REPORT NO. DOT-TSC-FAA-72-4

IMPROVING SHORT-HAUL AIR TRANSPORTATION-THE RTOL APPROACH

GARY C. WATROS
TRANSPORTATION SYSTEMS CENTER
55 BROADWAY
CAMBRIDGE, MA 02142

transpo 72
U.S. International Transportation Exposition
Dulles International Airport
Washington, D.C.
May 27-June 4, 1972

DEPARTMENT OF TRANSPORTATION ★ UNITED STATES OF AMERICA

January 1972
Preliminary Memorandum

Approved for Advanced Program Planning Division only. Transmittal of this document outside the Advanced Program Planning Division of the Transportation Systems Center must have prior approval of the Advanced Program Planning Division.

PREPARED FOR:
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20590

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-TSC-FAA-72-4		

4. Title and Subtitle IMPROVING SHORT-HAUL AIR TRANSPORTA-TION-THE RTOL APPROACH	5. Report Date January, 1971 6. Performing Organization Code
7. Author(s) Gary C. Watros	8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Transportation Transportation Systems Center 55 Broadway Cambridge, MA 02142	10. Work Unit No. R2144 11. Contract or Grant No. FA218
12. Sponsoring Agency Name and Address Department of Transportation Federal Aviation Administration Washington, D.C. 20590	13. Type of Report and Period Covered Preliminary Memorandum Nov-1 Dec '71 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report on the RTOL (Reduced Take-off and Landing) system is one of three six-week studies commissioned by the FAA V/STOL Special Projects Office to gather information pursuant to the preparation of a long-range, short-haul air transportation program plan.

The RTOL system is proposed as a pragmatic approach to increasing air system capacity, reducing system congestion and improving ground access. Basically, it entails the shifting of most non-connecting, short-haul air travel from saturated hub airports (La Gauardia, O'Hare, etc.) to existing but under-utilized metropolitan airports (RTOL ports), using quiet RTOL aircraft.

This report defines the RTOL concept and investigates it's feasibility and potential.

17. Key Words	18. Distribution Statement
RTOL Short-haul air transportation Air systems	Approved for Advanced Program Planning Division only. Transmittal of this document outside the Advanced Program Planning Division or the Transportation Systems Center must have prior approval of the Advanced Program Planning Division.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	125	

TABLE OF CONTENTS

I. BACKGROUND

The recently-established FAA V/STOL Special Projects Offices was originally charged with responsibility for promoting the development of V/STOL aircraft and the associated air system. Soon, its area of attention was expanded to include short-haul air transportation in general. Pursuant to this responsibility, the SPO must establish a long-range program plan which defines both objectives and actions to be taken in the interest of improving short-haul air transportation.

An attempt to form such a plan in October was only partially successful. A good statement of objectives was written but the program plan itself had to be based upon a number of basic assumptions. It seemed necessary to gather additional information in order to define the program with proper confidence. Therefore, three working committees were established to spend six weeks engaged in homework activities in designated areas. The committees and chairmen are as follows: STOL (George Cherry - NASA), Financial/institutional (Don Geoffrion - FAA), and RTOL* (Gary Watros - TSC).

This report, then, constitutes the findings of the RTOL (Reduced Take-Off and Landing) committee.

*For an explanation of the RTOL concept, see section IV.

II. STUDY DESCRIPTION

The decision to perform this homework exercise was made on or about October 15 and a termination date was set for December 1. Since it took about two weeks to assemble and coordinate the committees and outline tasks to be done, only one month was available for actual work. The man-power available amount to the equivalent of three full-time professionals. Therefore, this report represents about three man-months of effort. The expertise of those contributing to this activity was primarily in system analysis, program planning and economics.

The task flow and descriptions that TSC established for this effort are included in the appendix (item A). However, time and manpower constraints prevented completion of some of this planned work. Those tasks not completed should be included in subsequent activities such as those of the SPO support contractor and/or TSC.

The material for this report comes from several sources. Many personal contacts were made to gather opinion: FAA regional offices, airport operators, airline pilots and management personnel, airframe manufacturers, and so on. Also, there is considerable original thought and work in addition to that gleened from the documented references.

III. PROBLEMS OF SHORT-HAUL AIR TRANSPORTATION

To avoid falling into the "I've got a neat technology - what problem can I solve?" approach, one should examine again the short-haul situation (problem). Here the investigation is limited to the problems associated with high and medium-density air travel. Low-density, short-haul transportation is being pursued elsewhere.

The problems stem from congestion created by the overtaxing of the present commercial air system. The present system was never designed for the burden it has to cope with. Many aspects of the air transportation system (e.g., baggage handling, ticket taking, and parts of the ATC system) evolved not through carefully designed plans but through the need to plug small holes in the system as capacity problems arose. Terminals expanded as passenger demand exceeded facility capacities. Runways were extended to meet the demands of the jet. The ATC system was beefed-up and modernized as air traffic created an unbearable workload for controllers.

What is needed is a carefully planned, integrated system, where all of the factors associated with short-haul air transportation are designed and built, not independently as they are now, but inter-related with an eye for future expansion. Both airport and ATC improvements must be co-ordinated to obtain the most efficient total system. Lagging of either will result in system capacity and delay improvements only in step with the smaller of the two.

If the present system is not improved, the following can be expected:

1. Increased air traffic delays, resulting in direct economic loss to the airlines and the government.

a. Current estimates reveal airline losses to be between 153 and 180 million dollars a year.[1] This loss becomes a major airline concern when one considers that the total earnings of the commercial carriers in 1969 was 53 million dollars.[2] It also represents a sizable loss of federal taxes.

b. Wasted fuel alone cost U.S. airlines $140 million in 1970.[3]

c. A 15-minute delay on a 200-mile flight results in an average direct operating cost increase of 39%.[4] See figure 1. Direct operating costs increase substantially as a result of delays. Since the higher DOC must eventually be passed on to the passenger, it would seem ludicrous that they should pay higher fares for longer trip times.

d. Peak hour delay typical at high-density airports is expected to increase from approximately 30 minutes at the present to almost an hour by 1975. See Figure 2.[5]

e. Increased air traffic delays represent a sizable passenger revenue loss. Twenty-two (22) million passenger hours (valued at $90 million) were lost in 1969.[7]

2. Ground holds and stacking above airports increase both noise and air pollution.

3. Airport access times will increase for the traveler, as the volume of air travel increases, due to further ground congestion in and around busy airports.

In summary, the problems of short haul for both the system and the air traveler are relatable to DELAY which is caused in turn by CONGESTION. Refer again to Figure 2. Though this projection of future disaster may well turn out to be pessimistic, one can see the

FIGURE 1:

DOC SENSITIVITY TO CONGESTION

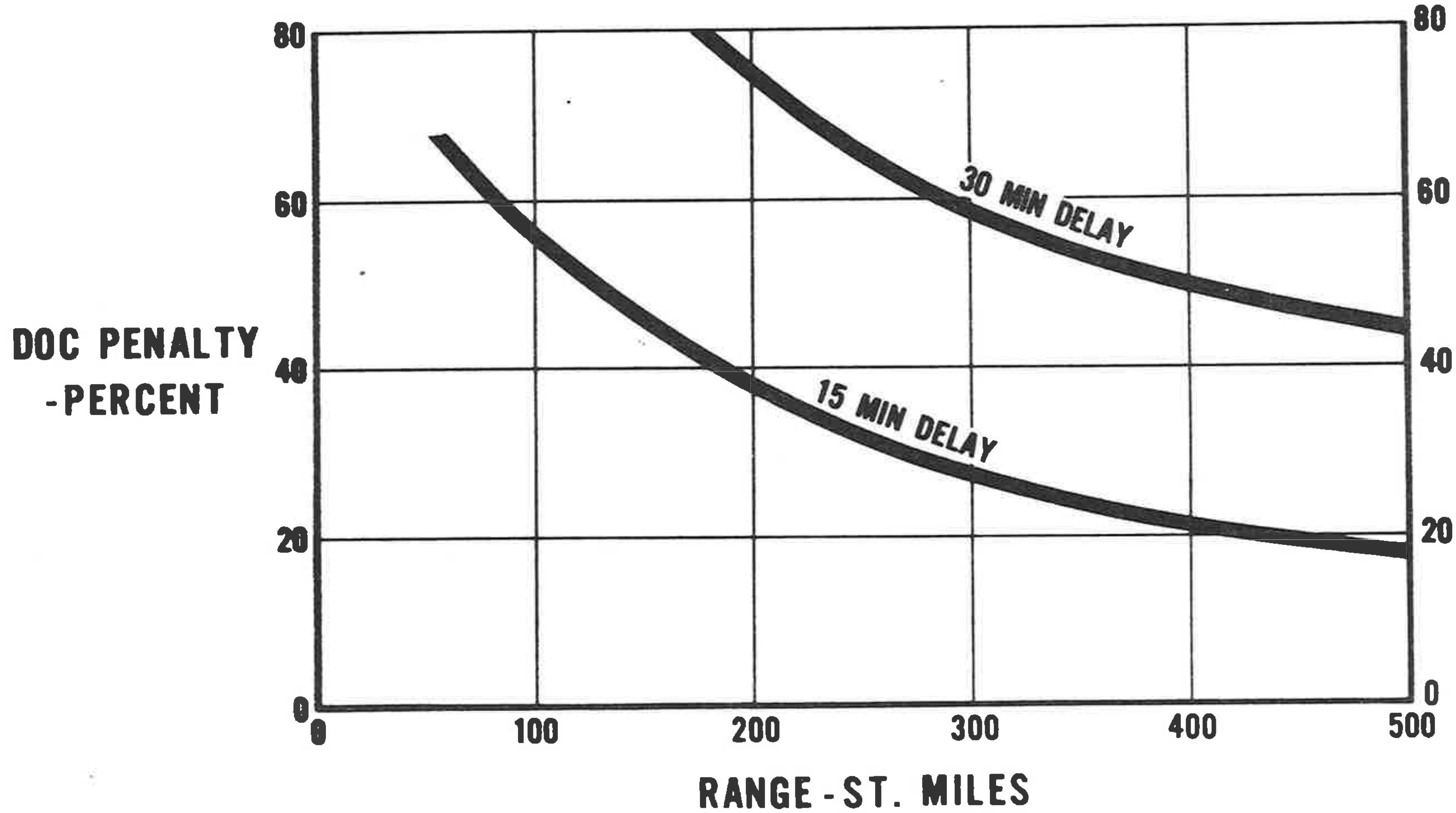
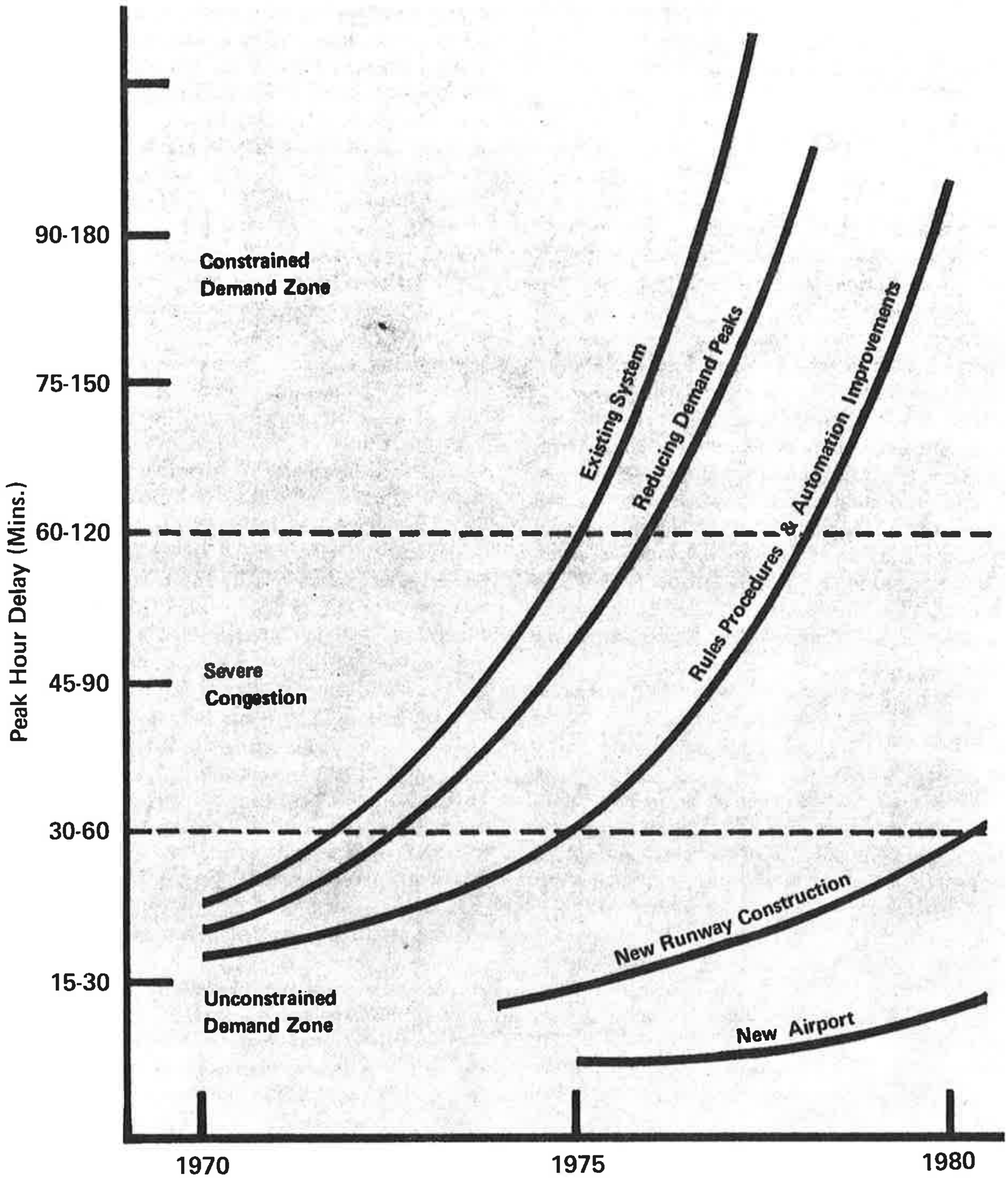


FIGURE 2:

Peak Hour Delays Typical High Density Airports



Reference 6

relative effectiveness of various ways of reducing aircraft delay. The availability of more runways and/or airports is by far the most effective measure. Furthermore, increasing the number of air service locations in a given urban area is probably the most effective and generally realizable method of reducing airport access times.

The RTOL approach promises to make these runways and airports available at relatively low cost and risk.

References

1. CARD Policy Study, Supporting Papers., March 1971, DOT/NASA, p.3-8.

2. Ibid.

3. STOL Developments Present and Future, DeHavilland Aircraft of Canada, Limited, Oct. 9, 1970., p.5.

4. Ibid.

5. The National Aviation System Policy Summary, DOT/FAA, 1970, p.18.

6. Op.cit., STOL Developments., p.7.

7. Op.cit., CARD, p.3-8.

IV. THE RTOL IDEA

A. OBJECTIVES

1. IMPROVE ACCESSIBILITY TO THE SHORT-HAUL AIR SYSTEM FOR THE TRAVELER BY -

initiating or expanding air service into metropolitan airports other than those now heavily used for commercial air service (i.e., general aviation, military, and small civic airports). Candidate airports would be those near the origins/destinations of short-haul travelers and which already enjoy good access, especially by automobile.

AND BY -

promoting high frequency, shuttle-type service on high density-routes, which in turn permits travelers to reduce airport access time allowances. A traveler would not have to allow extra time to be certain of meeting the flight for which he had a reservation. Instead, he would just go to the airport and catch the first plane leaving.

2. REDUCE AIRCRAFT GATE-TO-GATE TIMES BY REDUCING AND/OR AVOIDING AIRPORT AND AIRSPACE CONGESTION BY -

removing most of the non-connecting, high-density, short-haul traffic from busy hub airports to convenient, under- utilized, metropolitan airports.

AND BY -

providing for simultaneous and non-interfering RTOL (short-haul) and CTOL (medium and long-haul) operations at congested airports under VFR and IFR conditions.

3. IMPROVE THE OPERATIONAL EFFICIENCY OF AIRCRAFT AND GROUND FACILITIES USED FOR SHORT-HAUL BY -

operating economical aircraft, designed specifically for short haul.

AND BY -

employing ground facilities and operations which feature rapid transfer of the air passenger between transportation modes, minimum passenger/baggage handling costs, and quick turn around of aircraft.

4. PROMOTE EFFICIENT USE OF EXISTING AVIATION REAL ESTATE BY -

designating some runways and little-used taxiways of hub airports as RTOL runways and conducting simultaneous CTOL and RTOL operations.

BY -

promoting airline use of under-utilized metropolitan airports with quiet RTOL aircraft.

AND BY -

providing larger, short-field aircraft that will obviate the need for runway extensions at airports serving intermediate size cities.

5. TO REALIZE THE ABOVE OBJECTIVES WITH MINIMUM COST AND RISK TO ALL INVOLVED PARTIES BY -

utilizing aircraft that are as much like current CTOL's as possible.

BY -

avoiding reliance upon building new landing facilities or enlarging existing airports.

BY -

taking steps to make airport operations as unobtrusive as possible.

AND BY -

sponsoring demonstrations to prove system viability and/or community acceptance.

B. BASELINE SYSTEM DESCRIPTION

Introduction

STOL and VTOL systems have been proposed as solutions to the problems of short-haul air transportation. In spite of long-standing, intense advocacy of these systems, they have not materialized. This is apparently due, in part, to the fact that they are radical departures from the well-established CTOL system. Each party that would be involved in development of these systems (aerospace industry, airlines, airport operators, etc.) hesitates to commit himself without assurance that all others will do likewise. No such guarantees have been forthcoming. Furthermore, construction of new landing facilities (STOLports, VTOLports) within the metropolitan area is an essential element of these systems. Ever increasing community opposition to aviation activity casts doubt upon the availability of such sites in any significant numbers.

If one now searches for an alternative solution, one looks for a system which is as much like CTOL as possible and which uses only existing aviation real estate. One such alternative, the RTOL (Reduced Take-Off and Landing) system, is described below.

