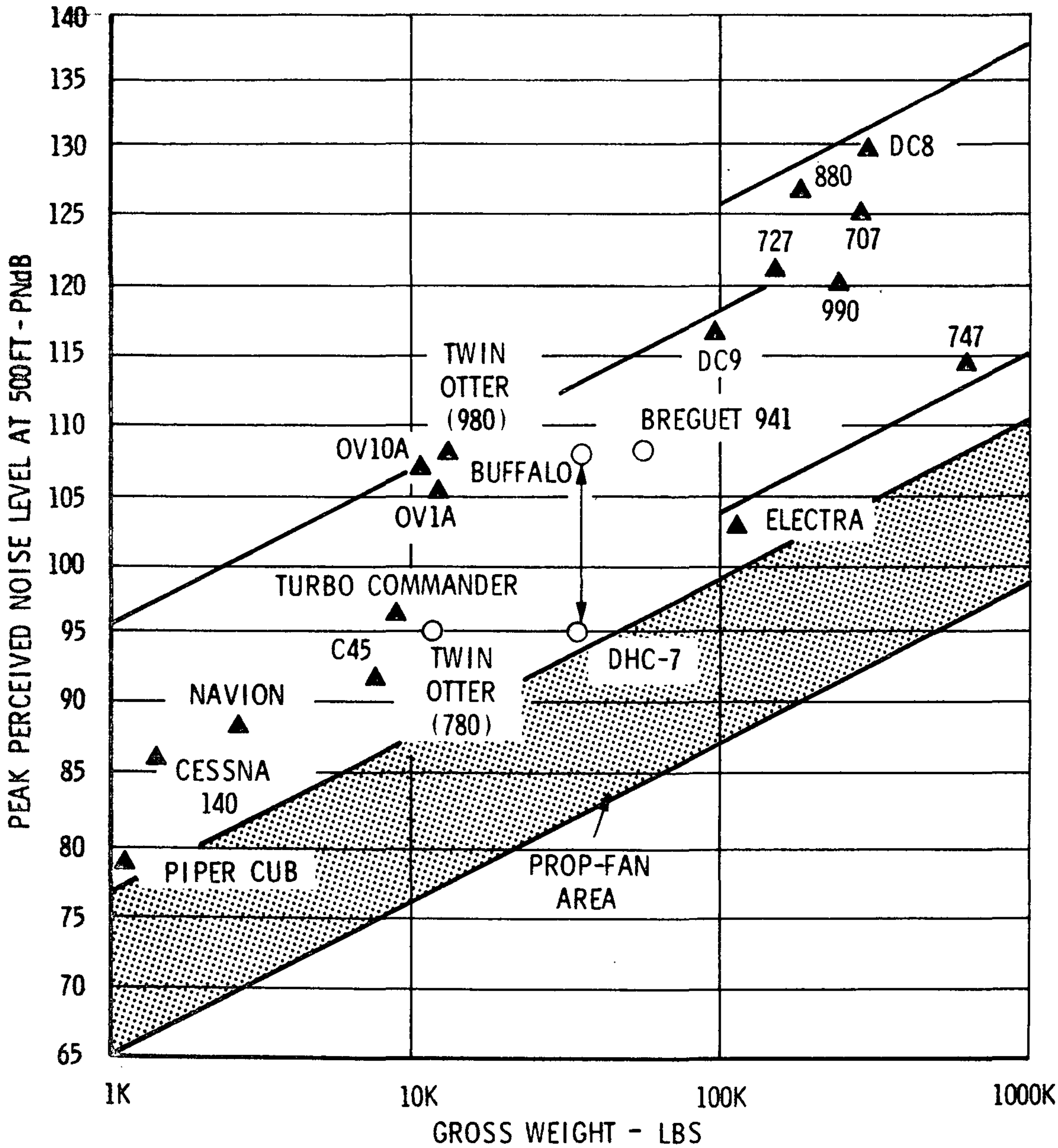
2 (9)

d) V/STOL Lift Fans (integral and remote). These should benefit from much of the technology gained with turbofan propulsion engines. Like (b) and (c) a large amount of power is required during approach to provide lift and the noise footprint might be the same as a contemporary CTOL aircraft. On the other hand lift fans do permit VTOL operations with yet steeper paths and then the footprint could be as little as 0.3-0.6 sq. miles.

In summary, future CTOL aircraft can be built which have as a noise footprint a small fraction of the area affected today. Turbofan V/STOL aircraft will not necessarily be intrinsically quieter just because they are V/STOL designs. It depends upon the V/STOL configuration and its noise generation characteristics. However, their low speed maneuverability, steeper approach and departure paths, and the possibility of curved take-off and approach paths should enable their noise footprints to be deflected away from particularly sensitive areas. It is pertinent to note that both of the propulsive lift wing configurations (b) and (c) proposed for the NASA experimental STOL aircraft presently have noise generation problems which must be solved before an acceptable short haul intercity transport can be built.

3.3.2 Turboprop Powered Vehicles

As shown in Figure 3.8, existing turboprop aircraft (left hand set of aircraft) generally make less noise than existing turbofan aircraft. Substantial reduction in noise from turbo-



NOTE:
TIP SPEED OF SOME PROPELLERS SHOWN IN PARENTHESES

Fig. 3.8 Perceived Noise Measurements at Takeoff -- Selected Aircraft prop aircraft can be accompanied by reducing tip speeds of the propeller with small penalties in performance for short haul aircraft. An example of this is the 17-18 PNdb reduction in the noise level of the DHC-7 STOL compared to a similar size STOL called the Buffalo. Even further reductions could be accomplished for future turboprop short haul aircraft by further reducing tip speeds, and perhaps using the variable camber propeller.

3.3.3 Prop-Fan Powered Vehicles

The lower shaded area of Figure 3.8 shows the noise levels now predicted for prop-fan aircraft. For a transport of 100,000 pounds gross weight, noise levels around 90 PNdb at 500 feet are shown. This is comparable with the forecast given in section 3.3.1, and indeed, the prop-fan is a particular example of how noise levels of this low order can be achieved.

The level of potential noise reduction offered by prop-fan propulsion is extremely large. For the same level of thrust, the prop-fan will make 17-20 PNdb less than the currently quiet turbofan engines of bypass ratios around 5 such as used on the DC-10. This is equivalent of reducing the noise footprint to roughly one-sixteenth. Such a major reduction indicates that probably all future short haul aircraft would be powered by this form of propulsion. The development of a full scale prop-fan engine for flight test purposes deserves consideration as part of any V/STOL Quiet Engine research and development program.

3.3.4 Rotary Wing Vehicles

The status and forecast of noise reduction for rotary wing aircraft is shown in Figure 3.9. Existing helicopters are the only aircraft which can now meet a standard of 95 PNdb at 500 feet. Figure 3.10 shows the measured noise in hover for the 50 passenger Boeing Model 347 at a gross weight of 45000 lbs. which is less than its maximum of 53000 lbs. A photograph of the Model 347 during a recent flight is shown in Figure 3.11. Quiet helicopters have also been built by Hughes and Sikorsky by modifying existing machines with off-the-shelf components. These aircraft have shown on an experimental basis that large reductions in noise from present helicopters are possible. Advanced commercial helicopters, pure or compound, could achieve further significant reductions in the late 1970's. By incorporating low noise design features, mainly low tip speed, in the design process from the outset, these reductions need not be accompanied by excessively large increases in direct operating cost. Continuing refinement of low noise design should result in the tilt rotor being even quieter when it appears in the early 1980's. The noise reductions shown here depend on quietening several noise sources: the rotors, the drive system, and the powerplant. At the moment the rotors appear to be the source whose quietening involves the greatest penalties. However, when the noise from all sources approaches 80 PNdb at 500 feet the powerplant may become the most difficult source to quiet and hence there may have to be a slackening in the pace of noise reduction.

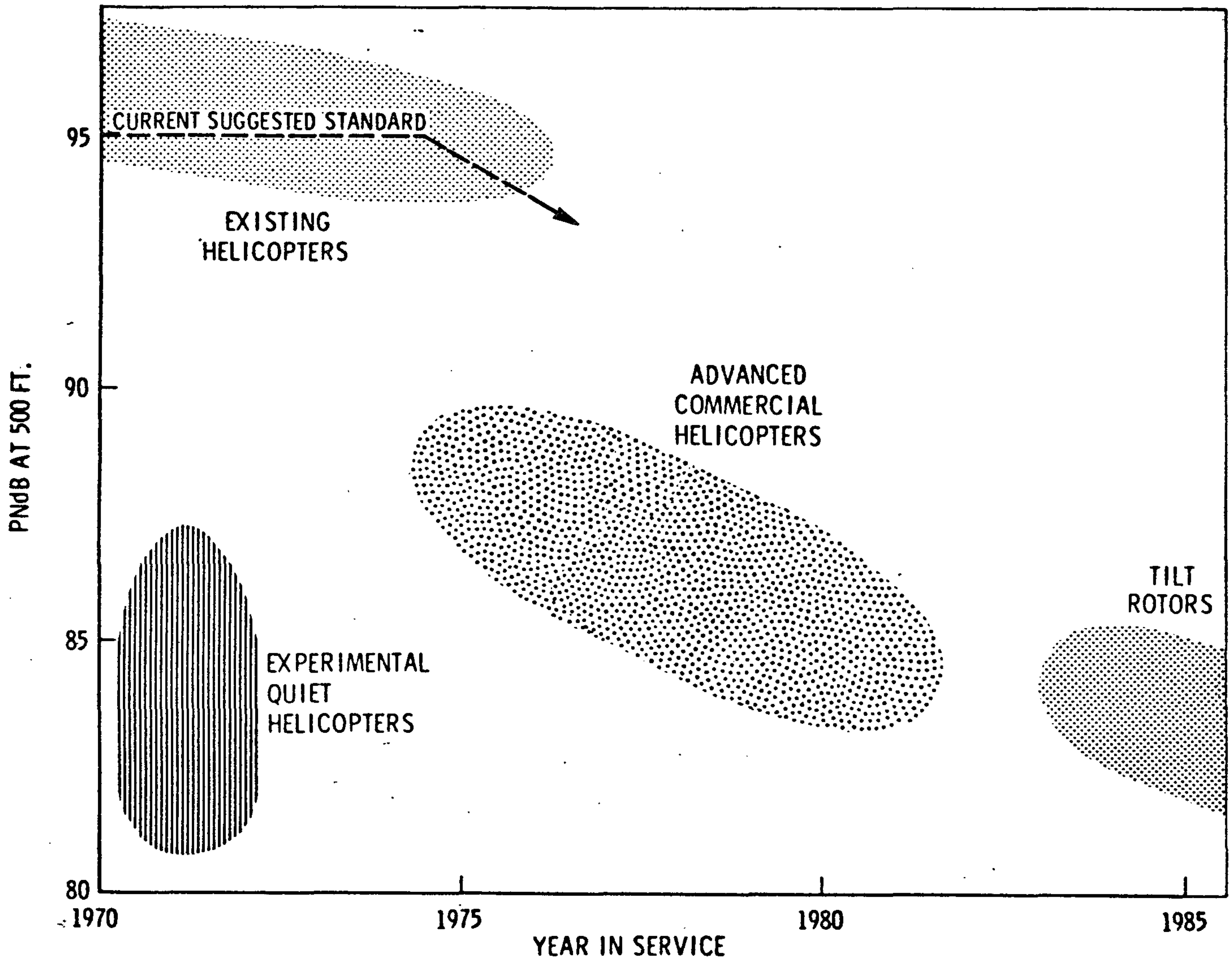


Fig. 3.9 Noise Trends for Future Rotorcraft

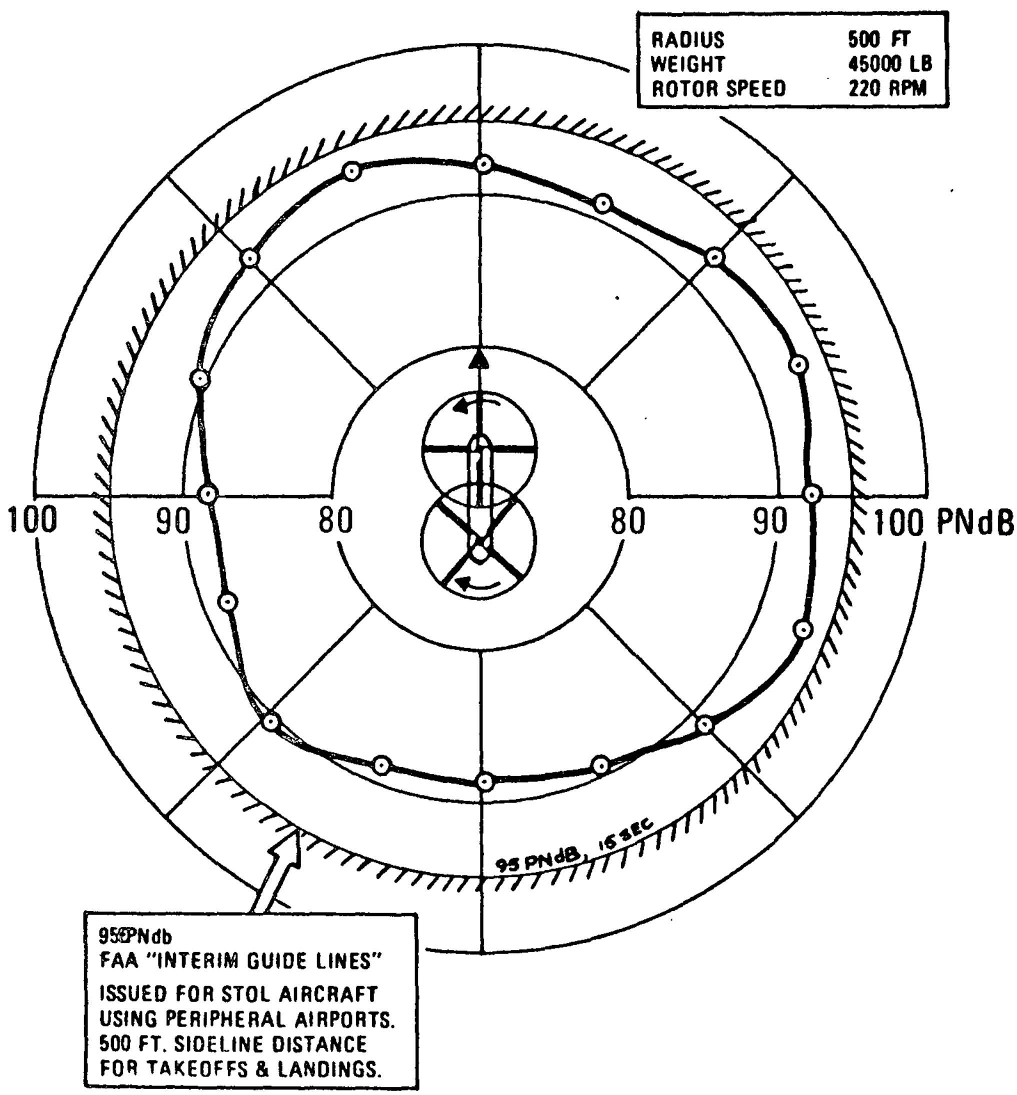


Fig. 3.10 Perceived Noise Level in Hover -- Boeing Model 347

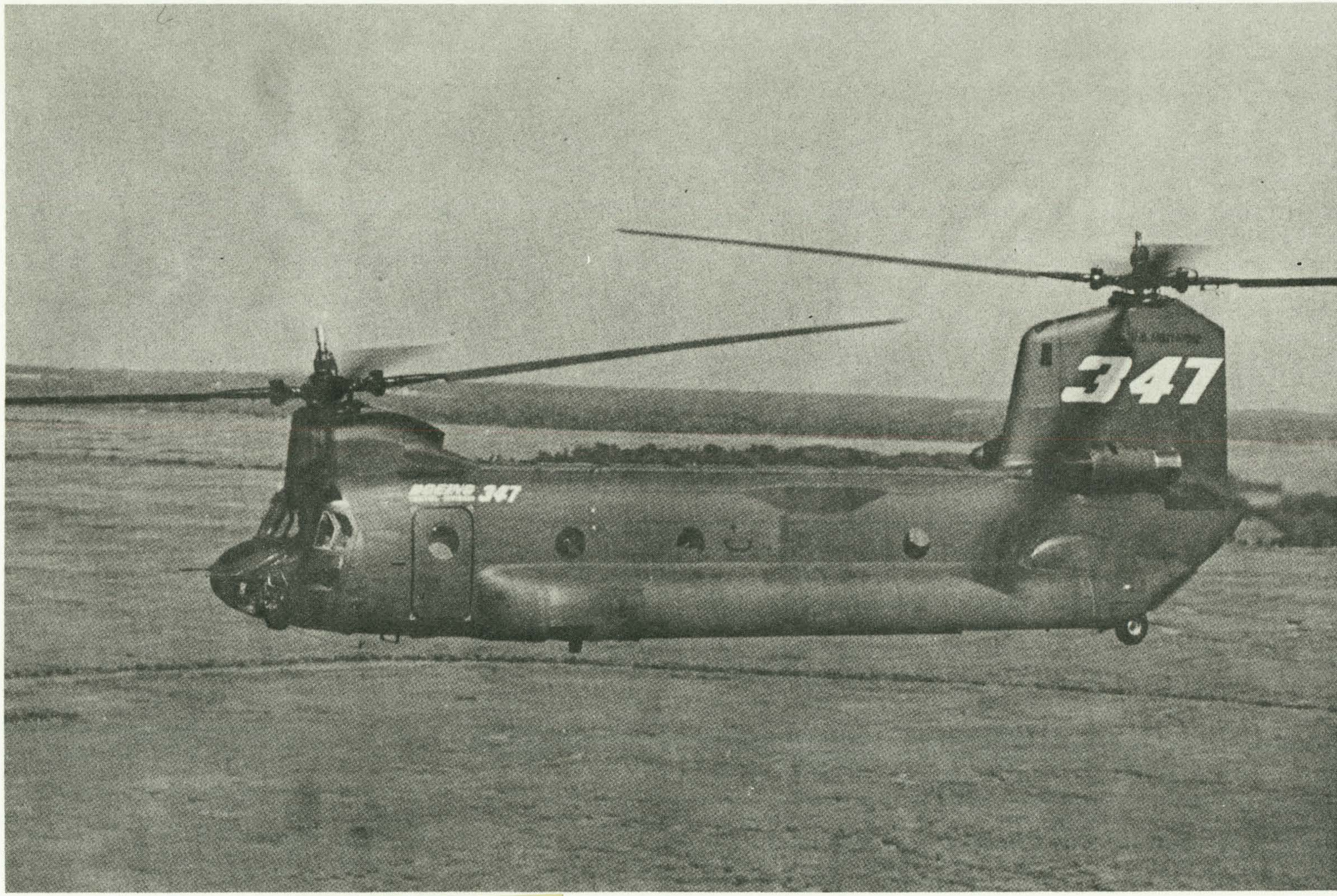


Fig. 3.11 Boeing Model 347 - advanced technology helicopter in flight.