System Description

The RTOL system is proposed as a pragmatic approach to increasing air system capacity, reducing system congestion and improving ground access. Basically, it entails the shifting most non-connecting, short-haul air travel from saturated hub airports (LaGuardia, O'Hare, etc.) to existing but under-utilized metropolitan airports. Each urban area has several such airports that currently serve only general aviation (and/or the military in some cases). Runways are often too short to handle large CTOL aircraft, but could accommode RTOL aircraft that needed no more than, say 4000 feet of runway. At least one such airport in each metropolitan area that currently experiences significant non-connecting, short haul traffic would be designated as an RTOL shuttle terminal. See Figure 3.

RTOL aircraft (quiet, short-field CTOLs) would fly frequent shuttle-type service to and from RTOL airports in nearby metropolitan areas. Passenger services would be designed primarily to accommodate the short-stay business traveler (e.g., carry-on baggage and no reservations) to reduce passenger handling costs and, likewise, fares. Flights would be very frequent and system capacity great enough that the traveler would simply go to the airport and catch the next plane out.

Though the RTOL shuttle network is the heart of the system, RTOL aircraft would be employed in other markets also. RTOL aircraft would operate from hub airports using, where possible, specially-designated RTOL runways. These would be little-used taxiways, short runways, and long CTOL runways split in half. When RTOL runways were available, CTOL and RTOL operations would be conducted simultaneously, thus increasing airport capacity. RTOL aircraft would be used for what shuttle service remains between hub airports and for connecting service between the hub airport and cities within short-haul range. Employment of quiet RTOLs on the latter routes provides cities with larger aircraft service without the hassle of attempting to extend existing runways.

The national air system that would follow RTOL incorporation would be one in which medium and long haul travel is handled by CTOL aircraft and confined to the larger hub airports where demand can be concentrated. RTOL aircraft would pick up the medium-density feeder service into these airports. Most high-density shuttle service would be moved from the hub airport to smaller RTOL airports. Shuttle service would be conducted in a less congested and more convenient environment, more economical/efficient equipment used, and passenger services trimmed so as to improve both the patronage and profitability of high-density short haul. Hub airport capacity would be increased and/or congestion reduced via simultaneous CTOL and RTOL operations. Medium density feeder (connecting) service could now employ larger, more economical aircraft, if warranted.

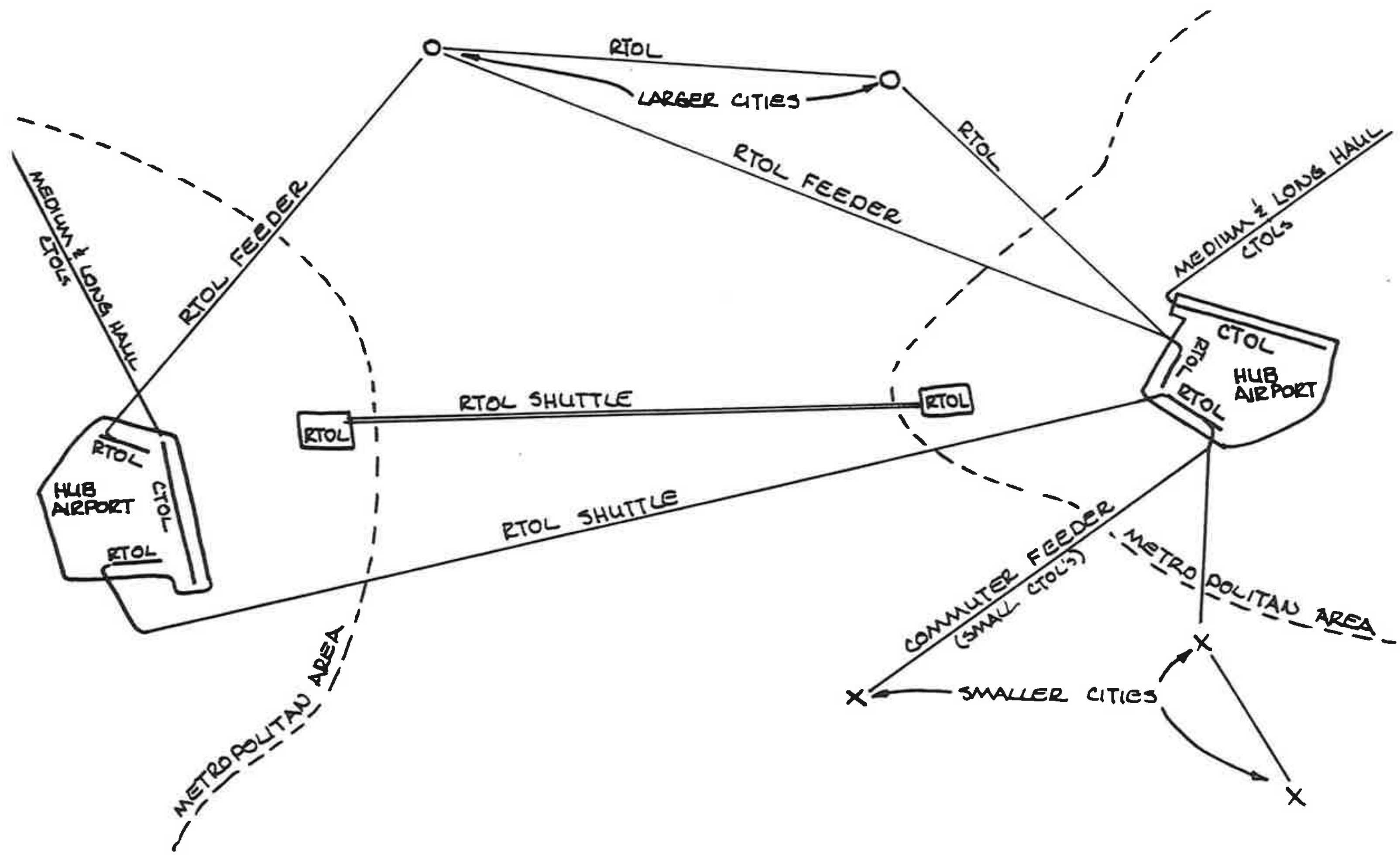


Figure 3. The RTOL-CTOL System

V. AIRPORT UTILIZATION

A. NATIONAL SURVEY OF CANDIDATE AIRPORTS

Essential to the RTOL concept (or V/STOL, for that matter) is the availability of new air service locations for urban areas. As stated earlier, the RTOL system is limited to use of existing airports (for this study at least). Therefore, a survey of some of the largest U.S. metropolitan areas was conducted to identify the numbers and characteristics of airports in these areas that could be used as RTOL ports.

Candidate airports were selected from aeronautical charts of each area. Airports which did not have at least one 2500 foot runway were excluded. Of those within a reasonable distance of the urban center (around 35 miles), several airports were chosen which appeared to give good geographic coverage for the entire area. Generally, the greater the population the more airports were chosen. The results of this survey are summarized in Tables 1 and 2. It is apparent that virtually all major urban areas have several suitable RTOL port locations. However, the survey also shows that several metropolitan areas do not have any near-city center airports (less than 10 miles) that could accommodate RTOL aircraft (e.g., San Francisco, Los Angeles, Phoenix). Furthermore, this survey did not determine if candidate airports are operating at or near capacity. This is very important and should be the subject of follow-on work. Table 2 indicates that about 85% of the candidate airports have runways in excess of 4000 feet - the maximum runway requirement chosen for the RTOL aircraft. Furthermore, Table 1 shows that most of the busy hub airports have runways too short for CTOL use but from which RTOL aircraft could operate, possibly avoiding CTOL congestion.

TABLE I. GEOGRAPHIC SURVEY OF METROPOLITAN AIRPORTS

Metropolitan Airports			Airport Data					Air Services		
Metropolitan Area	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Scheduled (1 and/or 2)	Taxi	Supplemental
New York	10 million and over	**JFK	113 113 100 84 27	SE	14 (15)	TR		1 & 2	x	x
		*La Guardia	70 70 20	NE	6 (8)	TR		1 & 2	x	x
		Newark	82 82 67	SW	10	TR		1 & 2	x	x
		Teterboro	70 60	NE	7.5	LG		1	x	x
		Morristown	60 40	W	23	LG		2		x
		Caldwell-Wright	47 42	NW	13	GU	P		x	
		Westchester	65 49 44	NE	25	TR		1 & 2	x	x
		Grumman Bethpage	66	E	25	GU			x	
		Islip MacArthur	60 50 32	E	48	LO		1	x	x
		Republic	75 65	E	30	LG	P			
Chicago	5 to 10 million	**O'Hare Int'l	116 100 101 74 53	NW	16 (19)	TR		1 & 2	x	x
		*Meigs	39	E	1 (1)	GU				
		Midway	65 56 55 61 47	SW	8 (10)	TR		1 & 2	x	x

Metropolitan Airports

Airport Data

Metropolitan Area	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Air Services: Scheduled (1 and/or 2)	Air Services: Taxi	Air Services: Supplemental
		Chicago-Hammond	25	S	23	B_1				
		Chicago-Hinsdale	32	SW	17	B_1	P			
		DuPage Co.	51 40 34	WNW	32	LG			x	x
		Glenview	80 50	NW	19	NAS				
		Elgin	26	NW	36	B_1				
		Chicagoland	32 24	NW	28	B_2	P			
		Pal-Waukee	50 34 44 33 22	NW	23	LG	P		x	x
LA-Long Beach	5 to 10 million	**LA Intnl.	129 120 102 89 32	SW	11 (17)	TR		1 & 2	x	x
		Santa Monica Muni.	49	W	12	LG			x	x
		Long Beach	100 61 54 50 42	SE	17	TR		1 & 2	x	x
		Fullerton Muni.	31	SE	20	B_2			x	
		Orange Co.	57 28	SE	34	LO				
		Los Alamitos	59 80	SE	21	LO				

Metropolitan Airports

Airport Data

Metropolitan Area	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Air Services: Scheduled (1 and/or 2)	Air Services: Taxi	Air Services: Supplemental
		Hollywood-Burbank	60 69	NW	12	LO		1 & 2	x	x
		Van Nuys	80 40	NW	18	LG			x	
		Ontario Intnl.	99 47	E	36	TR		1 & 2	x	x
		Brackett	40	NE	26	GU				
Philadelphia	1 to 5 million	**Philadelphia Intnl.	94 54 48	SW	6.5 (7)	TR		1 & 2	x	x
		N. Philadelphia	70 50	N	12.5	LG		2	x	
		Warminister	80	N	18	NAF				
		Willow	80	N	15	NAS				
Washington, DC	1 to 5 million	**Washington Natl.	68 52 47 15	S	5 (9)	TR		1 & 2	x	x
		Dulles Intnl.	115 115 100	W	24 (26)	TR		1 & 2	x	x

Metropolitan Airports

Airport Data

Metropolitan Area	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Air Services: Scheduled (1 and/or 2)	Air Services: Taxi	Air Services: Supplemental
		Tipton	42 21	S	19	AFB				
		Andrews	97 93	SE	9	AFB				
		Anacostia/Bolling	closed	S	3	NAS				
		College Park	27	NE	8	LG				
		Beltsville	43 38	NE	13			UNK	UNK	UNK
		Leesburg	50 49	NW	32					
Baltimore	1 to 5 million	**Friendship	95 94 60	S	8 (10)	TR		1 & 2	x	x
		Martin Marietta	80	NE	11	B_2				
		Frederick Muni	40 38	W	40	LG				
		Phillips	80 50 50	NE	26	AAF				

Metropolitan Airports

Airport Data

Metropolitan Area	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Air Services: Scheduled (1 and/or 2)	Air Services: Taxi	Air Services: Supplemental
San Francisco	1 to 5 million	**San Francisco	100 95 94 70	S	11 (5)	TR		1	x	x
		San Jose Muni.	89 44 30	SE	40	TR		1	x	x
		Oakland Intnl.	100 62 55 54	NE	13 (12.5)	TR		1 & 2	x	x
		Hayward Air	51 35	SE	20	LG				
		San Carlos	26	S	20	B_2				
		Palo Alto	25	SE	26	B_2				
Boston	1 to 5 million	**Logan Intnl.	100 100 78 70 24 18	E	2.5 (3)	TR		1 & 2	x	x
		Beverly	50 35 46	NE	17.5	LG			x	
		Hanscom	70 50	NW	13	LG				
		Norwood	40 40	SW	13	LG			x	
		So. Weymouth	70 60	SE	16	NAS				

Metropolitan Airports | Airport Data

Metropolitan Area	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Air Services: Scheduled (1 and/or 2)	Air Services: Taxi	Air Services: Supplemental
Syracuse	.5 to 1 million	*** Syracuse Hancock Intnl.	90 64 32	N	5.5 (7)	TR		1	x	x
Phoenix	.5 to 1 million	*** Phoenix Sky Harbor	103 87	SE	13	TR		1 & 2	x	x
		Luke AFB	78	NW	19	AFB				
		Falcon Field	43	E	20	GU				
		Chandler Muni.	26	S	14	GU				
		Williams AFB	104 93 102	SE	26	AFB				
		Scottsdale	48	NE	14	GU				
		Papago	35	E	5	B_1		UNK	UNK	UNK
Albany, Troy, Scenectady	.5 to 1 million	*** Albany County	60 40 35	Central	Central	TR		1 & 2	x	x
		Schenectady Co.	70 50 48	NW	3.5	LG			x	x
		Saratoga	40 40	N	20	B_2			x	

Metropolitan Airports

Airport Data

tropolitan ea	Population Class	Airport Name	Runway Lengths (100s of feet)	Compass Bearing	Distance from Urban Center (stat. miles)	Kind of Airport	Site Status	Air Services: Scheduled (1 and/or 2)	Air Services: Taxi	Air Services: Supplemental
pringfield	.5 to 1 million	**Bradley Intnl.	95 68 52	SW	12.5	TR		1 & 2	x	x
		*Barnes Muni.	90 40	NW	7.5	LG				
		Westover	116 70	NE	7.5	AFB				
.artford	.5 to 1 million	**Bradley Intnl.	95 68 52	N	13.5 (17)	TR		1 & 2	x	x
		*Hartford-Brainard	44 23	E	5	GU		2	x	
·ovidence	.5 to 1 million	**Green Ct.	64 60 49 39	S	6.5 (8.5)	TR		1 & 2	x	x
		*N. Central	50 32	NW	7	LG				

Key for Table 1

**	Major Airport
*	Closest to Urban Center
( )	Road Miles
1	Certificated Air Route
2	Commuter Service

Site Status

UNK	air service unknown
Blank	publicly owned - capable of development
P	not publicly owned but open to public

Kind of Airport

TR	CAB certified trunk carrier
LO	local carriers
B_1	basic utility - 2,000 ft. runway - handles 75% of general aviation
B_2	basic utility - 2,700 ft. runway - handles 95% of general aviation
GU	general utility - all general aviation except transports and business jets - minimum runway 3,200 ft.
LG	larger than GU - a general aviation airport that handles transports and business jets - minimum runway - 4,600 ft.
He	Heliport
SB	Seaplane Base
ST	STOL-port
NAS	Naval Air Station
NAF	Naval Air Facility
AFB	Air Force Base

TABLE 2:

METROPOLITAN AREAS: NO. OF AIRPORTS

WITH RESPECT TO RUNWAY LENGTHS AND AIR SERVICE

	Surveyed Metropolitan Areas with Pop. over 500,000 (14)		
Runway Length (feet)	No. of Runways	No. of Airports (longest rnwy. length)	No. of Airports w/ scheduled service
0-3000	16	6	
3000-3500	11	3	
3500-4000	9	2	
4000-4500	19	8	1
4500-5000	23	8	
Over 5000	98	47	26
TOTAL	176	74	27

One can conclude, therefore, that there are many convenient RTOLport locations in the metropolitan areas and the potential exists for simultaneous RTOL/CTOL operations at some hub airports.

B. OPINIONS OF FAA REGIONAL OFFICES

The heads of the Airport Planning Division (or their deputies) at seven FAA regional offices were asked for their opinions of the desirability/feasibility of the RTOL approach for their areas. The cities included: Boston, Chicago, Los Angeles, Miami, New York, and San Francisco. The following conclusions are substantially applicable to all areas:

Each area has one or more large general aviation fields with runways of 4000 feet or longer and adequate bearing strength for 100 K lb. aircraft. These airports typically experience 50K to more than 250K operations per year. Corporate aircraft and air taxis are found at all. Several are served by first or second level carriers (sometimes with reluctance).

While these fields do receive complaints about noise, they attract much less attention than hubs or military fields. Noise contour maps are not known to exist for them.

The FAA field personnel felt that a 95 PNdB aircraft (maximum noise at 500 feet) would be acceptable in all of these areas, although the NYC contact suggested an even quieter plane would be highly desirable. Provided the 95 PNdB target were achieved, no schedule, or frequency constraints should occur.

Only in Boston and New York were the prime candidate fields at or near saturation. In each case, the imposition of landing fees are believed necessary to reduce general aviation activity. Alternate G.A. facilities would have to be provided.

Virtually all of these fields depend on one or more forms of subsidy. Their operators would welcome additional commercial service, provided that they were not required to invest in new facilities beyond what they could expect to recover from fees. Unfortunately, the magnitude of the investment required to bring some of these fields up to typical airline standards of safety and passenger convenience is substantial (i.e., millions of dollars). They could be financed in part through the Airport and Airways Development Fund, but financing the remainder could probably be accomplished only if the carriers were willing to sign guarantees. (This is the usual procedure when airport authorities seek to issue bonds.)

Because of the abrupt shift in public attitude against aviation, the FAA field personnel felt it was impossible to predict the outcome of proposals for new services and facilities. They were reasonably confident that additional service could be inaugurated at existing fields with existing facilities. They were quite doubtful that any new airports could be constructed. But as to whether new facilities could be erected at existing fields, they rated the issue a tossup. The "low profile" approach seemed likely to evoke the least community opposition (and probably the fewest passengers).

The FAA personnel explained that, in the past, proposed new services had been automatically approved by local decision making bodies. Furthermore these bodies - airport authorities, county boards of supervisors, mayors' offices, etc. - could be expected to continue to support aviation interests. But they noted that there was the possibility (or probability) that the issue would arouse the citizenry and be blocked by legislative or judicial action. In general, the more densely populated the area, the more sensitive it was to noise, New York City being the extreme example.

It is the general consensus that public relations efforts, creation of "Noise Advisory Commissions," etc. will not placate the public. Compatible-use zoning can be effective only in the long run, if at all. Only the development of a truly quiet engine together with the retrofit/early retirement of the present fleet will end public antipathy toward air service.