A rough indication of the effect of noise reduction on direct operating cost of transport helicopters is shown in Figure 3.12*. (If we accept the rule-of-thumb that indirect operating cost equals direct operating cost, it can be seen that a 15 PNdb noise reduction will mean an increase in ticket cost of less than 15%. In practice IOC is usually higher than DOC for short haul.)

The attractiveness of rotary wing aircraft for very short haul intercity operations depends very strongly on the promise they offer for quiet city center operations and community acceptance. Present helicopters capable of transporting 50 passengers at 180 m.p.h. over 200 miles can meet a 95 PNdb at 500 feet criterion, and would be acceptable at most city center sites. The Sikorsky S-61 presently makes 93 PNdb at 500 feet and has been accepted.

Future rotary wing transports in built-up areas in Los Angeles, San Francisco and New York offer substantial improvements in noise performance for a direct tradeoff in operating cost which is acceptable for short haul travel. The goals of 80-85 EPNdb at the metroport boundary set by the CARD study for 1980 VTOL and STOL aircraft already appear to be achievable by rotary wing transport aircraft.

3.4 Technology Recommendations

As presented to the workshop, there are a large number of research and development projects concerned with short haul aircraft technology already in progress by NASA, FAA, DOD and industry. There appears to be much less work in progress con-

*Reference - A Systems Study of Noise Requirements on the Design of V/STOL Aircraft, R.W. Simpson, A.P. Hays, H.B. Faulkner, Helicopter Noise Symposium, Durham, September 1971.

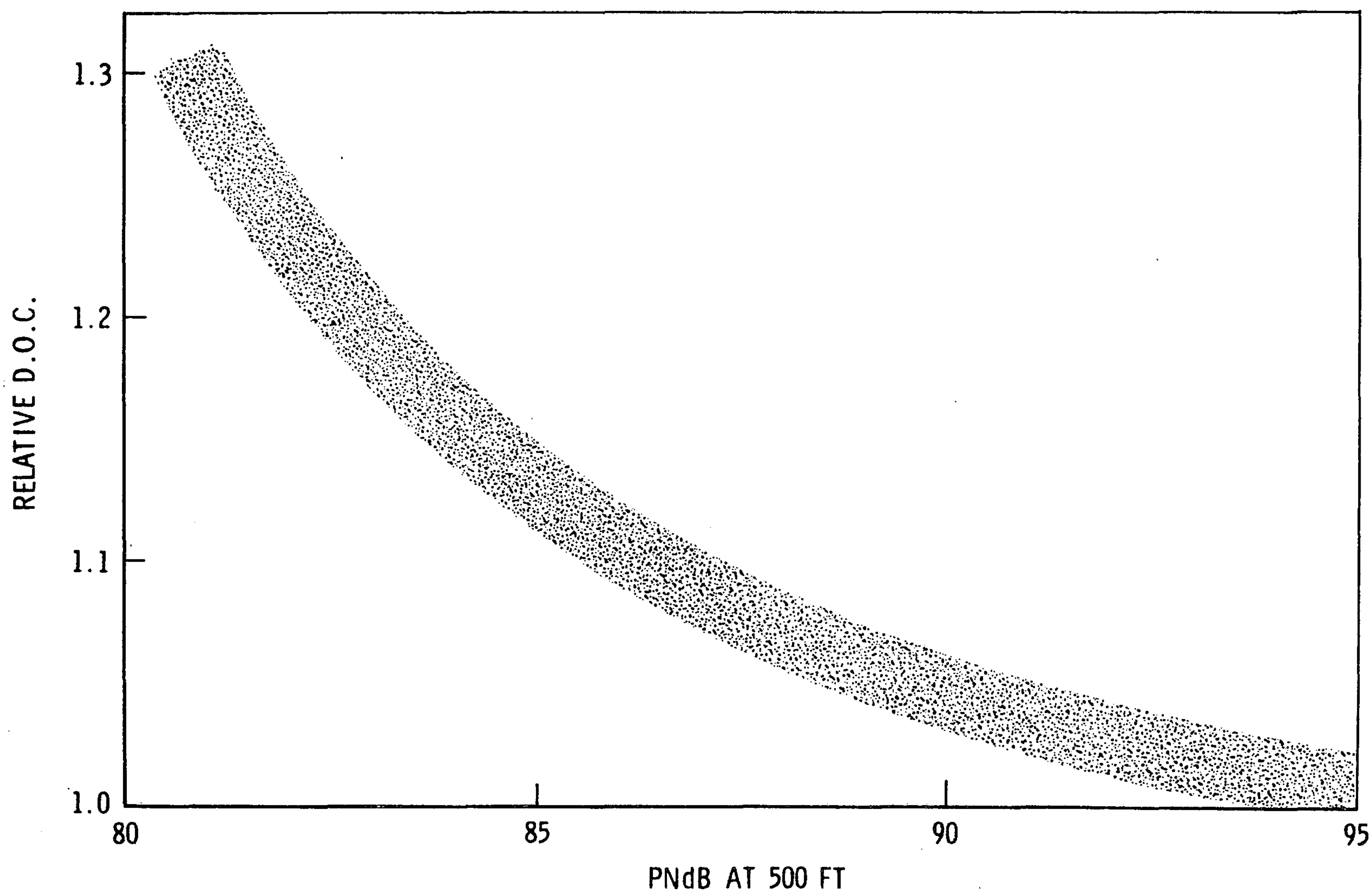


Fig. 3.12 Perceived Hover Noise vs Direct Operating Cost -- Future Helicopters

cerned with the other elements of a short haul system, i.e., the ATC system, and the airport or metroport. It is recommended that a review be made of the needs for research and development effort in non-vehicle areas to ensure the balanced development of a short haul air system.

For example, a need exists for the development of automated passenger handling systems for passenger terminals for all forms of public transportation, but especially for short haul air transportation where the costs of passenger processing are relatively more expensive.. For the public there is a need to ensure a consistent, standardized system to prevent carrying multiple credit card devices, and to prevent confusion for the user. For the computer and transportation industries, there is a need to cross modal and competitive boundaries to organize an initial development program which would stimulate the normal market forces in the private sector.

3.4.1 Quiet Propulsion

The NASA quiet engine program is well underway and appears to be achieving its goals. It is advisable that further work towards even lower noise goals be continued, and that current developments in engine technology by European and U.S. industry sources be monitored and used to redirect the quiet engine program when appropriate.

3.4.2 Short Haul Vehicle Research

The need for an experimental STOL transport to investigate the problems of propulsive lift STOL systems is clear, and the program has been initiated. Because of the promise of advanced helicopters and tilt rotor aircraft and their similar status in technological development, it is recommended that similar research programs be developed for these candidates. It is realized that this is a major commitment of the R & D resources of NASA and this nation, but the decisions as to the best vehicle for future short haul air systems, or the advisability of the air system itself cannot be made until some reduction in the uncertainties associated with these candidate configurations is made. The workshop strongly recommends the initiation of the Rotor Test Vehicle for flight testing advanced rotor concepts (in conjunction with the rotor test stand), and the Tilt Rotor Research Vehicle sponsored jointly by NASA and Army.

3.4.3 Vehicle Guidance and Control

The need for improved automatic guidance and control systems for short haul VTOL and STOL vehicles indicates that R & D efforts should be pointed towards flight demonstration of the various concepts which now exist. Stability Augmentation Systems, Velocity Control Systems, ride smoothing systems, automatic takeoff and landing systems for VTOL, etc., and the improvement of associated pilot displays are all worthy of development along lines which lead to applications for short haul air systems.

4.0 Problems and Issues

This section deals with the major problems and issues identified by the workshop which are associated with the introduction of new forms of short haul air services. Each section will briefly outline the workshop discussion of the problem and will make recommendations pointed towards resolving the issues raised.

4.1 Community Acceptance of Metroports

The most crucial issue for the development of short haul air transportation was identified repeatedly by workshop presentations as the community acceptance and noise problem. Because of jet noise associated with today's airports, and the well publicized frustrations of local communities and their political leaders in obtaining any relief from an existing situation, local communities are extremely wary of accepting proposals for new sites which open up the possibility of similar problems. In the present climate, the credibility of aviation proponents is extremely low, and rational discussion describing the quietness of future operations at new sites will be discredited by vociferous opponents from the lay public.

The issue is now placed directly before the public by the environmental hearings required for the expenditure of federal funds on new projects such as metroports. If the hearing finds that a significant environmental impact will occur, or that an alternative course of action which offers less impact exists, the funds will not be approved. Unless much quieter short haul aircraft are built, it is impossible for aviation to argue that there will not be a significant environmental impact, or that alternative forms of transportation do not exist. Therefore federal investment crucially needed to coordinate and assist local communities in providing the ground facilities for short haul air systems will not be available, and consequently no system will be developed.

However, the exciting developments in quiet helicopters and high bypass turbofan propulsion described to the workshop offer the prospect of much quieter short haul aircraft, for which noise footprint areas are reduced tenfold and more, compared with present values. Introducing such quiet short haul aircraft to divert passengers from noisier jet transports may clearly show a favorable environmental impact. This leads to the following recommendation:

AN EXTREMELY HIGH PRIORITY MUST BE ASSIGNED TO THE DEVELOPMENT OF QUIET AIRCRAFT FOR FUTURE SHORT HAUL AIR SYSTEMS, SUCH THAT THE ENVIRONMENTAL IMPACT HEARINGS CAN SHOW NET BENEFITS FROM INTRODUCING THE SYSTEM.

While the demonstration of quieter vehicles is absolutely necessary for community acceptance of future short haul air systems, it may not be sufficient. Fear of overflight, changes in patterns of activity and land usage around new terminals, television interference, and air pollution will be other points for the expression of community opposition. These disbenefits of the close-in local area must be balanced against the benefits to the wider area of the community in the form of good traveller accessibility, and industrial and commercial development. Although it should be concerned only with the environmental question, the hearing will cause a full discussion of whether the new metroport is beneficial to the community. An active program of public relations, prior to the hearing, and a strategy for preparing community proponents from the ranks of businessmen, travellers, Chamber of Commerce, etc.

will also be necessary. Much can be learned from similar programs newly developed for highway planning.

In the future, site location and development will have to be coupled with positive factors for the community such as recreational areas, multipurpose commercial development, payments to the tax base, tax easements for close-in areas, etc. What is an incentive for one community may not be for another. New employment may be valuable to urban renewal areas, whereas a residential area might want recreational development. This leads to the following recommendation:

STUDIES OF COMMUNITY ACCEPTANCE FACTORS SHOULD BE UNDERTAKEN TO COLLECT INFORMATION, AND DEVELOP STRATEGIES FOR WORKING WITH THE COMMUNITY IN THE PROCESS OF SITE SELECTION AND APPROVAL.

Another factor which the workshop identified as necessry for community approval of new sites was the existence of some form of guarantee of the future noise environment in the area around the site. It was argued that while quiet aircraft could be flown to demonstrate low noise levels to the community and its leaders, there still would exist objections concerning the possibility of future, yet unbuilt aircraft, both larger and noisier and with increasing levels of activity, which contribute to the overall neighborhood noise environment. It was also stated that guarantees made by aviation oriented organizations such as the FAA or airport authorities would not be accepted.

In discussing the form of the guarantees, it was clear that no satisfactory methodology exists for measuring community noise exposure. For quieter aircraft whose peak noise is close to background levels, or for VTOL aircraft where two peaks may exist, one for hover, and one for flyover, the present methods developed for jet transport breaks down. If possible, such methodology should use systems of noise measurement[1] which will be understood by laymen and politicans, and should be capable of being measured by automatic monitoring equipment located permanently in the metroport environs. This discussion leads to the following recommendation:

A NATIONAL METHOD OF MEASURING COMMUNITY NOISE AROUND AIRPORTS AND METROPORTS SHOULD BE DEVELOPED. LOCAL COMMUNITIES SHOULD BE ABLE TO SELECT STANDARDS FOR COMMUNITY NOISE USING THIS METHOD AND TO HAVE A NON-AVIATION AGENCY MONITOR AND ENSURE COMPLIANCE.

In order to provide incentives to the operators to buy and operate quiet aircraft, a landing charge based on noise footprint size, and which gave credit for quieter operations was also suggested. The money collected could be paid into the Airways-Airports Trust fund to support R&D efforts in noise reduction, or could be used locally to offset any tax easements granted to metroport neighbors as part of site approval. The level of charges established would thereby become a method of controlling metroport noise for local authorities, and this technique would levy charges directly against individual aircraft operators appropriate to their noisiness.

IN ORDER TO PROVIDE ECONOMIC INCENTIVES FOR OPERATORS TO BUY QUIET SHORT HAUL AIRCRAFT, A LANDING CHARGE SHOULD BE ESTABLISHED WHICH GIVES CREDIT FOR REDUCTIONS IN NOISE FOOTPRINT SIZE FOR TAKEOFF AND LANDING OPERATIONS.

In discussing demonstration projects for short haul aviation using VTOL, STOL, and RTOL vehicles, it became clear that some rather noisy aircraft might be suggested for early use in testing market response of passengers. The danger of adversely affecting community

1. The workshop found using noise footprint area a very practical measure, e.g., the area which hears peak noise above a given PNL during a landing and takeoff operation by the aircraft.

acceptance through influencing laymen visitors to the demonstration leads to the following recommendation:

ALL AIRCRAFT PROPOSED FOR USE IN SHORT HAUL DEMONSTRATION PROJECTS SHOULD BE SIGNIFICANTLY QUIETER THAN PRESENT DAY JET TRANSPORTS EVEN IF THEIR OPERATION IS AT BUSY AIRPORTS OR SMALL AIRPORTS WITH NO NOISE PROBLEM.

4.2 Passenger Acceptance

Another key issue to be resolved is passenger acceptance or market response to the various levels of service which might be offered by future short haul air systems. While the factors which constitute level of service can easily be identified (trip time, trip cost, frequency of service, accessibility, comfort and ride quality, reliability, etc.), and analytical models for demand can be constructed using pseudo-data from existing travel markets, it is impossible to place sufficient confidence in these hypothetical models to allow them to be used in rational decision making with regard to future forms of transportation systems. Answers to questions concerning diversion from other modes, levels of service offered by other modes, generation of new travel in the market, the attractiveness of new forms of transportation, levels of advertising and promotion by the modes, etc. show a sensitivity to assumptions which are well beyond that required for making rational choices of "best" systems, or determining economic viability of a new system.

Faced with this limitation of analytical techniques, the alternative is to resort to live experimentation in travel markets. Conducting a market research demonstration project will be a long term, expensive program which again may have some difficulties in supplying information for rational decision making. However it allows the decision maker to make a partial, less expensive decision rather than making a full commitment to developing a new form of public transportation in the face of major uncertainty as to its success.

Demonstration projects, or pilot projects, require that a small prototype system be constructed and operated in travel markets against existing modes. Passengers should receive a given level of service for some extended period of time so that they may make a number of trips to sample the service and determine their preferences. From the passenger viewpoint, the services offered by the system should resemble those which are eventually contemplated.

There are two distinctly different approaches to conducting demonstration projects which were identified by the workshop. One approach has been tried before. It is the approach of the entrepreneur where the goal is to find a economically viable system as quickly as possible. This is the approach that the federal government has taken in the past in cost sharing, or subsidizing the initiation of new forms of transport such as helicopter services. A second, and distinctly different, approach is that of the transportation systems analyst whose goal is to systematically study the market behavior of travellers as he uses the new system to offer various levels of service. The cost of providing these levels of service and the profitability of the new system at any experimental stage are only of secondary interest to the analyst. The primary goal is to obtain good market information to guide analytical studies which will later determine a "best" system. The private sector will have little interest in sharing the costs of obtaining this knowledge, especially if it becomes public information, so that the second approach will require higher federal spending.

For short haul air systems, demonstration projects should be constructed to provide information concerning the tradeoff between trip costs and travel times, where total costs and times including the access portions of the trip are considered. The second area of information gathering involves questions of ride qualities, or passenger comfort levels, on board some of the STOL and VTOL vehicles contemplated for future systems.

The resolution of the passenger acceptance issue was considered important enough that a fuller description of possible approaches to Demonstration Projects is given in section 5.0 of this report. At this point, we have a simple recommendation:

DEMONSTRATION PROJECTS FOR SHORT HAUL AIR SERVICES POINTED AT OBTAINING MARKET RESEARCH DATA SHOULD BE CARRIED OUT UNDER THE LEADERSHIP OF THE DEPARTMENT OF TRANSPORTATION.

4.3 ATC Congestion

Another issue which arises with regard to future short haul air systems is whether or not future ATC systems will be able to handle much higher levels of air traffic at lower enroute altitudes and in terminal areas airspace around major airports. There is little doubt that sufficient ATC capacity can be provided by various alternatives discussed by the workshop; the issue seems to concern the uncertainties of which alternative is best, and whether or not any alternative will be compatible with the on-going work of upgrading the new third generation ATC system.