The keystone of the public approval process is felt to be the demonstration of a quiet vehicle. This plane need not be the ultimate revenue-service aircraft, provided that decision makers are guaranteed that the commercial versions will be as quiet as the demonstrators. It should be noted, however, that these demonstrations are likely to trigger strong public demands that the existing fleet be retrofitted, possibly as a precondition for the establishment of any new services. More detailed comments from each city contacted follow.

Boston

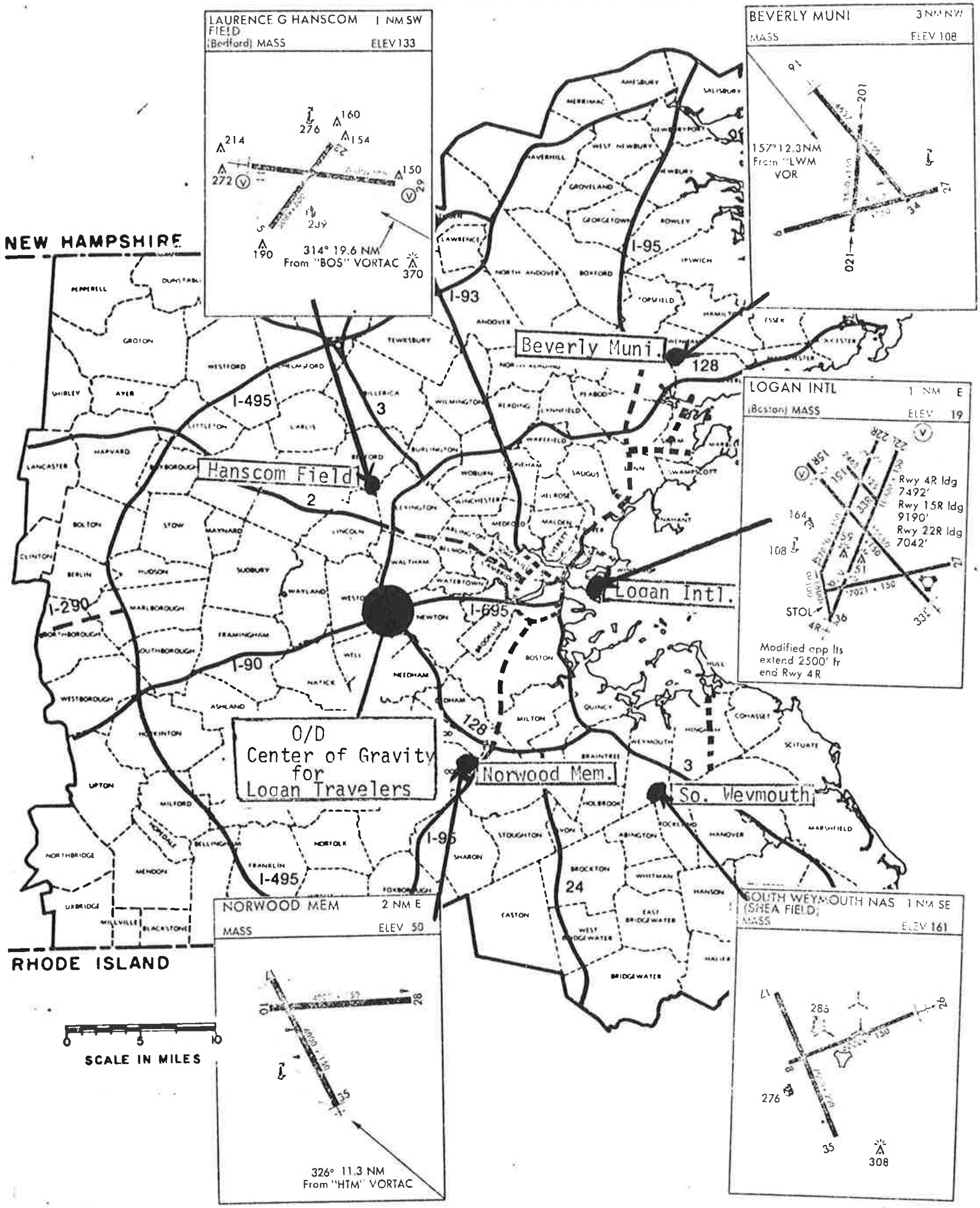
Hanscom Field appears to be the best suited candidate for RTOL service because of its proximity to the center of gravity of the air traveller origins and desginations and its already extensive facilities. However it is already very busy (around 280K operations per year) and would thus require either the construction of a new runway at a cost of more than $5 million or administrative action to curtail general aviation. The airport operator considers the latter course to be necessary in any case at some future time.

Hanscom's existing passenger handling facilities would be adequate for only a rudimentary service. If it were to offer any significant relief to Logan, say 1 million pax/year, new terminal buildings would have to be constructed at a cost of several million dollars, depending on amenities provided. The cost estimating relationship for passenger facilities is as follows:

1. Annual pax/year X .04% = typical peak hour pax (T PHP)
2. TPHP X 242 sq.ft./pax = required floor space
3. Required floor space X ($4 to $14/sq.ft.) - annual rent

Hanscom is situated near a major expressway, but lacks a direct connection, except via route 2A, a 2-lane highway running through Minute Man National Historic Park. Severe traffic congestion would be encountered at rush hours on this route, yet there is apt to be strong citizen opposition to its widening. The other alternative would require negotiation

Figure 4: CANDIDATE RTOL PORTS FOR THE BOSTON METROPOLITAN AREA



with the USAF to secure a right of way through its facilities for a connection to route 128.

The frequent operation of heavy military aircraft at Hanscom has created substantial public antipathy. An aircraft noisier than general aviation types would not be tolerated at all. Even a quiet plane may meet some opposition.

No local groups are known to be advocating scheduled service at the moment. Two third level carriers (Trans-East and Monmouth) have tried and failed at offering service from Hanscom to New York City. Their failures are attributed to undercapitalization, insufficient advertising and inadequate aircraft, i.e., Twin Otters. No airline is known to be seriously considering serving Hanscom at this time.

The Massachusetts Port Authority owns Hanscom and is known to favor the establishment of scheduled service there. However, until an inoffensive plane is developed, it is likely that citizens will block any proposal, with the probable assistance of the Governor's Office and perhaps local elected officials.

Chicago

Midway appears to be the first choice for RTOL service in Chicago. It is somewhat closer to the Loop than O'Hare and is served by a new freeway which is reportedly less congested than the one serving O'Hare (driving time about 15 minutes). Currently there are about 90 commercial operations per day with terminal facilities designed to handle a great many more.

The Cook County School Board owns Midway and is concerned primarily with increasing its rental income. The Board of Aviation Commissioners is the principle decision making body. It is known to favor strongly the inauguration of additional service at Midway.

The only significant objectors to more service at Midway are the airlines. They apparently regret that they ever promised to return there following the major rennovation which was completed a few years ago. Repeatedly they have cut back schedules only to yield to pressure from Mayor Daley to re-instate these services.

Their reasoning is that they are competing with themselves, i.e., the passengers traveling Midway would have flown on the same airlines via O'Hare without the airlines having had to bear the cost of duplicate facilities at Midway. Furthermore they maintain that load factors are not good enough to justify Midway's current services. (Load factors on individual routes are proprietory information). They argue that park and fly travelers dislike Midway because they may not find a convenient return flight to it, whereas flights to O'Hare are much more frequent.

Meigs Field might also be considered since it is very close to downtown (2 miles) and is popular with corporate aviation. However, its longest runway is 3900 feet and it lacks IFR equipment. The city of Chicago, which owns Meigs, recently refused to install IFR equipment on the grounds that even with the equipment it would still be dangerous to have planes flying near the skyscrapers of the Loop in bad weather.

Los Angeles

The Los Angeles metropolitan area abounds with airports capable of becoming RTOL-ports. Several of them already have scheduled services. Indeed, air service in California could be described in general as being more dispersed than is characteristic of the East Coast and elsewhere. In fact, the LA-Bay Area air service resembles the RTOL concept in several ways (see VIII. A .3). This condition follows as a natural consequence of the lower population densities prevalent there and, in particular, from the wide scattering of commercial and industrial facilities.

Carriers, particularly intrastate, have adapted to these conditions as best they are able with available aircraft. Local agencies of government have allowed if not welcomed these extensions of service. However, the construction of a large, new airport to relieve LAX substantially is another problem altogether. A 95 PNd B aircraft should win acceptance at any of the Los Angeles communities.

The principal technical challenge to aircraft design posed by the California market is to serve lower density routes frequently and economically. As the carriers have converted their fleets to pure jets, they have often found it prohibitively expensive to serve certain routes more than two or three times a day, whereas with piston craft, these same routes had had service six times a day or more. As a result, many travellers have opted to drive the whole distance in as much as there is usually a significant drive to and from the airport at both ends of the journey in any case. In some sense, what California wants is a DC-3 replacement.

Miami

The Miami Chamber of Commerce has been campaigning for the construction of STOL-ports in the metropolitan area to provide service to a number of other Florida cities. These proposals have met strong opposition from citizens in the potentially impacted areas, however, and to date, no plans have been made to start construction.

Although less conveniently sited than the proposed STOL-ports, Dade County does have two large general aviation fields, built as relievers for Miami International, which could be used by RTOL's. These airports (Opa-locka and New Tamiami) are owned by the Port Authority, which would be pleased to see them used more extensively (they both require subsidy from the profits of Miami International). Both are large enough to accommodate many more operations and also to permit construction of terminal buildings.

Community approval for RTOL service could probably be won by a 95 Pnd B aircraft. A demonstration by a prototype would be acceptable.

The function of air travel in Florida creates some special problems in designing an appropriate aircraft. The STOL system is envisaged as a means by which various recreation areas scattered about the state can be made readily accessible to vacationers who arrive via the Miami gateway. These travellers are apt to be encumbered with substantial baggage. Furthermore, they want to be taken as close as possible to their ultimate destination. Although STOL-ports might be built fairly cheaply and easily at some of these destinations, e.g., Disneyworld, the RTOL concept would not fit into the scheme nearly so well because of its much greater land requirement.

New York

In addition to its three major airports, New York has at least five other fields which might be seriously considered for R/STOL service. They are as follows: Teterboro owned by the Port Authority, Republic by the MTA, Westchester by Westchester County, Morristown by the City of Morristown, and Islip by the City of Islip. All of the owning bodies are favorably inclined toward the inauguration of additional services. In addition to the above, serious consideration is being given to the construction of a STOL-port in New Jersey to serve the Manhattan-bound traveller.

So long as any R/STOL services used existing facilities (and thus confined themselves to relatively small passenger volumes), public objection is not likely to be strong. However, even the suggestion that a large terminal might be built is likely to provoke a great outcry. Only the demonstration of a very quiet plane (around 85 PNd B) could possibly forestall the flow of injunctions. Even with the quiet aircraft, it is possible that objection will be made on other grounds, such as safety or surface traffic congestion. In concluding his remarks on the topic, the FAA official said "The question is not whether we can build any new airports but whether we'll be allowed to keep the ones we've got."

It should also be noted that virtually all airports within a 50-mile radius of Manhattan are being used at or near their practical capacities. Hence the institution of substantial increases in scheduled services will require the re-location of numerous private operations.

With regard to the experiences of carriers in serving the secondary airports of New York City, the following statements are pertinent: American Airlines reluctantly initiated Islip-to-Chicago service recently. The CAB issued route awards for this service to AA, UAL and TWA. It subsequently permitted UAL to drop out and granted TWA a stay 'til March 1972. American officials argued that the Islip passenger would have flown on American anyway out of LaGuardia or JFK and that, hence, they were competing with themselves at considerable duplication of expense. Estimates of load factor on the flights have ranged from "good" to "mediocre." See also V. D. 3.

On the other hand, such carriers as Mohawk and Allegheny have been delighted to receive route awards from Westchester and Islip to such distant cities as Boston and Washington because they had no other entry into these rich markets.

San Francisco

Like Los Angeles, the Bay Area is served by multiple airports which help to cope with the problem of traveller dispersion. These fields are all capable of handling RTOL's and have some room for expansion of physical facilities. None is any closer to the San Francisco CBD than SFO, however.

Each of these large fields is publicly owned. The California Public Utility Commission is the most significant decision-making body with regard to proposals for new services. It is sensitive to public opinion but not bound by it. A 95 PNd B aircraft could be expected to be approved.

The San Francisco Chamber of Commerce, acting through a non-profit corporation called NorCal STOL, has been seeking to establish STOL service to various Northern California cities from a downtown STOL-port. The prime candidate site is Crissie Field, a military helicopter base located on the waterfront just east of the Golden Gate Bridge. Crissie has only a 2500 foot runway and is severely obstructed by the bridge approach. Only STOL or VTOL are technically feasible systems for this field. The Bay Area is sensitive to environmental problems and will not tolerate a noisy plane. Crissie Field is the subject of numerous complaints about noise from the military helicopters stationed there. 90 PNdB would be a desirable target.

As with Los Angeles, the worst problem faced by the traveller other than congestion is poor access to smaller cities. No firm conclusions have been reached about the size of aircraft vs. frequency of service but a 30-50 passenger craft appears to be first choice for this feeder service.

C. TYPICAL CASES - BOSTON, CHICAGO, AND LOS ANGELES

Metropolitan areas differ considerably in the number and use of airports providing scheduled service. Boston, Chicago and Los Angeles are good examples of this variation.

All scheduled service for Boston is located at one airport (Logan) typical of most large urban areas. Feable attempts to initiate service at other airports in the past have failed - interest remains high, however. Ground access to the airport is bad and getting worse with little hope of improving the access system. Recent attempts to add a runway at Logan were crushed by public opposition and the Governor. Logan, however, is not yet considered a "congested" airport.

Chicago has air service at three locations - O'Hare, Midway and Meigs. O'Hare is officially designated as congested which means flight restrictions for the peak hours of the day. Midway, conveniently located nearer downtown, has resumed scheduled service after having none for several years following the opening of O'Hare. Meigs is situated in downtown Chicago but accommodates only third level air carriers due, in part, to its short runway (3900 ft.) and lack of IFR capability. As shown in Table 3, service into Meigs covers only a few hundred mile radius. This is apparently non-connecting since, in general, flights into Meigs are parallelled with flights into O'Hare for connecting service (see Official Airlines Guide). Comparison of flight frequencies of Midway and O'Hare on high density, short haul routes shows that about four times as many flights use O'Hare than use Midway. On the surface, at least, there seems to be an excellent opportunity to test the RTOL shuttle concept here. Basically, it would involve reversing the Midway/O'Hare flight ratio on one route so as to provide Midway with enough flights to simulate shuttle service. If successful, it could pave the way for making Midway solely a short-haul, non-connecting service location. The few long-haul flights now using Midway would be shifted to O'Hare which would then handle only connecting short-haul and long haul service.

Los Angeles exhibits advanced dispersal and segregation of air service facilities. Four major airports serve the Los Angeles basin - LAX, Burbank, Ontario, and Long Beach. LAX and Ontario accommodate all long haul travel while Burbank and Long Beach are strictly short-haul facilities. Utilization of the other three airports eases the short-haul demand on LAX considerably (e.g. less than 65% of flights from the San Francisco-Oakland-San Jose area to greater Los Angeles use LAX). For more details of the LA-San Francisco air system see section VIII, A, 3. Los Angeles, perhaps more than any other area, comes closest to the spirit of the RTOL approach.

TABLE 3:

UTILIZATION OF CHICAGO AIRPORTS
ON HIGH-DENSITY, SHORT-HAUL ROUTES

City	Pax/year (1000)	Distance (Miles)	Daily Non-stop Flights (both ways) Meigs	Midway	O'Hare
Detroit	493	238	6	14	40
St. Louis	428	256		12	42
Cleveland	361	311		8	28
Kansas City	288	407		2	38
Pittsburg	269	403		8	46
Indianapolis	195	168	8	8	24
New York	1720	720		6 (LAG)	130 (Total) 86 (LAG) 26 (EWK) 16 (JFK) 2 (ISP)

D. COMMUNITY ACCEPTANCE

The question of acceptance of new air service locations by the surrounding communities was addressed in the preceeding section - primarily in terms of acceptable aircraft noise levels. In this section are presented three recent cases in which attempts to initiate or expand air service met with varying degrees of success. All cases are in the Northeast, the area of the country where aviation opposition is probably strongest.

The recent action of the Suffolk County (Long Island) Legislature to restrict use of the Suffolk County airport to "non-certified operators," typifies recent 'victories' of jetport fear. Over 4000 residents signed a petition opposing use of this airport as a fourth New York City jetport, though such use was never proposed. Members of two communities which border the airport were the most outspoken, however. In response to these pressures the legislature adopted a resolution (16-to-1) which excludes trunk, regional, charter and supplemental carriers. However, the County Executive felt that 'the future of Suffolk County lies in the air ... especially the introduction of air freight' and so vetoed the resolution. The legislature subsequently overrode the veto (12-to-5) to the applause of 20 residents of communities adjoining the airport. Two New York Times articles concerning this case are included in the Appendix (B).

The city of New Haven, Connecticut was directed to pay a total of $18,400 to seven property owners on the approaches to New Haven's airport in return for a permanent easement of airport flights. The suit was filed in response to initiation of jet service at the airport which apparently increased noise exposure considerably. New Haven was concurrently involved in a long legal hassle over acquiring more land to lengthen its 5600 foot runway to handle larger jets. All jet flights were suspended for a time. However, the U.S. District Court eventually refused to ban jets or to close the airport, as asked by some property owners.

Furthermore, in the final judgement, damage awards were considerably less than those demanded and several claims were dismissed altogether. However, the judgement did state that, "upon payment of the judgements, defendant City of New Haven will acquire a permanent easement in the properties of these plaintiffs for the operation of a similar number of turbo prop planes and jet planes of the size in use at the time of the trial." This, in effect, limits noise exposure to current levels. Suffice to say that had quiet RTOL planes been available, all this hassle could have been avoided since New Haven would have no need to extend runways and noise levels would have been no higher than in the days of all turbo-prop operations. For more detail, see the Appendix (C).

The third example is the chronicle of a situation where the public wanted air service and got it - Islip, Long Island.

The communities surrounding Islip-McArthur Field have been for the most part favorably disposed toward aviation ever since the field was built. This attitude probably results from a combination of: (1) the high income, frequent travelling nature of the residents of Long Island. (2) the importance of the aerospace industry in the local economy. (3) the physical location of the airport such that no residential areas are exposed to very high noise levels.