Landing areas for future short haul air systems will exist at major airports, smaller peripheral airports, and at new metroport sites in urban areas. All of these sites will require takeoff and landing guidance systems, and the new generation of microwave systems seems to provide suitable solutions. Operation of vehicles at low altitudes at peripheral airports and metroports may cause surveillance problems, but there are various solutions possible such as a navigation down-link. The inclusion of many more small vehicles from a successful busy short haul system would cause communications, congestion or sectorization problems for the present organizational structure of the ATC system, particularly if radar vectoring is continued. However, improved navigation and guidance systems for short haul aircraft will allow smaller, more detailed corridors for terminal area arrivals and departures, and close parallel landings at major airports, which when combined with data up-link for command instructions will allow restructuring of the airspace and new modes of operation for presently busy terminal areas.

While all of these promising developments and alternatives exist, the workshop came to the following recommendation:

THE POSSIBILITY OF ACCOMMODATING A BUSY SHORT HAUL AIR SYSTEM OPERATING AT METROPORTS, PERIPHERAL STOLPORTS, AND AT BUSY MAJOR AIRPORTS SHOULD BE GIVEN FULL CONSIDERATION IN THE PLANNING FOR BOTH UPGRADED THIRD AND FOURTH GENERATION ATC SYSTEMS.

4.4 Institutional Factors

There are serious institutional problems to be solved if the federal government is going to carry out national policy making and planning for transportation systems. Unlike most other countries of the world, there is a division of the activities of the US transportation systems into the private as well as the public sectors of the economy. In aviation, the operators (airlines), the manufacturers and their investors are in the private sector; the operator of the airways, the research and development agencies and the regulator are from the federal government, and the airport owner and operator is some form of local government. Private investment is made in airport development through municipal bonds, while the federal government provides assistance for the airside only.

While it is possible for this collection of actors to work together in developing a growing, economically viable air system, the initiation of new, different forms of air transport cannot be done without leadership exerted by the federal government to create an environment within which these other elements can understand what is expected of them, and are willing to participate. This leads to the following recommendation:

THERE IS A NEED FOR DOT TO ESTABLISH A LONG TERM, CONSULTATIVE, PARTICIPATORY TRANSPORTATION PLANNING PROCESS TO PROVIDE A POLICY STATEMENT ON THE FUTURE OF SHORT HAUL AIR TRANSPORTATION.

This policy statement must recognize existing institutional constraints and, to be practicable, should basically live within these constraints rather than relying on major changes. The more significant of these constraints are:

1. The political and financial impediments to state and local governments taking more land for transportation facilities. Obviously, this is tied in with the noise problem.

2. The lack of clear evidence of profitability for both manufacturers and operators. This must be demonstrated to decision makers within the private sector in terms they understand. Modelling efforts are fine, but operator and manufacturer management must be convinced. We must directly address their prejudices and intuitions based on experience.

3. The financial experience and current financial position of the private sector of aviation must be recognized. It is doubtful that anyone in the private sector today is in a position to undertake a major high risk program. Moreover, it is doubtful that they would be willing to do so unless they could see a potential return at least equalling the risk.

4. The lack of action by the public sector in areas over which the private sector has no control is impeding private sector action in two ways:

   a. The lack of a clear definition of the future operating environment creates an inability by the private sector to define and evaluate what it has to do.

   b. The private sector cannot be expected to make major commitments without the assurance that the essential system elements, such as airports and airways, which the public sector must provide, will be available. (The Northeast Corridor VTOL Investigation is a case in point.)

This policy statement should address issues such as:

1. The definition of a national short haul air transportation system, what its objectives are and what its institutional characteristics are.
2. The government's commitment to provide the funds necessary for development of the system elements for which it is clearly responsible.
3. The government's intention to work with local communities to ensure the development of a system responsive to their requirements and at the same time technically and economically practical to the operators.
4. The possible need for some government incentive for private industry to undertake the financial risk in implementing such a system.
5. The fragmented Federal Government agency responsibility for matters pertaining to this system and its impact on effective action by the private sector.

This last issue is one which should be addressed in depth. We now have a situation in which no fewer than six Federal Government bodies are recommending or, in effect, making policy (OST, FAA, NASA, CAB, AAC, NASC). Their actions are not coordinated and, in many instances, seem to be actively contradictory.

The creation of the V/STOL SPO within the FAA will hopefully provide a mechanism for coordination, although it is not clear how the hearing processes of the CAB, the long range recommendations of the AAC, or the R & D planning by NASC relate to the project activities of the V/STOL SPO. There is no existing policy for short haul air transportation, and while the V/STOL SPO can be a catalyst in generating a policy, the final determination will be made at a higher level, and hopefully will involve participation by elements of the private sector. It may never be possible to get a complete, consistent policy statement on short haul air transport from our form of government. There may be an evolutionary development of this policy through incremental policy actions by the various agencies.

One of the more important institutional issues is whether or not new corporate entities should be formed to operate the short haul air system. Because of the institutional constraints within major airlines in the form of standards of service, labor relations, operating practices, etc., they seem most unlikely to be able to adapt to an efficient, low cost short haul operation. (This was clearly demonstrated to the workshop by a presentation by one of the major airlines of its expected indirect operating costs for metroflight service.) The short haul feeder operations of some local airlines are being taken over by an, as yet unrecognized, "Third Level" set of scheduled airlines which suffer from financial instability, management inexperience, and low traffic volumes over their route structure. The answer in developing good short haul operations may lie in allowing present airlines to establish separate divisions for short haul air services along the lines of the existing Allegheny-Commuter system. The existence of a separate organization for short haul is important to provide specialized management and procedures to achieve low cost operation, as well as having a distinctly separate cost reporting center so that costs can be identified, and proper emphasis can be placed on reducing costly activities.

Another institutional problem lies in the creation of Airworthiness Rules for certification of Powered Lift transport aircraft. The existing transport rules evolved over the history of the development of transport aircraft, and hopefully, a similar evolution can be envisaged for new kinds of V/STOL aircraft. It is necessary, however, that some determination of initial rules be made so that aircraft can be placed into public service for demonstration projects.

5.0 Demonstration Programs for Short Haul Air Systems

5.1 Why Do We Need Demonstration Programs?

The development of new forms of transportation cannot be implemented by any single party in our society. Operators, cities, airport authorities, financial interests, and vehicle manufacturers must be coordinated and led by policies laid down by the federal government. To determine these policies, a transportation planning process must be established and carried out by the Federal Government. This transportation planning process requires good information on alternative forms of transport. When new forms of transport do not exist, information on market acceptance, system performance, operating costs, environmental costs, etc., can only be speculative, and the uncertainty in this information may prevent making rational decisions for transportation policy.

Since these decisions in transportation policy are clearly major long-term decisions for the nation and its transportation system, it is possible that experimental pilot projects which demonstrate the new transportation system in a suitable area in order to reduce the uncertainties can be worthwhile. These projects would be neither inexpensive, nor short term exercises, but in view of the importance of the information obtained in establishing a rational transportation policy, and the size of national investment as a result of that policy, a demonstration project may indeed be the most sensible course. Transportation systems analysis and paper studies are not always sufficient to make policy decisions. Demonstration projects provide a chance to experiment, and to do market research to determine what the public wants for new, improved transportation systems.

Demonstration projects are not novel ideas. They are now being carried out by the Urban Mass Transit Administration of DOT for new forms of urban transit. High speed train demonstrations have been carried out by the Federal Rail Administration of DOT for the last few years between Boston, New York and Washington in an attempt to validate public acceptance of better train service. The CARD Policy Study of March 1971 recommended a demonstration for a high density, short haul air system, outlined the conditions which would justify federal involvement, and suggested the role that the federal government should play in such projects.

5.2 Objectives of Demonstration Programs for Short Haul Air Systems

The primary objective of all demonstration programs is to demonstrate the service offered by a new form of transportation to the travelling public. It is axiomatic to say that the public will not know what it wants until it experiences it. Lack of detailed knowledge about the short haul traveller's preferences inhibits the design of new systems, and can only be obtained by performing market research in the appropriate existing markets.

A secondary objective is to demonstrate the improved environmental aspects of noise, pollution, access traffic patterns, etc., to the non-travelling public for the purpose of obtaining community acceptance.

Another objective is to demonstrate operational and economic feasibility of the service to potential operators and their financial sources.

Demonstration of items of advanced technology should not be an objective of these projects since there is an obligation to provide safe, fully tested and certificated hardware for the travelling public. The results of demonstration projects should provide guidance for other research and development programs of the government and hardware development programs of the manufacturers. Demonstration of technical feasibility is a part of these R & D programs, and not of the demonstration projects. The one exception to this could be the use of a fleet of demonstration aircraft as ATC targets for improved surveillance systems and data link systems to demonstrate technical feasibility of ATC ground equipment where passenger safety is not compromised.

5.3 Planning for Short Haul Air Demonstration Projects

The following are factors to be considered in planning a short haul air demonstration project.