In an attempt to attract scheduled air services, the town of Islip built a passenger terminal in 1958 - a rather nice one by small airport standards. In 1960, Allegheny began service and Mohawk was added in 1967.

An organization called LIMBA (Long Island-McArthur Businessmen's Association) was formed to promote the airport. This group still breakfasts weekly at the airport restaurant.

As air congestion became severe in the New York area in the mid 60's, the CAB grew interested in the concept of satellite airports. On its own initiative, it studied the New York market and concluded that there was a substantial latent demand for service from Westchester County (White Plains) to Chicago. Contrary to its usual procedures, it took the initiative and announced route award hearings in 1967 for Westchester-Chicago service.

Airline managers, on the other hand, doubted the economics of the satellite concept because of the duplication of ground facilities and the likelihood of having to deadhead planes from hub to satellite airports and vice versa in accordance with the demands of business travellers.

They opposed the establishment of Westchester-Chicago service and were able to enlist the support of the County-Executive and citizens' groups who objected to the environmental degradation associated with airports.

LIMBA, with the support of the Long Island Association for Commerce and Industry (the most significant business association) seized upon the opportunity to win the route for Islip. More hearings were held, but this time with a parade of local citizens testifying to their need for scheduled air service. As a result, the CAB awarded routes to no less than three airlines, American, United and TWA in 1969.

The managements of the three lines were dismayed at the prospect of three-way competition on a route they felt could not make money for one carrier. United argued that it had already accepted too many losing routes and was let off the hook entirely. TWA was granted a stay until March, 1972. American, probably because of its superior financial position, was required to begin by June, 1971. This two year delay was necessary to lengthen and strengthen the runways to permit the use of 727's.

American actually began service on April 26, 1971, so as to coincide with their annual system-wide schedule changes. It offers one round trip a day Monday through Friday, departing Islip for O'Hare at a convenient morning hour (currently 8:50 a.m.) and returning that night. In between, the aircraft flies from O'Hare to Dallas and back. It spends the night at Islip. In addition, there is one westbound flight on Saturday and one eastbound flight on Sunday.

Load factor started out at about 60%, but dropped off about the time American introduced DC-10's on the LaGuardia-O'Hare route (and rescheduled the Islip plane from 8:00 to 8:50). In the last few weeks they have moved back up toward 60% (according to American spokesmen).

The airline is further reported to be seriously considering adding a second round trip flight a day and possibly even installing its own ground service equipment and personnel (Allegheny currently provides these services for a fee).

Meanwhile, LIMBA is campaigning for service to Atlanta and points beyond. A Washington law firm (apparently retained by Islip) is negotiating with the CAB and with such airlines as Eastern and Delta for another route award hearing. This time, however, it is expected the CAB will take no action until an airline makes the request.

E. FACILITIES AVAILABLE VS. REQUIRED

A few of the candidate RTOLports already have extensive terminal facilities and parking. These usually are old municipal airports which were phased out when new jetports were built. Examples are Hobby (Houston), Love (Dallas), Boeing (Seattle) and Midway (Chicago).

However, most of the general aviation and military candidates lack facilities adequate to handle any sizeable numbers of passengers. If facility planning emphasized simplicity and functionality (no Taj Mahal's, etc.), the average cost per RTOLport might be kept to several million dollars.

Ground access systems (highways) appear to be either adequate or such that they could be expanded relatively easily. More study of this and terminal facilities is required, however.

F. GENERAL AVIATION

When consideration is given to expansion of scheduled air service, the general aviation community must be considered. General aviation encompasses many more aircraft and flight operations per day and transports a volume of people comparable to the scheduled common carriers. Furthermore, the growth rate of commercial aviation, while remarkable, has been outstripped by general aviation. If a candidate RTOLport is of the general aviation type (as most are) and is operating at or near capacity, provisions must be made for general aviation (GA) before a committment to RTOL service can be made. GA congestion will cause delays for RTOL aircraft and poses a safety hazard. Basically, three options are available: build a GA-only runway(s), build a new GA airport, and/or move activities such as flight schools to less congested airports. Since public opposition of GA activity is not nearly as intense as for the airlines, airport and runway construction is feasible.

No attempt was made to determine the percentage of candidate airports that were of the congested GA type. However, this should be done to determine the degree to which general aviation might impact implementation of the RTOL concept and the dollar cost and feasibility of making GA provisions.

G. IMPACT ON AIRPORT PROFITABILITY

It appears that introduction of RTOL service at airports now without scheduled service would increase airport profitability. However, time did not allow proper treatment of this subject. This should be a candidate for further study.

VI. AIRCRAFT REQUIREMENTS

A. PERFORMANCE SPECIFICATIONS

The two most important parameters that affect RTOL aircraft performance requirements are runway length and noise. The runway length required must be kept short so as to increase the number of candidate airports but kept long enough that a CTOL-like aircraft can use it, avoiding the need for a more radical aircraft (e.g., STOL, VTOL). The aircraft noise level must be kept low to make aircraft operations as unobtrusive as possible. Since jet engines will not be quiet enough for wide RTOL application for probably a decade, two sets of aircraft requirements emerge: a short-term compromise using turbo-props and the long term solution employing turbo-fan engines. Tables 4 and 5 list typical requirements and the characteristics of some present day aircraft that come close to these specifications.

Table 4 :

AIRCRAFT REQUIREMENTS – SHORT TERM

	Candidate Aircraft	
	Lockheed Electra	Fairchild FH-227
Number of passengers: 50-80	66-98	44-52
Maximum speed: 400 mph	450 mph	300 mph
Engines: turbo-prop	turbo-prop	turbo-prop
Balanced field length: 4000 ft.	5250 ft.	3940-5000 ft.
Approach angle: 4°	2.65-3.0°*	2.65-3°*
Climbout angle: 10°		
Max. still air range: 800 miles	3400 miles	1520 miles
Unit price: $2,000,000		$1.3 million
Noise: 90-95 PNdb at 500 ft.		

*Current operational standard

Table 5

AIRCRAFT REQUIREMENTS – LONG TERM

Requirements:	Advanced Boeing 737	BAC 111	Hawker Siddeley Trident
Number of passengers: 80-110	88-115	84	109-179
Max. speed: 500 mph	569	550	590-610
Engines: turbo-fan	turbo-fan	turbo-fan	turbo-fan
FAA takeoff field length: 4000 ft.	4000 ft.	6900 ft.	7500-9020 ft.
Approach angle: 6°			
Climbout angle: 12°			
Max. still air range: 800 miles	450-750 miles	1450 miles	1000-1124 miles
Unit price: $4.5 million	$4.5 million	$3.35 million	$5.52 million
Noise: 95-100 Pndb at 500 ft.	95*		

*EPNdB at 1300 ft.

B. NOISE

The single most critical issue effecting RTOL aircraft specifications and development is noise. The degree to which new service locations are accepted by neighboring communities is a direct function of the noise produced by the operation proposed. Noise exposure can be reduced in two ways - use of quieter powerplants and changes in operational procedures.

The current status and future prospects of efforts to reduce jet engine noise were well put by the AIAA/FAA conference at Key Biscayne in June 1971. The following was extracted from Volume 1, Conference Summary, dated September 15, 1971.

> "Without question, the most immediate environmental problem which now faces the Air Transportation System is noise. Dr. Richard Shaw, Deputy Director General - Technical, of the International Air Transport Association, described noise as "unwanted sound." "The question is not 'how much noise is there," but 'how much unwanted is it?' A rock festival is much louder than an airplane at takeoff. The attitude of the person who hears it is most important. No scale ofmeasurement is realistic to everyone." The degree of annoyance is inversely proportional to the personal benefits derived by the hearer from the producer of the disturbance. Nevertheless, it is universally recognized that present day aircraft create sounds which are "unwanted" by large portions of the population, and it is the obligation of the technical community to do something about it.
>
> The primary source of noise in the current generation of aircraft, as well as in the wide-bodied types which are now coming into use, is the powerplant. The sources of powerplant noise in modern engines have been fairly well identified and can be discussed in two general categories. The first of these is fan and compressor noise. There have been significant accomplishments in reduction of this noise through design fixes and changes which have occurred in an orderly fashion.
>
> With the advent of large bypass ratio turbofans, the higher-frequency noise generated by the fans has been found to be of considerable annoyance to the listener. Two approaches have been used to improve this situation: reduction of the fan noise generated at the source, and suppression of the noise by wall acoustic treatment.
>
> Results of these efforts have achieved a fan noise reduction of 13 to 15 PNdB. ... to levels commensurate with the current aircraft noise requirements defined by Federal Aviation Regulation No. 36 (FAR-36).

Figure 5

TURBOFAN NOISE REDUCTION TRENDS

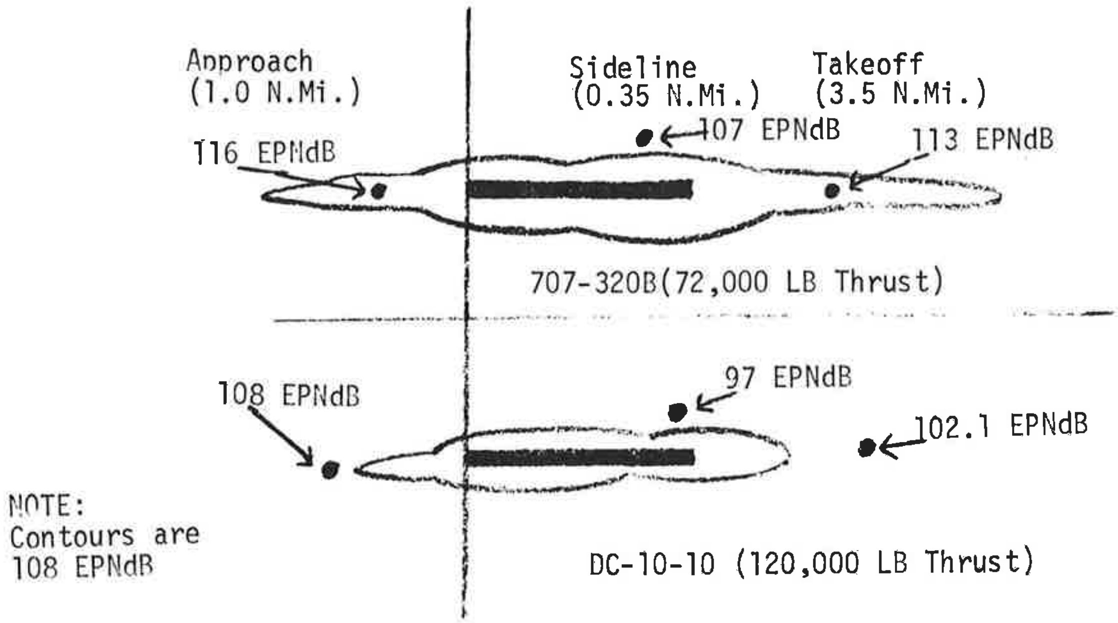
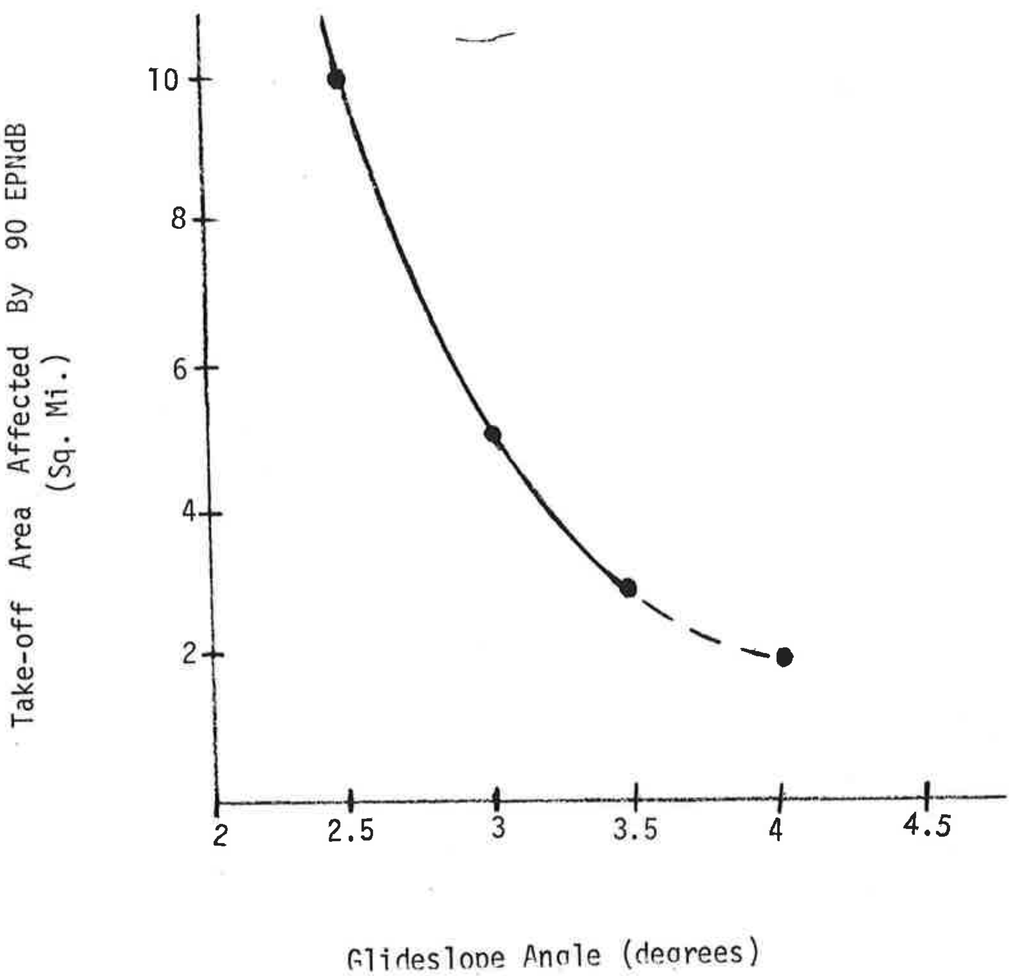


Figure 6

AFFECT OF GLIDESLOPE ANGLE ON COMMUNITY NOISE



The noise reduction features incorporated in the present generation of high bypass ratio engines have resulted in some increase in weight with practically no degradation in performance. Further fan noise reductions, however, will probably be expensive.

Reduction in fan noise by the order of 10 to 20 db now appears to be within the realm of possibility. This will focus increasing attention on the contribution of the compressor and turbine to the overall noise level of the engine. Although experimental and analytical investigations have been carried out in the last few years to define compressor noise, not much has been done to reduce it. Very little work has been done in this country on the prediction or reduction of turbine noise.

Methods similar to those used in attacking the fan noise problem could be applied to the compressor and turbine; ... These features, however, would undoubtedly be detrimental from the weight and performance standpoint, and considerable research is therefore required to provide a better understanding of the noise generating mechanisms in this part of the engine and to develop suitable suppression techniques.

The problem of noise generated at the jet end of the turbine engine has not been given adequate attention in the past, and as a result it is less well understood. Efforts at suppression have been designed more intuitively than on the basis of scientific information. Several types of nozzle noise suppressors have been developed, including corrugated, multitube, and teeth type. All of these are directed toward turbulent mixing of the jet exhaust and cause some degradation in performance of the engine.

With respect to engine noise on conventional aircraft of the present and next generation, the economic question looms large. We are far from having a reliable measure of annoyance factor. There is the possibility that large sums of money would be invested on retrofit modification of existing aircraft, or design compromises which would accomplish reduction in noise as measured in engineering parameters, but which the public would not recognize as improvements. Research to date on retrofit programs has been directed toward technical solutions with too little emphasis on their economic impact. Future research in this area should be oriented to achieve a balance of technical and economic factors.

The levels of noise at airports and on approach and take-off paths which have been assumed to be acceptable with the parameters and measuring techniques developed thus far will in all probability have to be lowered. On the other hand, other factors must be taken into consideration in establishing criteria for tolerance limits. Among these are the "dwell" factor which relates the duration of exposure to noise to its acceptability by the public. In the New York area, for example, it has been found that if the active runway is changed at intervals of eight hours or less, the number of complaints received from residents

under the takeoff and landing paths is not significant. Additional research is necessary to determine what other factors such as weather, time of day, and season of the year might influence noise tolerance to the extent that they could be built into the regulations, and thus relieve economic penalties.

The noise problems related to STOL and VTOL operations are inextricably interwoven in the development of the system.... The sources of such noise and its character will vary according to the configuration of the aircraft. In the case of a blown flap design, for example, the interaction of the jet with the flap would be an important contributor. Even with a high bypass ratio, which would probably be used in the engines for such aircraft, the noise directly beneath the flight path may be accentuated because it is directed straight down. A technical solution can undoubtedly be found for this problem, but with the present technology it is questionable whether this can be done without unacceptable economic penalties.

Operational Techniques for Noise Reduction

Apart from the reduction of noise at its source through design changes and innovation, significant improvements in the level of noise to which the community is subjected can be achieved through modifications to operational procedures. Study and flight testing during the past five years have led to significant progress toward this goal.

The objective of these operational changes, of course, is to remove the airplane from the noise sensitive area. To utilize such procedures and techniques, however, some flexibility must be ingroduced in the regulatory area. This would include changes in holding and maneuver altitudes, optimized traffic patterns, steeper and perhaps two-segment approaches, and higher glide slope intercept altitudes. If this flexibility can be achieved, there are a number of things which the airlines and manufacturers can do to develop procedures which will lead to effective noise reduction, including delayed flap and gear extension, varying flap position for takeoff and landing, and further automation in aircraft control systems.

To illustrate the gains which can be obtained, a change in holding altitude on a 727 type aircraft from 1,500 to 3,000 feet reduces the noise level on the ground about 9 EPNdB, assuming zero flaps and gear-up in both cases. Comparing the clean configuration at 3,000 feet with the normal maneuvering situation with flaps and gear down at 1,500 feet, the net gain is 16 EPNdB. Some of this is already being accomplished with the current "fly high" regulation promulgated by the FAA.