5.3.1 Service Parameters

The parameters of the kind of air service being offered to the travelling public in a given short-haul market in rough order of importance are:

a) fare structure

b) schedule frequency

c) trip time

d) accessibility

e) comfort and ride quality

f) advertising and promotion

It is unlikely that there would be enough time and effort put into any demonstration project to allow a market researcher to fully explore even a small range of all of these parameters. Some period like 6 months is required to stabilize the market response to new service parameters since there must be sufficient time for repeat travellers to sample the service and determine their travel preferences. Seasonal variations, or changes in service offered by competing modes, may make isolation of the parameter effects a very difficult task.

The workshop identified an interesting issue which arises between the experimenter and the entrepreneur when the set of service parameters attracts enough traffic to make the project economically viable - Should the experimenter be allowed to finish his market research, or should the demonstration project be turned over to the private operator once a profitable service is demonstrated? The market data gathered might be useful to transportation planners and policy makers in other markets at later times, so that it be preferable to finish a complete controlled experiment rather than repeat a demonstration project in other situations.

5.3.2 Market Selection

The selection of an area in which to demonstrate new concepts must be the subject of more detailed investigation than the workshop could make. Discussions with local authorities and operators to enlist their participation are advisable, and a survey to determine present travel patterns and traveller profiles, accessibility to potential sites, etc. should be carefully carried out in preparing a proposal for a demonstration project.

However, the workshop did consider a number of possible areas and came up with the following list as suggestions for further investigation.

a) Portland-Seattle-Vancouver
b) Cleveland(Burke)-Detroit(City)-Chicago(Meigs)-Toronto(Island)
c) Miami-Orlando-Tampa
d) Dallas-Houston
e) New York-Philadelphia-Washington
f) Montreal-Ottawa

There is a letter of understanding between the US and Canada concerning V/STOL development, and the West Coast and Great Lakes suggestions might be areas where joint efforts could be undertaken. As well, the announced Montreal-Ottawa project could provide opportunities for US participation for the purpose of determining operational factors for STOL, or passenger response to ride smoothing systems for a STOL Twin Otter.

5.3.3 Demonstration Equipment

A major difficulty for any near term demonstration project is the lack of properly certificated, quiet short haul vehicles in the classes RTOL, STOL, or VTOL. The following tables list potential candidates discussed by the workshop and are grouped into certificated vehicles, and those which might be certificated in the near term with some development effort. There exists an established procedure for certification for RTOL and helicopter transports, but not for aircraft which rely on powered lift in the STOL and V/STOL category. Since it is advisable that demonstration aircraft be properly certificated as safe for public transportation, this would delay use of powered lift V/STOL aircraft in demonstration programs.

Table 5.1 Available Certificated Transport Aircraft

	Cruise Speed (mph)	Capacity (passengers)	Noise (PNdb at 500 feet)	Timing
Helicopter				
S-61	125	26	93	now
Prop STOL				
Twin Otter	170	19	107	now
Caribou	160	26	?	USAF bail
Turboprop				
F-27 (off loaded)	280	< 44	?	now
Electra (off loaded)	400	< 80	103	now

Table 5.2 Possible Demonstration Transport Aircraft

(quietened, certifiable at some expense)

	Cruise Speed (mph)	Capacity (passengers)	Noise (PNdb at 500 feet)	Timing
Helicopter				
BV-347	190	50	< 93	2 years
S-65-40	173	46	< 95	1 year
Turboprop STOL				
DHC-7	240	48	95	3 years
Jet RTOL				
DC-9-10 (off loaded)	600	< 90	reengined?	2 years
B-737-SF (off loaded)	600	< 100	reengined?	2 years

Approach and landing guidance can be supplied from existing operational microwave landing systems like TALAR, or MODILS, and aircraft can be equipped with existing operational R-NAV equipment so that efficient ATC terminal area procedures can be established for new sites.

5.3.4 Demonstration Operators

Guidelines for participation in demonstration programs described by the CARD Policy Study suggest that jointly funded ventures between industry consortia and the government is a preferable course of action. The consortium might consist of a manufacturer, airline, and third level carrier and perhaps an airport or local transportation authority. The federal responsibility now seems to rest with the FAA V/STOL SPO to provide project management and analysis, and to coordinate the various branches of the federal government which might be involved.

5.4 Examples of Demonstration Projects

Two possible demonstration projects which the workshop discussed in some detail are described in this section.

5.4.1 Great Lakes RTOL Demonstration

Because of the unavailability of larger STOL or VTOL transports, the workshop considered starting intercity services between Chicago, Detroit, Cleveland, and Toronto in the Great Lakes area using existing, certificated short field transports like the F-27 and Electra. Modified RTOL aircraft like the DC-9-10 or B-737-100 could be introduced at a later stage, or STOL transports such as the Twin Otter, or DHC-7.

These four cities all have small airports located conveniently to the city center which could be used by quiet short field transport aircraft. All of the airports would enjoy accessibility advantages over the conventional airports so that total trip times would be less than for CTOL. Competitive services exist from automobile, bus, and rail at varying trip times, costs, and frequencies.

By varying fares and frequencies of service, and providing safe, reliable service comparable to present airline service, an experiment can be proposed to examine the market response. This project is quite clearly pointed not at demonstrating V/STOL technology, but at obtaining evidence about market response to improved accessibility and frequency of service at perhaps higher fares. This data is needed to project traffic volumes in other city pairs where V/STOL performance is required to achieve improved accessibility for the traveller.

5.4.2 Bi-Centennial Demonstration

The plan for the Bi-Centennial Celebration in Philadelphia in 1976 currently includes three widely separated sites. A helicopter service connecting the three sites seems to be an attractive idea, and would require the construction of three heliports. The next problem is how visitors arriving by airline transportation get to the celebration sites. It would be desirable to share the airline traffic load amongst several airports in the Northeast Corridor rather than just the Philadelphia airport. Therefore, the suggestion arises to link the New York, Philadelphia, Baltimore, and Washington airports to the sites by either helicopter, STOL, or RTOL service. This might require that a short runway be constructed for at least one site, perhaps as part of an elevated parking garage.

At this point, the suggestion to use the New York to Washington market for a short haul air demonstration project to begin before the Bi-Centennial, supply these services during the celebration, and to continue after 1976, begins to become a very efficient proposal. This plan would place a short haul air system in direct competition with the high speed train services, and provide an acid test for traveller preferences. It would demonstrate ATC operational feasibility within the busiest airspace in the nation, and by diverting the short haul air passengers, would provide additional runway capacity at some of our busiest airports through the seventies. It is suggested that this project will have good visibility throughout all branches of federal government, and that the Bi-Centennial would be an excellent occasion to demonstrate new forms of short haul air transportation developed by US technology.

The provision of quiet, fast helicopters in the New York, Philadelphia, Washington corridor is quite attractive because of the potential availability of the BV-347 and S-65-40. Travel times are less than a half hour, and a helicopter could visit all three fair sites.

The length of runways which might be available at one or more Bi-Centennial sites needs to be determined, but if an RTOL or STOL runway can be built, then service from New York and Washington using these types of aircraft can also be considered. It will be vital to ensure the quietness of these demonstration aircraft to visitors while at the celebration, so as not to prejudice community acceptance of future short haul air systems.

A study would be required to determine the availability and cost of suitable R/STOL transports for the Bi-Centennial. It may be feasible to use other locations throughout the Northeast Corridor for day visitors to the celebration, as well as major jetports. Small airports on Long Island and in New England could be connected by STOL Twin Otter service operated by commuter airlines, as well as existing heliports such as at Wall Street. Again, operations from these sites should demonstrate the quietness of future aircraft.

After the celebration is finished, facilities established for the celebration traffic could be used to continue a market demonstration project for more normal flows of business and pleasure travel. Fares, frequencies, and comfort levels can be varied in conjunction with services of the improved high speed rail service to provide a head-to-head competition between the two modes proposed for the Northeast Corridor.

6.0 Towards a National Plan

This section draws together the technological developments, problems, and recommendations of previous sections to construct an initial framework of a plan. The plan is not rigid or detailed in its present outline, and will require further understanding and consultation with the whole aviation industry to define its final formulation. The plan is a package with some emphasis on the marketing and public relations aspects to make it understandable and saleable to the nation. It places prime emphasis on solving the crucial noise problem identified by the workshop, and while the plan covers the future development of all of air transportation, its major activities are focused on the short haul system.

6.1 The Long Term Problem of Air Transportation

The major long term need for domestic air transportation is additional system capacity to accommodate future growth and to relieve present congestion and delay. The system capacity which is needed can be classified as ground facilities - runways, airports, metroports, or more precisely, concrete. There is a parallel need for improving the ATC system with improved technologies and procedures, but for the most part, the capacity restriction is not in the air, but rather on the ground.

But while the ATC system will be improved over the next decade, there is a serious barrier to providing additional ground facilities - community acceptance and the noise problem. Recent history at several U.S. cities has led many aviation leaders into publicly asserting that we have built the last major jetport in this country, and surrounding communities are now aware that any planned improvement to existing airports will expand its capacity to make noise. A new factor is the requirement for an environmental hearing before federal funds can be expended on additional runways, or airfield improvements. The community is thereby given an opportunity to block all increases in the capacity of existing airports, and will do so at most of the major jetports.