There is considerable controversy about the feasibility of increasing glide slope angles. Pilots, in general, seem to be

reluctant to adopt this type of approach to noise reduction, and this feeling has been reiterated by representatives of the International Air Transport Association. On the other hand, there has been a considerable amount of experimentation by airline pilots and manufacturers' test pilots with increased angles, and this has been common practice in the U.S. Air Force for a number of years. Increasing the angle from 2.5 to 3 degrees produces a gain of about 2-1/2 db at the one mile point and about 3-1/2 at the seven mile point. If the angle is increased to 3-1/2 degrees (the standard angle at Berlin), the gain is approximately 7 db. In addition, the area of 90 EPNdB is reduced approximately 70% with this increase in slope.

To overcome pilot objections to increase in glide slope angle will require convincing demonstration of the reliability of the system under adverse flight conditions and probably some improvement in cockpit displays.

The key to successful introduction of such a procedure is the creation of the stable platform, along with improved instrumentation. It is also likely that widespread use of higher glide slope angles will not take place until automatic flap and speed control, with an extremely high degree of reliability, have been demonstrated. When the necessary degree of confidence has been established, it will be possible to go to glide slope angles as high as 6 degrees with conventional aircraft and 7-1/2 on STOL types.

With these extremely high angles, of course, a two-segment approach is virtually mandatory. Maneuvering with zero flaps and gear-up may introduce some problems in observing the 200-knot speed limit in the terminal area, but studies of the two-segment approach and take-off have indicated that this can be dealt with by procedures. Another problem which must begiven consideration is the possible increase in wake turbulence at higher approach angles. This would be accentuated if direct lift control is used in the steep approach technique.

C. POLLUTION

No emission levels were defined for the RTOL aircraft but this does not mean none are required. It signifies the lack of attention paid to aircraft engine pollution by the aviation community. The myopic vision of these parties in this regard is incredible in view of the out cry raised over aviation noise. It seems apparent that once noise is brought within decent limits and automobile air pollution efforts achieve success that aviation pollution will become a primary target of environmentalists.

As with noise, improvements can be realized by both reduction of emissions at the source, the powerplant, and through operational procedures. The AIAA/FAA Conference summary report recognized the problem but only addressed the first means of pollution reduction. The following is extracted from their treatment of the subject.

> There is no doubt that air pollution is a problem associated with air transportation. The extent of the problem with respect to its effect on the environment and the general public is somewhat difficult to evaluate. It has been said, for example, that aviation contributes less than 1% of the pollutants in the atmosphere over the United States. This figure is misleading to the extent that the amount of pollution varies considerably according to the location of the measurement. At airports, for example, it is estimated that the amount of pollution caused by aircraft is about equivalent to that contributed by ground vehicles. It can also be shown that on the basis of pollutants emitted per passenger mile of transportation the airplane is roughly the same as an automobile.
>
> This type of analysis, however, shown only that there are other machines used by society which are also polluters of the atmosphere, and does not relieve aviation of its obligations to reduce the adverse effects which it contributes. Furthermore, this comparison with the automobile will become much more one-sided within the next five years when more stringent regulations are imposed on ground vehicles, unless some drastic action is taken by the aviation industry within that same period of time.

COMPARISON OF POLLUTANT EMISSIONS/PASSENGER-MILE

(GMS/MILE)

	3-Engine Jet* ("Smokeless" JT8D)	Automobile** 1970	1976
Carbon Monoxide	18	47	4 7
Hydrocarbons	1	4.6	0.45
NO_x	15	6	0.40
Particulates	13	0.3	0.03(?)
SO_2	3.5		

*50% LOAD FACTOR
**ONE PASSENGER

CHART I

The components of exhaust emissions from jet aircraft engines are fairly well defined. They are essentially the same in kind as are emitted by automotive engines; that is, nitric oxide, carbon monoxide, unburned hydrocarbons, and particulate matter. In jet engines the oxides of nitrogen and solid carbon (mostly of visible size, called soot) are given off principally during take-off and landing. At medium to high power, carbon monoxide and unburned fuel are emitted. During idling and taxiing operations these pollutants amount to between 1/10 of 1% and 1% by weight of the fuel burned.

NON-VISIBLE EMISSIONS

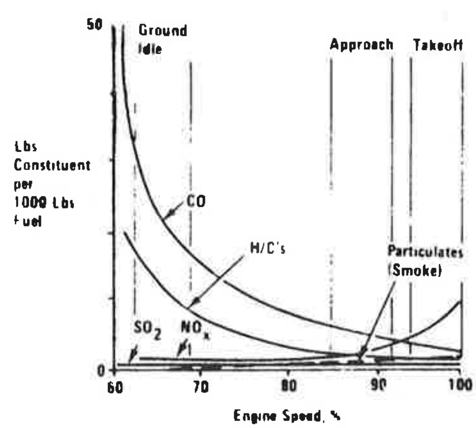


CHART 2

To determine some priorities in attacking this problem, it would be desirable to know which of the air pollutants are most harmful and at what levels and how they are related to the specific sources. This requires the ability to predict the dispersion patterns of pollutants emitted from known sources. Measurements of this nature are extremely difficult to make and their reliability is questionable; nevertheless, a considerable amount of research has been done using various types of models, and some progress is being made.

The importance of this with respect to aircraft as polluters is that although the point of generation is concentrated at the airport, there can be significant effects at some distance downwind. The high altitude effects of the emission of the exhaust products have hardly been explored at all, and this should be the subject of a concentrated research effort."

Changes to current aircraft operating procedures while in the airport vicinity have received scant attention. Probably the most fruitful means of lowering pollution at the airport is to reduce engine running time during taxiing and waiting in a queue for a take-off. Powered aircraft wheels and aircraft towing have been suggested. However, benefits are limited by the fact that engines have to be running during pre-flight checkout (8-10 minutes) since the systems being checked rely on the engines for power. Not all engines need be running, however. It is standard practice to perform taxiing and checkout with only the outboard engines of the 727, for example. The center engine is not started until the last minute before take-off and is shut down immediately after landing. This is done in the interests of fuel economics, not pollution, however. The feasibility of providing clean auxiliary power to aircraft for taxi and checkout power should be investigated.

D. DEVELOPMENT OPTIONS

The earlier section outlining performance specifications defined both short and long term requirements, due to the length of time necessary to develop a suitably quiet jet engine. The short term requirements are those that can be achieved using turbo-prop powerplants.

Suitable turbo-prop aircraft can best be obtained through modifications of currently flying aircraft. The option of producing an all-new turbo-prop is not elected because of the development costs. Since the RTOL system is not proven, per se, this represents a risk to the aircraft manufacturer which it might not accept especially in view of the current financial straits of the aerospace industry. Furthermore, the risk is heightened by the trend from turbo-props to jets by the airlines and the preference of the traveler for jets. If an aircraft is needed within the next decade to initiate the RTOL system, the only reasonable means of obtaining one is to modify the design of an existing turbo-prop CTOL (e.g., Electra,F-227 and the YS-11A). This would probably entail addition of slots and flaps to the wing, larger power plants, and application of quiet turbo-prop technology such as that already developed for the DeHavilland DHC-7. Such modifications might take about three years from the go-ahead. Costs have not been estimated nor the source(s) of the funds identified.

A note here in passing. Though a modified turbo-prop was chosen, the efforts of some manufacturers to quiet the operation of their short-haul jets should be considered further. Boeing, for example, has reduced the field length requirements of the 737 (down to 4000'), is actively engaged in quieting the engine, and is investigating such operational changes as a 4° glideslope to further reduce noise (Appendix D). The net effect of these efforts could be a jet aircraft that approximates the near term specifications except for noise. However, it may be quiet enough to be acceptable in enough new air service locations to initiate an RTOL system. This possibility deserves further consideration.

The long term aircraft requirements represent the more ideal solution and reflect the 10-15 year R&D period necessary to produce a quieter, lower emissions jet engine. Development of all-new airframe should not be necessary. It should be sufficient to modify the most efficient (for short haul) CTOL aircraft of that time frame in a manner similar to the turbo-prop conversion mentioned above. This effort would commence at a point in time such that modification designs would be complete when the engine is first available. By this time frame the RTOL concept should be well proven using the turbo-prop aircraft and the development risk low enough that private industry will take the initiative without prodding.

VII. NAVIGATION AND AIR TRAFFIC CONTROL

No attempt was made to conduct an in-depth analysis of this aspect of the RTOL system. The subject of ATC has been extensively investigated for STOL and does not appear to be a constraint upon establishment of that system. The en-route requirements of RTOL should be similar to those of STOL since both would employ area navigation, fly similar flight profiles, and result in like numbers of flights. For the terminal area, RTOL requirements would be much less stringent than those of STOL. RTOL landing and take-off control would closely resemble that of the current CTOL system whereas the STOL environment (elevated or ground-level STOLports in dense urban areas) and STOL aircraft performance place much higher demands upon the ATC system.

VIII. POTENTIAL RTOL SYSTEM

A. CURRENT TRENDS TOWARD RTOL

1. Aircraft developments -

There has been considerable interest shown recently by aircraft manufacturers in modifying current CTOLs to reduce runway requirements and noise. Two are briefly mentioned here as examples of RTOL aircraft "developments."

As mentioned earlier, Boeing is quite actively engaged in modifications to the 737. The recently introduced Advanced Model 737 features an improved high lift system (slats 'n flaps), automatic brakes and more horsepower. This permits operations from a 4000 ft. runway with 100 passengers and a range of over 700 miles. Furthermore, current powerplant quieting efforts should shortly reduce sideline noise from 103 to 95 EPNdB (at 1/4 mile). Use of 4° glide slope and a decelerating approach (both under study) would reduce approach noise further (93 EPNdB at 1 mile from threshold). See Appendix D.

In November 1971, the London Daily Telegraph reported that consideration is being given to modifying the Trident, replacing its four engines with two RB.211 engines (TriStar type) which would cut the aircraft's noise in half and permit it to take off in 3000 feet with 200 pax. See Appendix E.

2. Eastern Shuttle Operations -

Since it was anticipated that the RTOL shuttle concept would resemble the current shuttle operations of Eastern airlines (Boston - New York - Washington) in many ways. The manager of Eastern's shuttle was interviewed to gain some insight. The following notes are based on a conversation with Mr. W.A. Murphy, Manager, Shuttle Operations, Eastern Airlines.

The Shuttle is currently operated with a dedicated fleet of DC-9's, each with a capacity of 107 seats. These aircraft differ from the DC-9's used elsewhere on the Eastern system in that they have only a half galley (which is no longer used at all) and an enlarged garment bag compartment.

The DC-9's are backed up by a fleet of Electras which provide a second or third section when necessary. The 80 to 92-passenger Electras are being phased out as quickly as Eastern can find buyers. By next July, the Electra fleet should be reduced to 10. Eastern intends to replace the Electras with five 727-100's in 98-seat all coach configurations. The decision to replace was based not on superior speed (there is only a five minute difference in flying time on the Boston-NYC run) but on seating capacity, operating economics and passenger appeal. Beginning in late 1973, 727-200's in 150-seat, all-coach configuration will be phased in to replace the DC-9's. An RTOL aircraft designed for high-density shuttle routes should be configured much like the 727-200's Eastern will be using.

As traffic volume builds over the coming years, all the DC-9's will be replaced with 727's removed from other Eastern routes where 1011's will be phased in. This transition should begin in 1973. Some years from now, wide bodied planes are likely to be introduced on the shuttle, but no plans to do so have yet been formulated.

Earlier this year, Eastern experimented with ticketing shuttle passengers on the ground so as to permit the cabin attendants to serve beverages. It was concluded that this alternative was less attractive to customers who seemed to attach greater value to the time savings afforded by in-flight ticketing. Hence, Eastern has eliminated all beverage service, but it now serves coffee and donuts in the boarding lounge from 7 to 9 a.m.

Mr. Murphy would like to inaugurate shuttle service on Eastern's NYC-Montreal route and re-instate it on Boston-Washington. He regards 500K pax/year as the minimum necessary for a shuttle service: the four existing shuttle routes carry a **total of about 3 million pax/year.**

For an assessment of high density short haul routes that may support RTOL shuttle service, see Section VIII, C.

3. L.A. - San Francisco Air Service -

The dispersed nature of air service locations in both the Bay Area and the Los Angeles Basin, the extensive use of shuttle operations, and the segregation of non-connecting short haul from other flight service make the L.A. - San Francisco air "system" very much like the RTOL system. The following description of that situation refers to Figure 7.

Usually when one considers flying to either the Bay Area or Los Angeles or between the two, one thinks in terms of the SFO and LAX airports. To be sure, each is the busiest airport in its region but, in fact, secondary airports in both areas handle a very significant amount of scheduled air traffic. These are Oakland (OAK) and San Jose (SJC) in the Bay Area and Burbank (BUR), Ontario (ONT) and Long Beach (LGB) in the Los Angeles Basin. All long haul and most medium haul service is located at LAX and SFO. However, some medium haul (e.g., Denver, Salt Lake City, etc.) service is available from OAK, SJC and ONT. BUR and LGB offer short haul flights only.

Service between the Bay Area and greater Los Angeles is extraordinary - <u>nine</u> (count 'em) different non-stop routes to choose from. Over five million passengers are accommodated by an assembly of three trunk carriers, one regional, and three intra-state carriers. Of course SFO-LAX is the densest route but only half the direct flights between the two areas use this route. Service using the secondary airports is quite frequent and uses 100-pax plus aircraft.

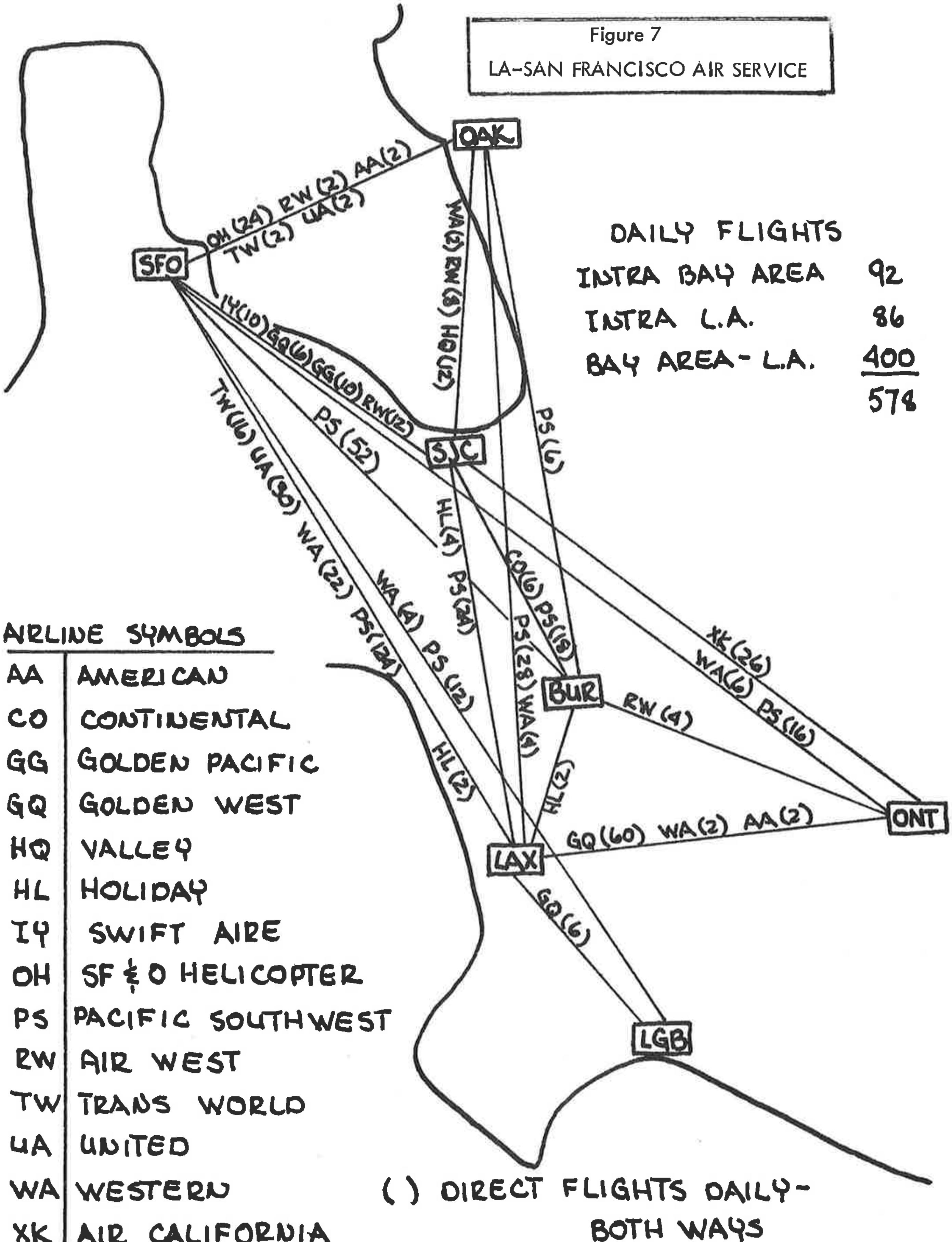


Figure 7
LA-SAN FRANCISCO AIR SERVICE

Of the 184 such direct flights using secondary airports, 180 use either 737 or 727 aircraft while the remaining four flights are Electras.

The extent to which the secondary airports are being used is further underscored by the fact that a trunk carrier (Continental) has gained entry into West Coast short haul market without using either LAX or SFO. The airline flies an ONT-BUR-SJC-Portland-Seattle route and the reverse. Thus they provide short haul service between the Northwest, San Francisco and Los Angeles using only secondary airports in the latter two areas.

The major difference between this California air system and the RTOL system lies with the aircraft. Both areas are fortunate to have secondary airports large enough to accommodate small CTOL jets and to have been using these airports for scheduled service before the recent outcry against aviation noise. However, a further expansion of air service locations will probably require a quiet RTOL aircraft.

It also differs somewhat from the 'pure' RTOL concept in that the Bay Area does not have any exclusively short haul airports.

The air fare between Los Angeles and the Bay Area is quite low. The intra-state fare for all nine routes is about $16 for a 340 mile trip - 5 cents a mile!

Where else can a traveler injoy such frequent service, a wide choice of routes, fly on excellent aircraft and pay only 5 cents a mile? Certainly there are conditions here which make the situation unique, not the least of which is the presence of well-run intra-state carriers. This investigation was not able to explore this properly. However, it does seem that a detailed study of what makes this "system" tick would find the key(s) to application of this service to some other parts of the country. That is, to find the conditions that must prevail (e.g., CAB regulation changes) in order to extend this RTOL-like service elsewhere.

B. RTOL/STAR ANALYSIS

TSC was involved to some extent with the recently completed STAR (Short Haul Transportation Analysis for Research and Development) study of the California corridor. This experience provided an opportunity to compare RTOL with the other short haul systems that the STAR study evaluated as possible solutions to California's future transportation needs. In this "back of the envelope" analysis the RTOL concept was compared with upgraded CTOL, STOL, VTOL, TACV, and Autotrain systems. The assumptions, description and evaluation results are as follows.

1. RTOL Ports in California

Assumptions

Ports for RTOL operation were selected by the following criteria:

a. RTOL will use the same fields as the ones selected in the STAR Study for V/STOL, if the capital cost of using these fields is the same or less for RTOL as for V/STOL.

b. If a. is not applicable, then RTOL will use an airport with 4000 foot runway that is closer to the CBD than the CTOL port.

c. If neither a. nor b. are applicable, then RTOL will use the CTOL port.

RTOL Ports Selected

Criterion a. RTOL will use the same facilities as V/STOL at:

Superdistrict	6	Oakland
	8	Stockton
	10	San Jose
	11	Modesto
	12	Merced
	13	Monterey
	14	Fresno
	16	Bakersfield
	18	Santa Barbara
	20	Los Angeles - San Francisco
	23	Riverside
	24	Santa Ana
	27	Las Vegas

Criterion b.:

Superdistrict 3 - Sacramento - RTOL will use Sacramento Municipal Airport 3 nm S of the CBD. This is the old commercial Sacramento airport. CTOL now uses Sacramento Metropolitan (SMF) 10 nm NW. SMF continues to handle long haul traffic.

Superdistrict 22 - Los Angeles East - RTOL will use Brackett Field 1 nm SW of La Verne, California. Ontaria (ONT) remains CTOL port and is used for long haul only.

Criterion c.:

Superdistrict	5	San Francisco - No facility for RTOL. Will use SFO.
	9	San Mateo - SFO
	21	Los Angeles Center - LAX
	26	San Diego - SAN

2. RTOL - Nominal Case

RTOL provides the only short-haul air transportation in region. Uses RTOL terminal network as defined in 1.2. Gets no subsidy.

3. Evaluation of RTOL by STAR Scorecard Items

This evaluation is strictly an estimate of the relative position that RTOL would occupy if the RTOL case were analyzed through the STAR models.

Item	RTOL Position[1]	Remarks
Annual Pax Volume (million)	A>T>C>R>V>S	C = 6.6 million, R is probably slightly lower than C, but closer to C than V (3.4 million)
Annual Pax Miles	C>R>T>A>V>S	Very close to C (2,059 million)
Cost/Pax Mile	(C)<V<S<A<T (R)	C and R highly comparable (4.61¢)
Capital Investment Required	(C)<V<S<A<T (R)	Comparable to C ($144 million)

[1] R = RTOL; C = CTOL; S = STOL; V = VTOL; A = Autotrain; T = TACV.

Annual Subsidy	\$0	By definition
Door-to-Door Time: LA-SF	$V < S < C < (T) < A$ (R)	R higher than C (174 min.) closer to T (192 min.)[2]
Door-to-Door Cost: LA-SF	$(C) < A < T < V < S$ (R)	R about same as C \$17.39
Congestion - Pax Diverted	$V = S > A > T > R > C$	C = 0; R nearly 0, only diversion at Sacramento
Peak Year Impact of Construction	\$0	By definition, C also equals 0
Urban Land Acquisition	0	By definition
Rural Land Acquisition	0	By definition
Taxes Lost	0	By definition
Household Displaced	0	By definition
Energy Bill	No estimate	
Household Noise Impacts	$S = V < (C) < A < T$ (R)	Comparable to C (11,000)
Social Impacts	No estimate but highly comparable to C	

4. <u>Summary Evaluation</u>

RTOL, as a system, looks much like CTOL for California for at least two reasons. First, as mentioned earlier, the CTOL system there embodies some of the RTOL concepts such as multiple air service locations and segregation of non-connecting short haul. Second, RTOL ports alternatives for LAX, SFO and SAN were not available, due, in part, to the assumptions made (see 1. b.). It is felt that a more detailed analysis would show that RTOL would be an improvement over CTOL - the system which STAR concluded was probably most suitable for California's needs.

[2] Turboprop RTOL (400 mph) used.

C. HIGH-DENSITY ROUTE SYSTEMS

1. Typical Case

The RTOL concept is intended primarily to solve the current deficiencies in high density short haul air service. Even though an economical, quiet RTOL aircraft would also be beneficial on lower density routes, the aircraft would be used in the same way as CTOLs are now employed in this part of the system. For the high density situation, RTOLs would be used primarily on a network of RTOL shuttle routes between RTOLports.

The RTOL shuttle (see Figure 3) would be operated in a manner similar to the Eastern and PSA shuttle flights. As mentioned in Section IV, B, the shuttle will be oriented toward accommodating the non-connecting short-stay traveler (primarily the "go-in-the-morning, come-back-at-night" businessman). Flight frequency would be the maximum warranted - ideally every 15-20 minutes during the peak business travel hours. During off-hours, flights every hour or so should suffice. During these hours, the "excess" aircraft would fly short haul feeder routes into the hub airports. No flights would depart before 6:30 a.m. nor after 8:00 p.m., however, in deference to the surrounding communities. Extra 'sections' (a la Eastern) should be available if a flight is over sold.

Passenger services and facilities are trimmed to only those necessary for this type traveler so as to minimize fares. No baggage handling system is required since only carry-on baggage would be allowed. For those exceptions, two dollars would be charged per handled bag and this would be done manually. No advance reservations would be made (pay after boarding). Ground servicing and aircraft design are oriented to minimize gate time for the aircraft.

2. National Potential

To estimate the national potential for the RTOL shuttle concept, the higher density short-haul air routes were identified. It was calculated that if at least 270,000 ticketed (non-connecting) passengers per year flew between a city pair, then a viable RTOL shuttle service could be established on that route. Critical to this calculation is the requirement that only one airline initially operate a shuttle route and that an additional airline would be introduced only when that it can be proved that the route would continue to be profitable for both operators. Some 25 routes were found to have had over 270,000 non-connection pax/year (see Figures 8 - 11). A further survey was taken to identify those routes that had over 30 daily flights (both ways). This was done for two reasons: first, this flight frequency would probably support a quasi-RTOL shuttle and second, these routes would probably soon surpass the 270,000 pax/year assuming an increasing demand for air travel in general. Routes,which met this second criterion only, handle between 150,000 and 270,000 pax/year and numbered 14.

The 39 candidate RTOL shuttle routes naturally form five separate regional systems. The largest (23 routes and 12,023,000 pax/year) is the Northeast Corridor-Great Lakes system (see Figure 8). The second biggest (7 routes and 7,102,000 pax/year) is the Greater California system which includes the Los Angeles-Bay Area service discussed before (see Figure 9). Other systems, in order of pax, are Hawaii (3 routes and 949,000 pax/year), Greater Texas (3 routes and 713,000 pax/year), and Northwest (2 routes and 365,000 pax/year).

D. COST/BENEFIT ASSESSMENT

While time did not permit a proper assessment, some observations can be made. First, compare RTOL with CTOL. The benefit (improved short haul service for the future)

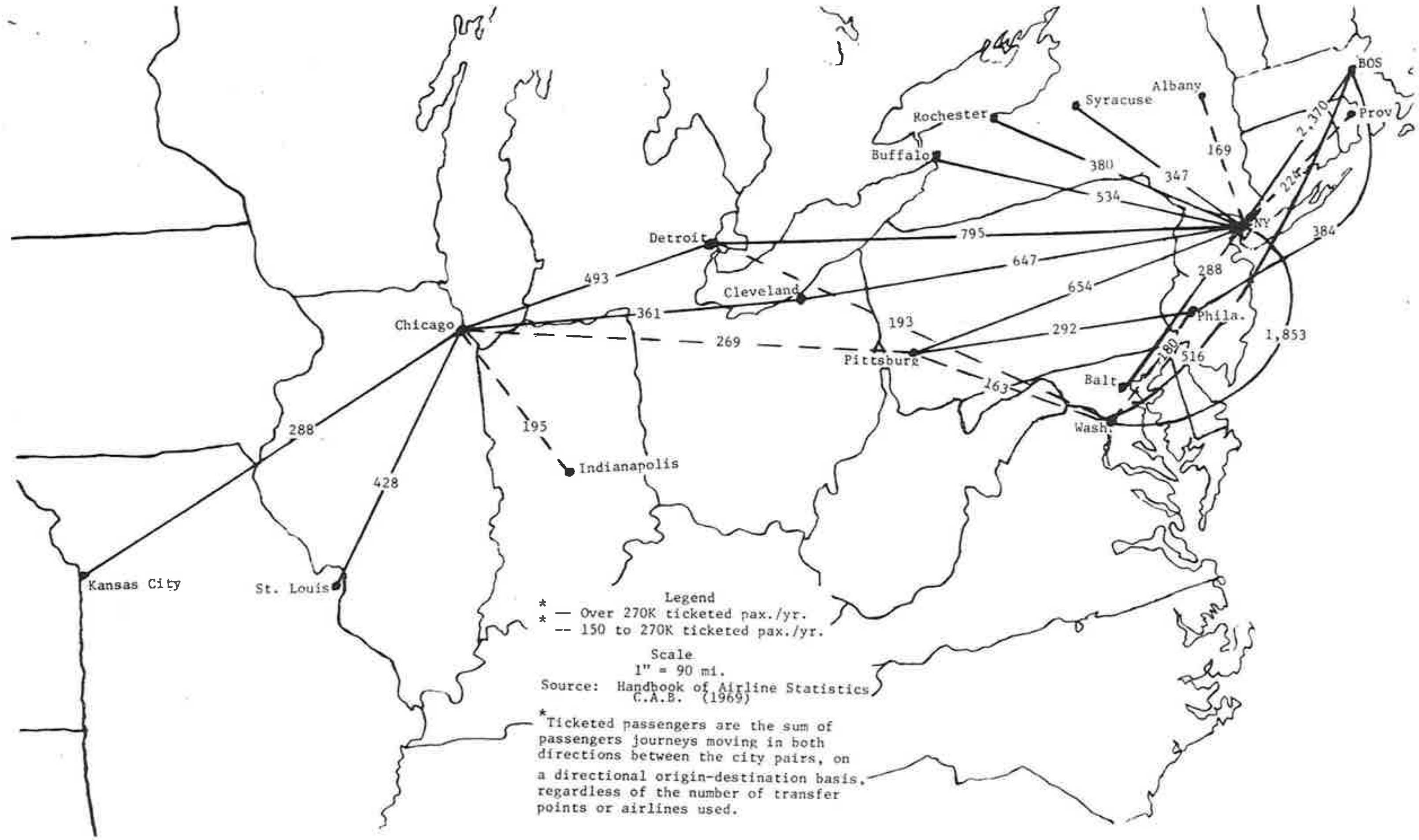


Figure 8. Eastern USA High-Density Routes (Under 500 Miles)

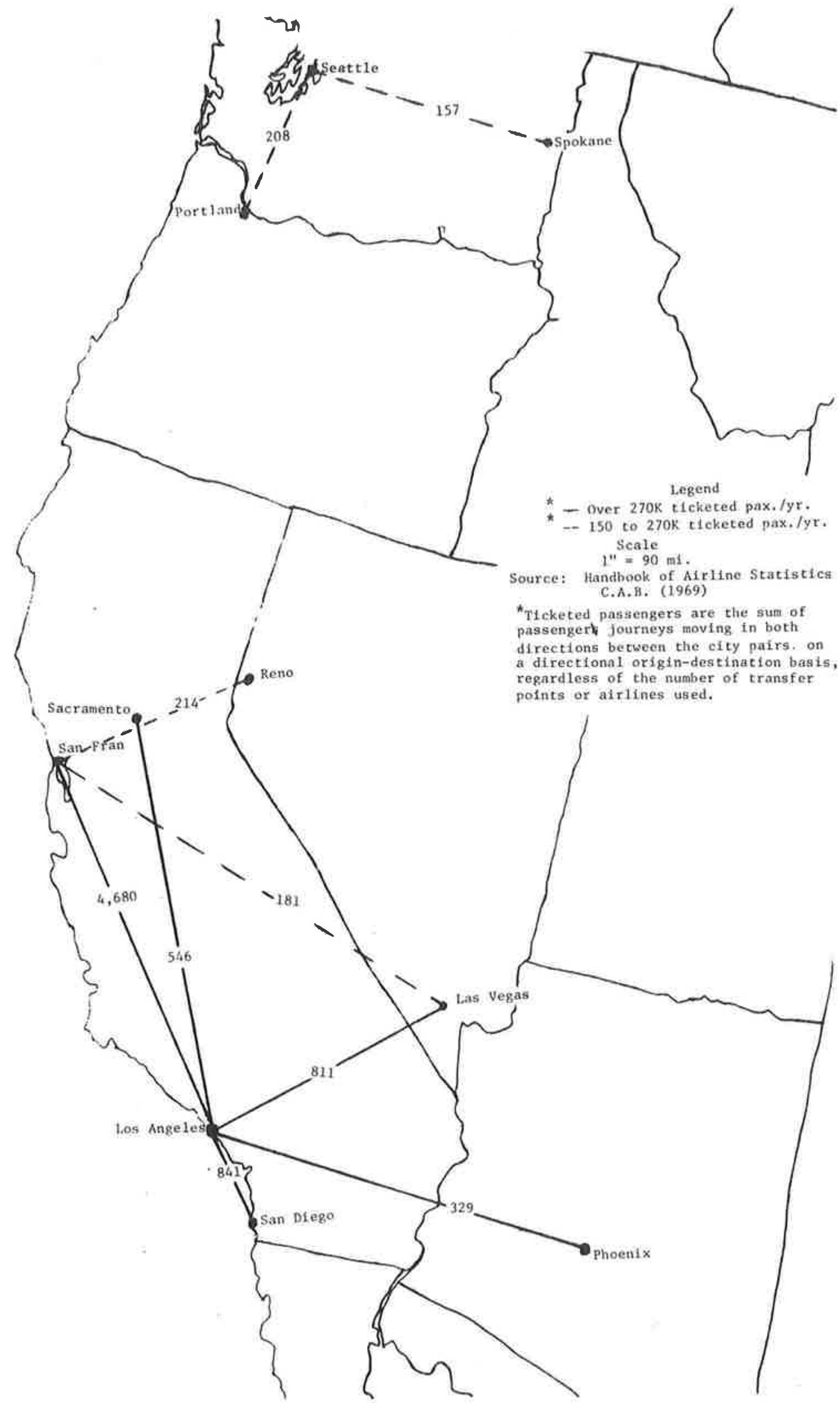
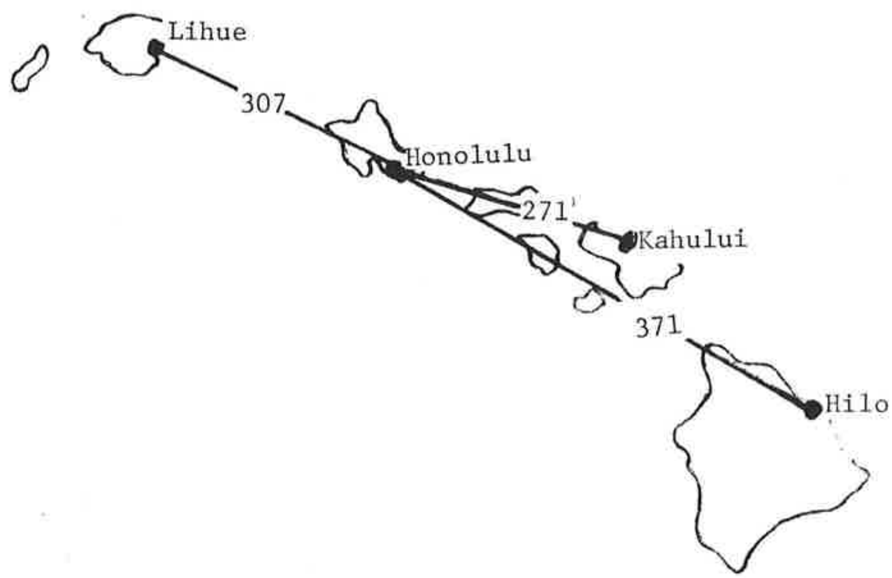


Figure 9. Western USA High-Density Routes (Under 500 Miles)



Legend

* — Over 270K ticketed pax./yr

* -- 150 to 270K ticketed pax./yr.

Scale

1" = 90 mi.

Source: Handbook of Airline Statistics C.A.B. (1969)

*Ticketed passengers are the sum of passengers journeys moving in both directions between the city pairs, on

a directional origin-destination basis, regardless of the number of transfer points or airlines used.