As well, the tenor of our times has led us into a political climate where local government actions may cause reductions in existing capacity. Curfews are current local issues at a number of airports, and more restrictive quotas or operational restraints are a threat for the coming decade.

The alternatives to solve the noise problems have been well discussed in recent years. Briefly they may be listed as:

1. Nacelle Retrofit Program
2. Re-engine Program
3. Remote or Offshore Jetport Construction
4. Land Acquisition around Major Airports
5. Avigation Noise Easements

For the U.S., all of these alternatives are generally multi-billion dollar, ten year programs, and much discussion has been generated concerning the costs, time scale, and noise benefits of variations or combinations of them. One or more of them must be adopted to ensure long term viability of the air transport system. The financing of any such solution will be undoubtedly done using the Airways-Airports Trust Fund although some amendment of the present legislation will be needed.

A new alternative has now emerged from the workshop deliberations. It is mainly concerned with future course of developments in the short haul sector of air transportation, but provides an attractive solution to the long term problem of all of air transportation.

6.2 The "QTOL" Program

The QTOL (Quiet Takeoff and Landing) Program is a suggestion that the air transport industry should dedicate itself to a long term program aimed at quietening the environment around aviation ground facilities, while at the same time continuing to improve short haul and long haul air services for the nation.

The first steps in this program may be said to already have occurred with the introduction of the DC-10. The quiet engine technology used on that medium-to-long haul aircraft (and the coming L-1011) reduce the noise footprint size to roughly one quarter of that of the prior DC-8 which carries only one half the passenger load. These new planes will gradually replace their noisy equivalents over the next several years.

The second step is to use still quieter engine technology in intoducing a new set of short haul vehicles and an improved short haul air system. A gradual replacement of DC-9 and B-727 aircraft can occur as airline short haul traffic is diverted to the new quiet short haul system, and the existing runways freed for long haul service. The elements of this system are now discussed in more detail. All elements have been tagged with a label "Q" to emphasize the thrust of the program in dealing with **laymen and legislators.** It is, quite frankly, a marketing device to continually remind the industry and the public of the major goal of the program.

6.2.1 Q-PLANES

A Q-PLANE would be defined as a vehicle with two distinct improvements in performance:

1) It meets some Q-criterion such as 95 PNdb at 500 feet when at full power, or a 95 PNdb footprint size less than some value.
2) It has improved navigation and guidance capabilities for steeper, more complex paths for approach and departure.

There are three classes of quiet short haul vehicles which have been identified by the workshop:

1. QVTOL (quiet vertical takeoff and landing)

2. QSTOL (quiet short takeoff and landing in less than 2000 feet)

3. QRTOL (quiet reduced takeoff and landing in less than 4000 feet)

As discussed previously, these aircraft are now technically and operationally feasible for some size of vehicle, although they are in varying stages of technological development. If the Q-criterion for noise were placed at lower levels, the aircraft would be smaller in size and more costly to operate. As Q-technology in the form of improved quiet propulsion and new guidance systems is developed, the vehicle's size and economic performance will be improved.

6.2.2 Q-PORTS

A Q-PORT is a facility which accepts only Q-PLANES, and whose noise environment has been guaranteed to the surrounding community as part of the approval process for the facility. Automatic listening devices would monitor the noise environment, and enforcement of these guaranteed standards would be the responsibility of a non-aviation agency. Q-PORTS would be of two main types:

1) A conversion of an existing peripheral airport to handle short haul passengers. Improvements in runways, lighting, landing guidance, terminal buildings, parking, and access roads would be made.

2) Construction of metroports of reduced acreage at suitable sites in existing urban areas for V/STOL Q-PLANES. These sites might be downtown at the waterfront, or at expressway interchanges.

As part of the Q-PORT development, route awards would be made to operators authorizing new short haul services from this site.

6.2.3 Q-WAYS and Q-PADS

A Q-WAY is defined as a new short runway restricted to usage by Q-planes and constructed at congested jetports to accomplish two objectives:

1) to provide less noise at the jetport by diverting short haul passengers from the present noisy jet transports to Q-planes.
2) to increase the capacity of the jetport by diverting short haul flights from the presently busy jet runways to the additional Q-ways.

There is adequate space on major airports for the shorter Q-ways for both RTOL and STOL aircraft. One attractive layout would be to build a Q-way parallel to the main runway and centrally placed such that the approach and departure paths are both vertically displaced from the CTOL paths, and thereby, hopefully avoid the wake vortex interference problem. The improved navigation and guidance of Q-PLANES would be used to get into and away from Q-WAYS. For QVTOL aircraft, this improved guidance capability would allow paths directly to Q-PADS on the periphery of the terminal ramp area.

6.2.4 Q-FUNDS

The financial aspects of the QTOL program would be funded by establishing a landing charge for all aircraft based on the takeoff and landing footprint size above a given noise level. Credit would be given to operators who use technical or operational means to reduce their noise footprint. These charges would be part of the user charges of the Airways-Airports Trust fund, and would be earmarked for use in the QTOL program, or as a credit to the Q-FUND account in the event that early QTOL program spending outdistances income from Q-CHARGES.

6.3 National Benefits from the QTOL Program

A brief review of the benefits and costs of the QTOL Program for the various parties will be given in this section.

6.3.1 Community Benefits

1. Reduction in noise exposure around major jetports.
2. Reduction in land usage by air transport facilities.
3. Reduction in local investment in air transport facilities.
4. Continued growth in air transport services and regional industry.

6.3.2 Traveller Benefits and Costs

1. Reduced congestion, delay for long haul passenger.
2. Improved services, travel times for short haul passenger.
3. Improved accessibility to air transport system.
4. Short haul air fares may be higher than present.

6.3.3 Airlines, Operator Benefits

1. Future aviation growth is possible.
2. New travel markets are created.
3. Reduced congestion and delay, and operating costs for long haul.
4. Avoid retrofit, reengine costs.
5. Trade higher short haul operating costs against landing charge credits, improved efficiency.

6.3.4 Airport Operator Benefits

1. Capacity of existing airports is increased.
2. Avoidance of land acquisition, curfews.
3. Quieter regional airport operations.
4. Future aviation growth is possible.

6.3.5 Aviation Manufacturer Benefits

1. New market for quiet propulsion engines.
2. New market for short haul Q-PLANES.
3. Future aviation growth is possible.

6.3.6 Federal Policy Maker Benefits

1. QTOL Program can be self-supporting using Airways-Airports Fund.
2. QTOL System can be used for regional development and planning.
3. QTOL System elements contribute to export balance.
4. Converts large public investment in R&D to commercial use.
5. Provides a mission for underemployed aerospace industry.

6.4 The Two Mainstreams of Development

The presentations to the workshop identified two distinct and complementary streams of development for the quiet short haul air system. The first is a very short haul system operating over stage lengths of 5 to 200 miles and using quiet rotary wing transports. We shall call this the QVTOL stream. The second is a short haul system operating over stage lengths from 100 to 500 or more miles using quiet fan engine RTOL and STOL airplanes. We shall call this the QR/STOL stream. For those familiar with both these streams, their development is clearly complementary and not competitive. Planning for both streams should be coordinated and cognizant of underlying developments in the military R & D programs which continue to support both of them. We shall now describe a future scenario for both of these streams in order to provide a rough framework for a development plan for the quiet short haul air systems of the QTOL Program.

6.4.1 The QVTOL System

The QVTOL System is envisaged operating at very short stage lengths from 5 to 200 miles from Q-PADS located in the CBD's (Central Business District) of major cities, in the suburban areas at Q-PORTS or other locations and at major jetports. Its role is to provide urban access to the CBD and jetport, and to provide short haul intercity service between CBD's of adjacent cities in a megalopolitan area like the Northeast Corridor, or the Great Lakes Corridor. Most of the services introduced by the QVTOL system would be new services, presently not operated by airline systems, and would be competitive with automobile, bus and train travel. Because the markets are new, market demonstration projects will likely be required to initiate services. New corporate forms may be needed to participate in demonstration consortia, establish more efficient operations at lower standards of service than the long haul airline standard, and to allow good cost reporting for the very short haul operations. As confidence is gained in the existence of viable air travel demand for such services, ordinary route awards can be made to existing QVTOL carriers. This new system of services will have a great impact on airport planning and urban planning for its region.

It was surprising for the workshop to discover that the quiet helicopter programs of the military had already developed the first Q-PLANE, and that two large, quiet transport Q-helicopters carrying 50 passengers at 180 mph could be available for commercial certificated service within roughly two years. The continuing military R & D program for rotary wing vehicles promises larger, faster, and quieter commercial transports as compound helicopters and tilt rotor vehicles are developed.

Since the helicopter is already operating in city center areas, and since these new helicopters are capable of meeting Q-criteria for noise, it seems desirable to initiate city center services in the next few years using these vehicles to obtain community acceptance for city center Q-PORTS, and accustom the public to the concept of short haul service by air from the city center. Subsequent provision of Q-WAYS for QSTOL vehicles available in the 1980's should be considered in the planning for these city center sites in order to develop a full Q-PORT with its longer range services into the CBD.