Figure 10. Hawaiian Island High-Density Routes

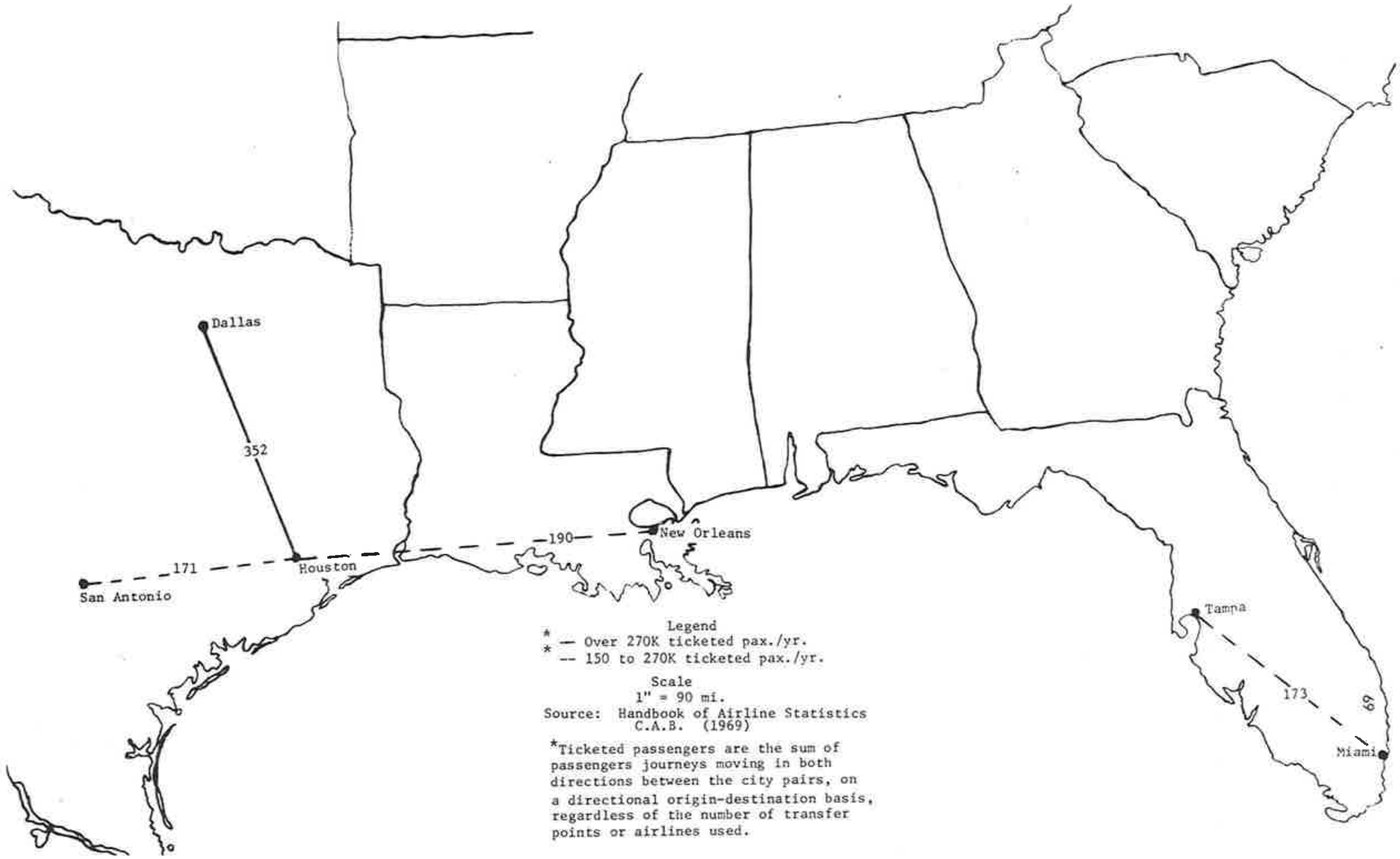


Figure 11. Gulf Coast High-Density Routes
(Under 500 Miles)

associated with RTOL is expected to exceed that of an upgraded CTOL (better ATC, bigger planes, but same airports) system. However, costs should be comparable. Thus RTOL should have a better cost/benefit ratio than CTOL.

Now compare CTOL with STOL, VTOL, TACV, Autotrain, HSR and bus. Part of the STAR study dealt with such system comparisons for the North East Corridor. One measure of comparison was productivity, defined as passengers carried times average block speed divided by annual cost (pax-mph/dollar). This benefit/cost analysis showed CTOL to be superior to all other modes for all levels of demand. Furthermore, the Rand analysis for the California Corridor came to a similar conclusion (i.e., CTOL is the best short-haul system for that area for the future).

This cursory treatment cannot be considered conclusive - a proper cost/benefit assessment is needed. However, it seems that RTOL would have very favorable cost/benefit ratio when compared with other potential short-haul systems.

IX. RTOL DEVELOPMENT

A. CRITICAL PATH ANALYSIS

This analysis was performed for a two-phase development program resulting in a national system using jet RTOL aircraft. The first phase concerned achieving initial RTOL-service using quiet turbo-props and the second involved developing the initial system into a second generation system using pure jets. The detailed explanation of the analysis is included in the Appendix (F).

Conclusions:

- Initial service is feasible in three or four years.
- The key initial system activity is the negotiation (FAA/CAB/airlines/airport operators with the communities) program.
- Second generation service would take from eight to ten years to implement.
- The pacing link for the above is the quiet jet development program.

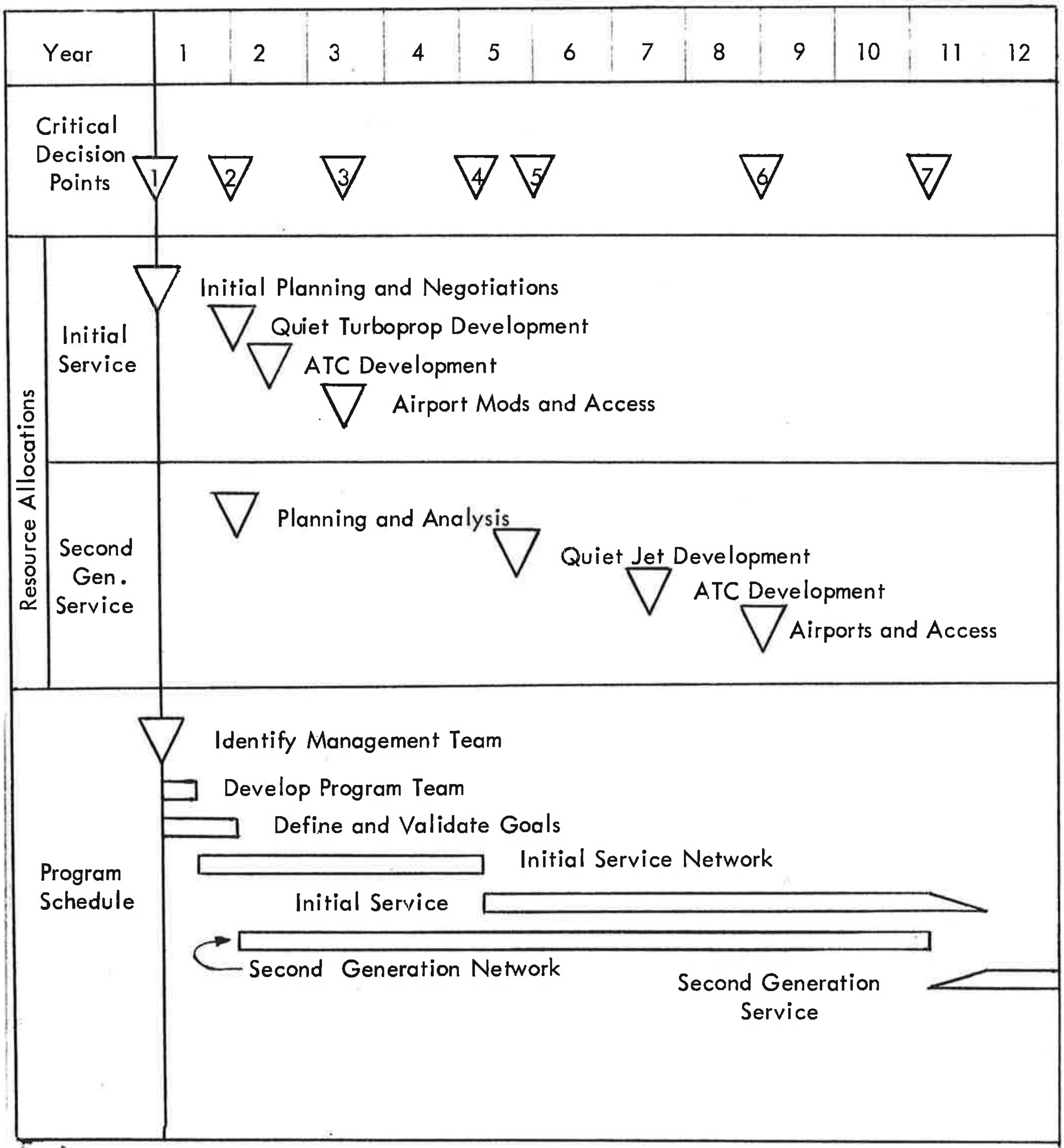
Recommendations :

- Because of its importance to RTOL or any alternative (STOL, TACV, etc.), institute an exercise to determine how best to deal with communities.
- Since quiet jets are mandatory, begin a specific development program for an engine(s) to be used on a short-haul aircraft.
- Identify participants and their roles in the RTOL program.

B. DEVELOPMENT PLAN

Figure 12 presents the proposed RTOL implementation schedule.

FIG. 12 : RTOL IMPLEMENTATION SCHEDULE



The seven go-no go decisions are:

1. Initial go ahead.

2. Based on effort to validate goals, and point where must commit to A/C development (quiet turboprop).

3. Determined by success of the negotiation program for initial service.

4. Point where communities can kill program if promises not kept.

5. Based on operating service, initial system. Must commit to Q-jet program

6. Determined by success of Q-jet program and negotiations to that point.

7. Same as 5. for second generation system.

C. DEMONSTRATIONS

The initial service described in the critical path analysis section constitutes a full scale demonstration. Beyond proving specific technological and operational improvements no further demos are suggested because:

- There is sufficient near-RTOL service in California to permit analysis of demand, operating problems and so forth.
- A certified "Q" turboprop aircraft will not be available until very near the initial service implementation date, and early aircraft will need to be used to verify promises to communities.
- A demonstration program per se would take almost as long as the initial service to start and would require almost as much money and resources.

Special technological and operational improvement "demonstrations" might include:

- Test passenger processing concepts using the existing CTOL system - examples would be: automated ticketing (insert card - get ticket) and no baggage processing on shuttles.
- Verify that RTOL flight profile and ATC system are safe and efficient - could be used as part of negotiation program using "noisy" aircraft.
- Using simulation techniques, determine and demonstrate to participants benefits of the system:

Operators:	Profitable Short Haul
Communities:	Improved traffic flow
	Tax revenues
	Jobs
FAA/CAB:	System operates more efficiently
Customers:	Reduced trip time.

- Demonstrate and verify each element of initial system as it becomes operational to:

a) Prove to participants they work as promised.

b) Debug system as much as possible prior to operations to minimize dissatisfaction through hang-ups.

X. CONCLUDING REMARKS & RECOMMENDATIONS

Any conclusions derived from this initial quick-look analysis of a "new" concept for short haul air transportation must, of course, be tentative. However, the results of this investigation seem to say that:

- There are many good candidate airports that can be used by RTOL,
- Quiet RTOL aircraft can be obtained relatively cheaply and soon,
- The system will work well and,
- It can and should be made a reality.

The next step is to complete the job started with this report by committing to an in- depth analysis of those areas so noted in the body of the report. A listing of these recommended subjects is as follows:

1. "RTOL Task Flow & Descriptions"
   (Appendix A) addresses work necessary to define and evaluate a short-haul system and its development program-p. 2

2. Degree of congestion at candidate airports- pp. 13 & 41

3. Establishment of metropolitan airports that provide only non-connecting, short-haul service-p.33

4. Effect of scheduled service initiation upon airport profitability-p.41

5. RTOL aircraft performance requirements-p. 44

6. Development of "clean" auxiliary power for aircraft taxiing and systems checkout-P. 52

7. RTOL aircraft development options- p.53

8. Possible use of Boeing's Advanced 737-p. 53

9. Analysis of the California air systen for national applications-p. 60

10. Inclusion of the RTOL system in the STAR analysis of short-haul system candidates-p. 63

11. Detailed cost benefit assessment of the RTOL system-p. 70

12. Community acceptance program–p. 71

13. Development program for a quiet, low-emissions jet engine for short-haul use–p. 71

14. Potential technological and operational "demonstrations"–p. 74

APPENDIX A: RTOL TASK FLOW AND DESCRIPTION

1. PROBLEMS OF SHORT-HAUL AIR TRANSPORTATION

Collection of statements and data pertaining to the current and projected problems besetting short-haul air, to the balance-of-payments situation and aerospace's contribution, and to the plight of the aerospace industry. The statement should include the views of all related parties:

airframe manufacturers, airlines, airport operators, air travelers, and the aviation opposition. The statement should present a concise, factual and coherent assessment of the situation which then forms the basis for a National Short-Haul Air Transportation Program.

2. RTOL SYSTEM BASELINE DESCRIPTION & OBJECTIVES

Definition of the RTOL concept and its relations to CTOL, STOL & VTOL. Include a description of potential national application of the concept. State the objectives of an RTOL system as they relate to the problems outlined in Task 1.

3. RTOL STAR

Constitutes a re-running of the STAR program with an RTOL system inserted as an additional alternative. To the extent possible, parameters that describe RTOL should be estimated as values that lie between the corresponding ones for CTOL & STOL. Use Task 2 description for guidance in aircraft and airport selection. The objective is to provide an indication of the relative viability of RTOL, STOL, TACV and CTOL systems.

4. NATIONAL AIRPORT SURVEY

An estimate of the number and utility of smaller U.S. airports that might be used by RTOL, STOL and/or VTOL aircraft. Maximum use will be made of Boeing, MDAC, and FAA surveys of this nature. Output will address numbers, size, classes (by runway lengths) and geographic locations in relation to the urban area. An assessment will be made of the degree to which DASLU objectives could be met through use of these airports (unrestrained by aircraft performance and community objection.)

5. TYPICAL AIRPORTS SURVEY

Select several small airports that might be used by RTOL, STOL and/or VTOL for detailed study. For each, determine nature of current operations, demography and geography of the area, degree of community objection to current aviation activity, ground access situation, profitability of airport operations, current noise exposure, ground facilities, runway bearing strengths, scheduled air service of past and present , etc. Enough airports should be studied such that one can confidently project findings into a national picture of current status of candidate airports. Include some smaller airports that have recently initiated air service (e.g., Islip).

6. AIRPORT USE

For the airports surveyed in Task 5, determine the conditions under which use of these airports would be possible including:

maximum allowable community noise exposure; aircraft noise levels; operations frequency, and schedule; arrangements with current users (general aviation and military); community involvement in airport control; airport operators' interests (including airport profitability); incentives to airlines to commence service; improvements in airport access, ground facilities, ATC, runways, etc.

7. PUBLIC ACCEPTANCE CRITERIA

From current maximum intrusion standards, studies already complete, and results of Task 5 (Typical Airports Survey) derive a set of aviation intrusion limits that the short-haul air system could meet and that would represent conditions under which most communities would permit initiation of air services at existing airports. Make note of likely deviations from this standard as a function of region of the country, demographic character of the neighboring communities, site geography, etc. Determine whether these intrusion limits would tend to be more relaxed or more stringent for communities which do not now have an airport.

8. PUBLIC RELATIONS PROGRAMS

Outline the objectives and contents of the following programs: Public Information Program (PIP) which attempts to get across to the general public the message that the Short-Haul Air Program is doing good things for people and the nation. (Reference

AMTRAC type advertizing); Community Assistance Program (CAP) which attempts to aid local proponents of air service initiation in their effort to win popular support. The output should only be detailed to the extent necessary to ascertain the role demonstrations may play in these programs and to enable PERT analysis of that portion of the development program attributable to gaining public support.

9. AIRCRAFT REQUIREMENTS

Identify both near and long-term requirements for RTOL aircraft including performance (including field length, cruise speed, control features, climbout, etc.), capacity(s), amenity level, appearance, operating cost, and noise level.

10. AVAILABLE AIRPORTS

From Tasks 4, 7 and 9 determine the probable numbers and typical location (in relation to the urban area) of existing airports one could hope to use in the RTOL system. Do the same for STOL aircraft field length and noise characteristics as determined by the STOL committee.

11. AIRPORT ACCESS

Develop a "shopping list" of viable airport access solutions from which one would select a system(s) best suited to 'new' air service location. The objective, of course, would be to provide for access such that the highway system of the neighboring communities would not be clobbered by airport traffic.

Consideration should also be given the concept of providing ground transportation that not only addresses airport access but also provides intra-urban transportation for the communities near the airport. Estimate access costs for typical new air service location.

12. GROUND FACILITIES

Compile the results of design studies done for short-haul ground facilities to obtain a composite picture. Make a rough estimate of typical facilities costs as a function of passenger through-put.

13. AIRPORT PROFITABILITY

Investigate reasons for current unprofitability of many airports. Is the profitability of small airports likely to improve with the advent of major scheduled air service? Determine effect on hub airports of the diversion of most short haul air service to other locations. List suggestions that have been made to improve airport profitability in general.

14. ATC REQUIREMENTS

Determine if current ATC equipment and procedures are adequate for RTOL local control and extensive use of area navigation. Estimate the cost of local ATC for "new" air service locations.

15. PROBABLE RTOL SYSTEM

Determine the likely dimensions of a national RTOL system, assuming it represents the only major effort to solve short-haul air problems and no improvements in inter-city rail (beyond application of turbotrain and Metroliner technology) are implemented. Scenerios for both a "first generation" system, available between 1975 and 1980, and an ultimately realizable system are necessary. Both descriptions should include aircraft numbers and types, numbers and type descriptions of new and augmented service locations, passengers carried, airline operators, flights per day, etc. In any event, sufficient detail should be included for both systems to permit estimates of national benefits and costs of each.

16. RTOL COSTS

Determine the total costs of both the first generation and ultimate national RTOL systems. Costs shall include expenditures for aircraft development, ground access and facilities, aircraft purchase or conversion, additional ATC equipment and personnel, etc. Also include national noise exposure and pollution of the RTOL systems and of all airline activities with and without RTOL. Address the shift in noise and pollution exposure from major airports to dispersed locations.

17. RTOL BENEFITS

Determine the national impact of the RTOL systems upon door-to-door short haul trip times, air and ground congestion relief and short haul profitability. Address the relative noise exposure of CTOL and RTOL operations. Assess the impact of U.S.

RTOL aircraft upon the balance-of-trade and the health of the aerospace industry. Estimate the potential increase in total air system capacity afforded by RTOL.

18. COST/BENEFIT ANALYSIS OF NATIONAL RTOL SYSTEM

Combine the findings of Tasks 16 and 17 into an assessment of the cost effectiveness of an RTOL system when compared to other short-haul system alternatives (CTOL, STOL, TACV, VTOL). Address also the relative likelihood of system realization of each alternative and the markets and situations which each system enjoys greatest advantage. Discuss the impact of other efforts to improve the air system (e.g., 4GATCS) upon RTOL effectiveness and the relative cost effectiveness of these efforts when compared with RTOL.

19. AIRCRAFT DEVELOPMENT OPTIONS

Identify development options for obtaining RTOL aircraft for both "first generation" and "ultimate" systems. For each option, determine development cost and time, describe the end product aircraft, identify incentives needed and any relationships with military programs, and assess the degree to which the U.S. aerospace industry would benefit and the potential overseas market.