6.4.2 The QR/STOL System

The QR/STOL system envisages operations by quiet aircraft over stage lengths from 100 to 500 miles from Q-PORTS located at existing peripheral airports and CBD's and from Q-WAYS located at major jetports. Its role would be to provide regional access to major jetports for the connecting long haul passenger, and to provide intercity short haul air service over links connecting Q-WAY to Q-WAY, Q-PORT to Q-WAY, and Q-PORT to Q-PORT. The system would be a modification, or extension, of the present airline system, would divert a large portion of present airline short haul traffic and allow it to access the air system at Q-PORTS instead of jetports. The vehicles would not be restricted to megalopolitan areas, but would cover low and high density regions of the nation as part of the airline network. New services would be authorized from the Q-PORTS to control the development of the system and to encourage airlines to initiate QR/STOL services. Establishing separate short haul operating divisions of the airlines might be considered as part of the development plan to allow new labor practices and different standards of service more appropriate to short haul.

The nearest vehicle in the Q-PLANE class for RTOL or STOL vehicles is the propeller STOL DHC-7, carrying 48 passengers at 275 mph, which might be available in three years time. QRTOL vehicles require emphasis on producing a quiet, high bypass ratio for engines of suitable size. If priority development were given to such engines, a parallel development of engine and airframe could provide suitable QRTOL vehicles in the later part of the decade. Such vehicles may be available from Europe. The design of a propulsive lift QSTOL awaits development of a body of certification rules, and this seems to be related to the construction and flight testing of the NASA experimental STOL transport. This would seem to delay introduction of this kind of STOL aircraft until the 1980's.

A very difficult question in planning the QR/STOL system is determining the field length required. It will depend upon the complete set of sites, Q-PORTS, Q-WAYS, and city center STOL runways envisaged by an individual operator as part of his network of services, and the likelihood of community acceptance of suburban Q-PORTS and city center STOL runways. One operator may be quite happy with RTOL performance, where another critically requires STOL performance.

A study is needed to determine the length of possible Q-WAYS at major jetports, and the runway lengths existing at likely peripheral Q-PORTS. A set of such runways would show whether reasonable short haul service could be initiated with QRTOL vehicles in certain areas of the country. The QSTOL vehicles could operate from all of these sites plus the city center sites, and whichever jetports require STOL Q-WAYS. It seems likely that one of the key issues in determining the need for QSTOL will be whether or not the community will accept STOL runways at city center Q-PORTS. If not, most systems could probably use RTOL performance to supply services from Q-WAYS and peripheral Q-PORTS, and QVTOL vehicles would be used to access the city center from these sites.

This major uncertainty in community acceptance of Q-PORTS for both city center and suburban locations makes it very difficult to perform any systematic analysis for planning, and again emphasizes the key role of noise and community acceptance for the short haul air systems.

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MIT Summer Workshop on Short Haul Air Transportation

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Panel C) Status and Forecast of Future Technology

- B. Davey, T. Sills, N. Ham, H. Faulkner, R. Long B. Doolin

Panel D) Problems and Issues

- J. Vittek, R. Dutton, S. Crossfield
- P. Hoxie, J. Hooper, N. Taneja, W. Swan
- L. Dowdall, A. Hays

Panel E) Demonstration Projects

- E. Stout, J. Hosford, G. Kenyon, J. Reibe

APPENDIX B

MIT/NASA WORKSHOP PRESENTATIONS

Monday, 2 August

Discussion of Workshop Goals and Panel Structure
R. Simpson, MIT, FTL

Overview - Four Phases of V/STOL Systems Development
G. Cherry, NASA-OART

Tuesday, 3 August

Review of SFO Intraurban Study for NASA
C. Rushmer, Boeing Seattle

Review of Western Governors' Short Haul Air Study
E. Hinz, Aerospace

Regional Air Services Program in Ontario
W. B. McCarter, DOT Ontario

Wednesday, 4 August

Review of Detroit Intraurban Study for NASA
L. Riedinger, Lockheed California

Economics of Short Haul Transport
L. Vaughn, Lockheed California

Choice of a V/STOL System for NE Corridor
W. Swan, FTL, MIT

Short Haul V/STOL Air Systems
B. Davey and R. Bustin, British Aircraft Corp.

Thursday, 5 August

Economic Problems for Short Haul Air Transportation
D. Klein, Eastern Airlines

Economic Analysis for Air Transportation Systems
M. Roberts, MITRE

Aspects of Noise and Pollution for V/STOL Systems
J. Vialet, MITRE

American Airlines Planning for V/STOL
R. Ransone, American Airlines

Presentations (Continued)

Friday, 6 August

V/STOL Noise Propagation in Urban Areas
R. Lyon, MIT, M.E.

V/STOL Noise Generation Studies
S. Widnall, MIT, Aero

Community Considerations in Planning V/STOL Facilities
J. Finley, Battelle

Results from Quiet Helicopter Program
N. Hirsh, Hughes

Federal STOL Programs
G. Cherry, NASA-OART

Vertol Noise Reduction Programs
E. Schaffer, Boeing Vertol

Optimal Noise Trajectories for Tilt Rotor Aircraft
W. Stepniewski, Boeing Vertol

Noise Research on the STOL DHC-7
F. Cicci, DHC; F. B. Metzger, Hamilton Standard

A Noise Level Demonstration
P. Bauer, MIT Aero Dept.

Monday, 9 August

Economic, Environmental and Engineering Applications for STOL
H. Perritt, Lockheed Georgia

V/STOL Vehicle Design and Technology at Lockheed
W. C. Garrard, Lockheed Georgia

V/STOL Programs at Sikorsky Aircraft
J. McKenna, Sikorsky

Tuesday, 10 August

Assessment of Command Augmentation Control Systems for STOL
H. Redeiss, NASA-FRC

Development Status of VTOL and STOL Aircraft Research
R. Kuhn, NASA-Langley

Presentations (Continued)

Tuesday, 10 August (Continued)

Status of Noise Research for VTOL and STOL Aircraft
D. Chestnutt, NASA-Langley

Canadian STOL Demonstration Program
D. Pratt, DOT Canada

Legal Aspects of Noise
J. Vittek, MIT, FTL

Wednesday, 11 August

Tilt Rotor Development at Bell
J. C. Kidwell, Bell Helicopter

Folding Prop Rotor VTOL Aircraft Development Programs at Bell
J. A. DeTore, Bell Helicopter

Northeast Corridor Short Haul Systems Analysis
R. Nutter, MITRE

MODILS - a Landing System for STOL
M. Myer, Raytheon

Application of Dial-a-bus to Metroport Access
N. Wilson, MIT, C.E.

Thursday, 12 August

System Analysis for Short Haul Air Systems
J. Duvivier, Boeing Vertol

V/STOL Applications of TALAR
J. Taylor, Singer-Kearfott

An Approach to V/STOL from an Operator's Viewpoint
J. Borger, Pan Am

Propulsion for V/STOL
G. Rosen, Hamilton Standard

Presentations (Continued)

Friday, 13 August

Metroports - A Flexible and Convenient Transportation Interface for VTOL
R. Simpson, MIT, FTL

STOLports and Approaches
L. Achitoff, PONYA

Flow over Elevated STOLports
J. Riebe, NASA Langley

Analytic and Simulator Studies of Automatic Flight Management Concepts for Terminal Area Operations
B. Doolin, NASA Ames

Role of V/STOL SPO
J. Dzuik, FAA V/STOL SPO

Monday, 16 August

ATC for STOL
S. Crossfield, Eastern Airlines

Federal V/STOL ATC Programs
G. Cherry, NASA-OART

North N.J. V/STOLport
R. Snowber, Parsons-Brinkerhoff

ATC for V/STOL
J. Stultz, Sikorsky

Tuesday, 17 August - no presentations

Wednesday, 18 August

Lift Fan Technology for V/STOL Aircraft
D. Hickey, NASA-Ames

Review of the Experimental Program for Terminal Area Guidance
J. Christiansen, NASA-Ames

Presentations (Continued)

Wednesday, 18 August

Tilt Rotor Technology at NASA
B. Harper, NASA Ames

Thursday, 19 August - no presentations

Friday, 20 August

STOL Development at DeHavilland, Canada
R. B. McIntyre, DHC

The Marine Corps Harrier Program
N. New, USMC

Experimental STOL Transport Research Airplane
G. Cherry, NASA-OART

A Review of Progress in N.E. Corridor Hearing
D. Heynesfeld, CAB

Monday, 23 August - no presentations

Tuesday, 24 August

Commercial VTOL Programs at Vertol
J. Duvivier, Boeing Vertol

Patronage and STOLport Models
J. Hosford, McDonnell Douglas

Wednesday, 25 August

Ride Smoothing for STOL Transports
R. Holloway, Boeing Wichita

Updating USAF Activities for V/STOL Transports
B. Lindenbaum, FDL/USAF

Thursday, 26 August - Briefing Review

Friday, 27 August - Final Briefing