20. FAA CERTIFICATION

Determine if FAA certification requirements for CTOL aircraft are acceptable for RTOL. If not, size the effort to develop the needed specifications.

21. DEMONSTRATION REQUIREMENTS

Determine if proof-of-(system) concept, market/service experimental, technological, and/or community acceptance demonstrations are necessary. If affirmative, state objectives and timing of each demo.

22. ENGINE NOISE PROGRAMS

Identify ongoing and proposed engine quieting programs and, for each, state the output, schedule and prospects. Note areas where additional work may be required for RTOL applications.

23. PERT & CPM ANALYSIS

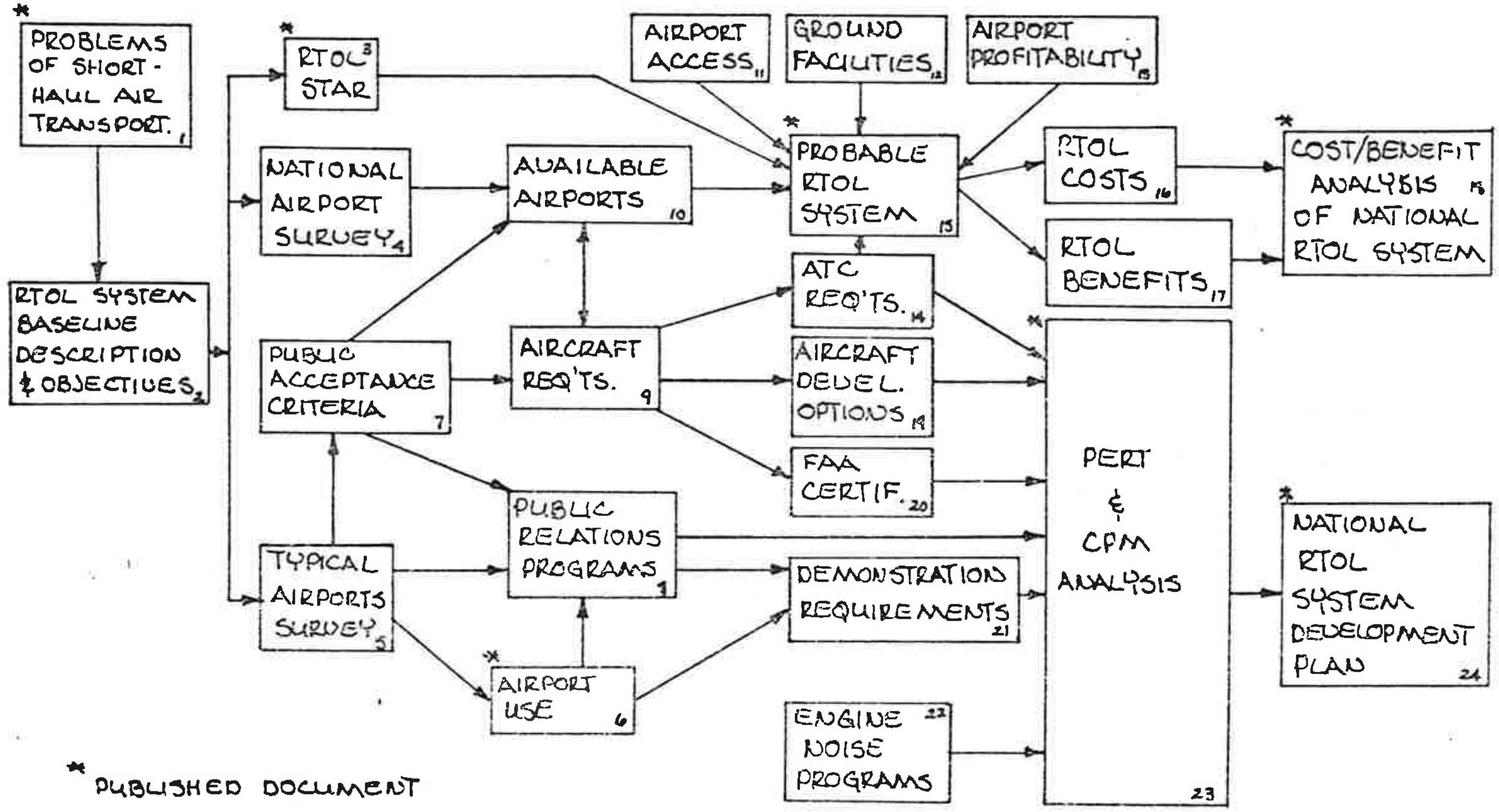
Perform a PERT/CPM analysis of development programs for both "first generation" and "ultimate" RTOL systems. The purpose of this activity is twofold: first, to determine length of the development period, identify the relationship between the critical path and development options, and make preliminary resource allocation decisions; second, to provide a method which forces identification and sizing of all activities necessary to system development.

24. NATIONAL RTOL SYSTEM DEVELOPMENT PLAN

Based upon the results of the PERT/CPM analysis and other investigations (see chart), outline the development program for the "first generation" and "ultimate" RTOL systems. Describe in detail the activities identified during the PERT process. Identify those elements of the plan that are common with a

V/STOL program and those which are worthwhile efforts even if no "new" short haul system development is pursued. Identify major decision points in the program, outline the options available and the information needed to make these decisions.

RTOL ACTIVITIES UP TO 1 DEC '71 TIME →



* PUBLISHED DOCUMENT

G.C.W. '71

From the New York Times:

Suffolk Legislature Acts To Restrict Airport's Use

By DAVID A. ANDELMAN
Special to The New York Times

RIVERHEAD, L. I., Oct. 26—The Suffolk County Legislature today took a major legislative step toward preventing the development of the Suffolk County Airport at Westhampton into a jetport.

In a resolution adopted today, use of the airport was restricted to "noncertified operators, operators who have not received a certificate of convenience and necessity from the Civil Aeronautics Board."

"Such definition, therefore," the resolution continued, "excludes trunkline air carriers, local or regional service carriers and charters or supplemental carriers."

After today's legislative session, however, County Executive H. Lee Dennison, who has favored the development of the airport at least as a major jet cargo facility, indicated that he might veto the bill. He has 15 days in which to do so.

"The future of Suffolk County lies in the air," Mr. Dennison told a news conference after the County Legislature's action. "I've emphasized the need for aviation development, especially the introduction of air freight Highways are insufficient to move freight to the eastern end of Long Island."

The action today marked the first time that a local legislative body in the metropolitan area has been able to take concrete steps to prevent an airport from becoming a major regional facility. In all other instances, the airports have been under the control of a regional body, such as the Port of New York Authority or the Metropolitan Transportation Authority, so that local governments could merely protest but take no legal steps.

The wording to today's bill, submitted by John V. N. Klein, Republican-Conservative of St. James, presiding officer of the Legislature, was based on Federal Aviation Administration definitions of a general-aviation airport, he said, but would not preclude other uses of the facility, including those of the Air National Guard, servicing of major jetliners by the large airlines, or air freight of noncertified operators, which Mr. Klein conceded was less than 1 per cent of the air freight traffic in the nation today.

The resolution, Mr. Klein said, was in response to pressure by local residents of Quogue and Westhampton Beach, which border on the former Air Force Base at Westhampton, who fear that the county does plan, despite numerous protestations to the contrary, to make it into the metropolitan area's fourth major jetport.

SUFFOLK REJECTS AIRPORT GROWTH

Legislators Override Veto on Issue by Dennison

By JONATHAN KANDELL
Special to The New York Times

RIVERHEAD, L. I., Nov. 23—The Suffolk County Legislature today reaffirmed a resolution to prevent the expansion of the Suffolk County airport into a jetport or terminal for major airlines.

By a 12-to-5 vote, the legislators overrode a veto by County Executive H. Lee Dennison, who said the resolution "could mean the death knell of aviation in Suffolk County."

The resolution — strongly backed by community residents, some of who attended today's meeting and applauded the results—means that Suffolk will not provide an alternative major airport to relieve congestion at Kennedy, La Guardia and Newark Airports.

Community Attitude Cited

Last Oct. 26, the county legislature adopted a resolution, by a 16-to-1 vote, restricting the use of the airport to "noncertified operators, operators who have not received a certificate of convenience and necessity from the Civil Aeronautics Board."

The same resolution excluded from the airport, in Westhampton, "trunkline carriers, local or regional service carriers and charter or supplemental carriers."

However, Mr. Dennison vetoed the resolution on Nov. 9, settin gthe stage for today's action at the Riverhead County Center.

In a brief, emotional speech preceding the roll-call vote, John V. N. Klein, presiding officer of the County Legislature and County Executive-elect, urged that the veto be overridden.

"We made a commitment to the communit yand any other disposition of the resolution would be a slap in the face," said Mr. Klein to the applause of some 20 residents of Quogue and Westhampton who attended the meeting.

In a news conference after the session, Mr. Dennison said the Legislature's action would be detrimental to the economic growth of Suffolk.

"I think it's a sad day for Suffolk—the county has been sold down river for the sake of one community," he said.

"I've said it a thousand times—the future of this county lies in the air," he added.

Mr. Dennison also asserted that the resolution would encourage residents of other Suffolk communities to block airport construction proposals in their locales.

"A major airport is not compatible with this county's future," rebutted Mr. Klein.

Before the votes in today's session, legislators heard appeals from officials and residents of communities near the Suffolk County airport who urged that the site not be expanded.

Some Support Expansion

One woman handed in a list of 656 signatures from residents opposed to a jetport to supplement a previous list of 3,622 signatures turned over to legislators last summer.

The legislators also heard arguments in favor of the expansion of the Suffolk County airport short of converting it into a jetport.

Arthur Bauer, president of the Aviation Council of Long Island, asserted that "no other airports" could operate "if they were saddled with the restrictions" imposed on Suffolk County ariport by the Legislature's resolution.

He said that the action would "eliminate charter flying, air taxi operations and limited charter freight operation."

Mr. Bauer also warned that the resolution could lead to the possible loss of state and Federal funds for airport improvement and maintenance.

APPENDIX C: THE NEW HAVEN CASE

From the New York Times, November, 1971:

AIRPORT DAMAGE TO NEIGHBORS SET

Judge Awards $18,400 to Seven in New Haven

Property owners on the approaches to New Haven's airport suffer damage because of air traffic, a Federal judge ruled here Tuesday, and he directed the City of New Haven to pay for the loss.

The judge, under a novel appraisal formula, ordered that a total of $18,400 be paid the owners of seven properties in return for a permanent easement of airport flights.

Judge Edward C. McLean of the Southern District of New York, in an opinion to be filed in New Haven, used a real estate appraiser's calculations to award from $2,100 to #3,300 to the property owners, who protested that jet flights over their part of the town of East Haven reduced the market value of their land and homes.

The weighted formula, which had been suggested in real estate appraisers' trade publications, took into account the flight altitudes, up to 500 feet; the distance of properties from a center-line extension of the runway, up to 2,000 feet, and the distance from the end of the runway, up to 25,000 feet.

Judge McLean noted that the defendants - including the City of New Haven and Eastern Airlines - called an expert witness who said that noise, soot, vibration and smell had not damaged those living or conducting business under the approaches and takeoffs.

"This conclusion defies common sense, and I decline to accept it," Judge McLean said. "I have no doubt that plaintiffs have been damaged."

During the long litigation over New Haven's acquiring 73 acres in the town of East Haven to stretch its north-south runway, jet flights were suspended, although eventually a Federal court decision absolved Eastern which flew jets, and Allegheny Airlines, which operated turboprops, of negligence at Tween-New Haven Airport.

Eventually, the United States Court of Appeals here handed down a decision that would permit the resumption of jet flights.

Last July 30, Judge McLean refused to ban jets or to close the airport, as asked by some property owners on the outskirts of town, in a contest between what he called "two warring municipalities."

At the time, Judge McLean ordered the subsequent proceedings as to compensation, finding that the flights interfered with enjoyment of land ownership enough to "constitute a taking."

APPENDIX D: BOEING 737 IMPROVEMENTS

November 9, 1971

Patented Model 737 Improvements for "RTOL" Applications, Model 737 performance and noise data for STOL applications as requested by DOT is attached:

Currently certified Advanced Model 737 takeoff and landing performance is sufficient to allow a 730 N.Mi. range with 100 passengers when operating from runways 4000 ft. in length. Recognizing that low noise levels are a requirement for short field operation, several configuration alternatives have been identified which reduce the noise at the F.A.R. part 36 measuring points.

Attachment 1 summarizes a few of these items to reduce noise. These items are added to the Advanced Model 737 and show substantial reductions in community noise. For example, Configuration "D" has a maximum noise level of 96 EPNdb (approach) while carring 100 passengers 450 N.Mi. out of and into runways 4000 ft. in length.

Approach noise can be reduced by allowing a glide slope greater than 3°, as shown by configuration "E".

Several configuration modifications have been identified to regain the payload-range performance lost because of the acoustic treatments. Configuration "F" shows a 750 N.Mi. range is possible when operating from 4000 ft. fields with noise no greater than 95 EPNdb.

Advanced 737

The Advanced 737 is the improved version of the 737-200. All of the changes are designed to improve the short field capability. The major configuration changes are:

- Improved high lift system
- More efficient anti-skid brake system
- Automatic wheel brakes

6Q00 1098 ORIG.3/71

Attachments 2 through 5 present the pertinent performance of the Advanced model. Configuration (A) on attachment 1 summarizes the performance from 4000 ft. runways.

Quiet Nacelle

The successful quieting of the Boeing Model 727-200 provides the basis for the 737 quiet nacelle. This quieting is a result of acoustically treating the inlet, engine fan case, and tailpipe. Configuration B illustrated predicted benefits derived from these changes. The 737 quiet nacelle will be flight tested in the first quarter of 1972.

Ejector Suppressor

The ejector-suppressor application to the JT8D-15 engine on the 737 is based on work being done under contract with the FAA. Noise data shown with configuration C of attachment 1 indicates a reduction in jet noise of up to 7 EPNdb.

Decelerating Approach

The reference describes the concept and hardware requirements of deceleration on approach. This technique allows lower power settings, thus lower community noise. There is approximately a 3 EPNdb benefit at one mile from the landing threshold, attachment 1 configuration D.

Glide Slopes Greater Than 3°

The reference describes the community noise benefits of using higher than conventional glide slopes (2.5° to 3°). Acceptability of high glide slopes is dependent upon adequate aides for piloting. Test work and design studies done by Boeing indicates high glide slope angles are feasible.

Improved Model 737

Development work leading to the Advanced 737 identified several features which provides additional takeoff and landing performance. Attachment 6 lists the main features considered. These changes were flight tested and demonstrated to airline operations personnel. Configuration F of attachment 1 summarizes the short field performance benefits of these changes. Attachments 7 through 13 presents additional description and estimated performance.

William K. Howell

V. E. Callaway

Attachments

MODEL 737 SHORT FIELD CAPABILITY

		CONFIGURATION	RANGE(1)	RUNWAY REQUIRED(2) TAKEOFF	RUNWAY REQUIRED(2) LANDING	COMMUNITY NOISE(3) APP	COMMUNITY NOISE(3) CUTBACK	SIDELINE
(A)		Model 737 Advanced JT8D-15 Engines (95400)	730 N.Mi.	4000 Ft.	3500 Ft.	112	96	103
(B)	(A)	+ Quiet Nacelle	730 N.Mi.	4000 Ft.	3500 Ft.	103	89	103
(C)	(B)	+ Ejector Suppressor (93500)	450 N.M.	4000 Ft.	3500 Ft.	99	88	95
(D)	(C)	+ Decelerating Approach	450 N.M.	4000 Ft.	3500 Ft.	96	88	95
(E)	(D)	+ 4° Glide Slope on Approach	450 N.M.	4000 Ft.	3500 Ft.	93	88	95
(F)		Model 737 with Improved Flaps and Nose Wheel Brakes (97300)	750 N.Mi.	4000 Ft.	3000 Ft.	93	89	95

- o Quiet Nacelle
- o Ejector Suppressor
- o Decelerating Approach
- o 4° Glide Slope

(1) Range with 100 passengers

(2) F.A.R. Part 121 Field Length Criteria
Sea Level altitude and 84° temperature

(3) F.A.R. Part 36 noise measuring points of 3.5 N.Mi from brake release for cutback, .25 N.M. for sideline and 1 N.M. from threshold for approach.

APPENDIX E: TRIDENT MODIFICATIONS

From <u>Aviation Daily</u> (Nov. 15, 1971):

INTEREST SHOWN IN MODIFYING TRIDENT AS A STOL AIRCRAFT

A Trident equipped with two RB.211 engines similar to those used on the Lockheed TriStar would have almost double its present takeoff horsepower, would be half as noisy as the present jet, and could take off in 1,000 yards carrying 200 passengers, according to a report in the London Daily Telegraph.

A development such as this could mean a third London airport would not be needed until the next century, the report says. The Trident can carry 180 passengers now and would need minimal development to enlarge capacity to 200 passengers. It now has three Spey engines developing 12,000 pounds thrust each and a fourth engine with 5,000 pounds thrust for takeoff boost. Both British European Airways and Hawker Siddeley have shown interest in such a quiet, short-takeoff-and-landing jet, the report said.

* * *

APPENDIX F:

CRITICAL PATH NETWORK ANALYSIS

The following two networks are a first cut at determining the interrelationships that exist in:

a. Introducing initial RTOL service using quiet turboprops (Fig. 1) and,

b. Developing the initial system into a second generation service using pure jets (Fig. 2).

This report discusses the network links, presents a critical path analysis and makes some conclusions and recommendations.

Discussion of Network Links

Initial Service Network (Fig. 1)

- Link 1-2: "RTOL System Definition and Specifications"

  "Improving Short-Haul Air Transportation - the RTOL Approach" is essentially this definition and specifications development effort - it will be complete once those areas noted herein as needing more work have been completed. A critical element in the validation process will be a cost/benefit analysis which adequately competes the RTOL concept with other alternatives (TACV, CTOL, V/STOL, etc.) and with different mixes of each.

- Link 2-4: "Initial Service Implementation Plan"

  A working plan which determines the minimum system necessary, identifies route structures, airports, aircraft, etc. and determines resource requirements including dollars, time and manpower.

- Link 3-4: "Identify Institutional Constraints"

  In a general sense, these have been identified in an A.D. Little, Inc. report prepared for DOT entitled "Institutional Factors in Civil Aviation."[1]

[1] DOT report No. DOT-TST-10-1, January 1971.

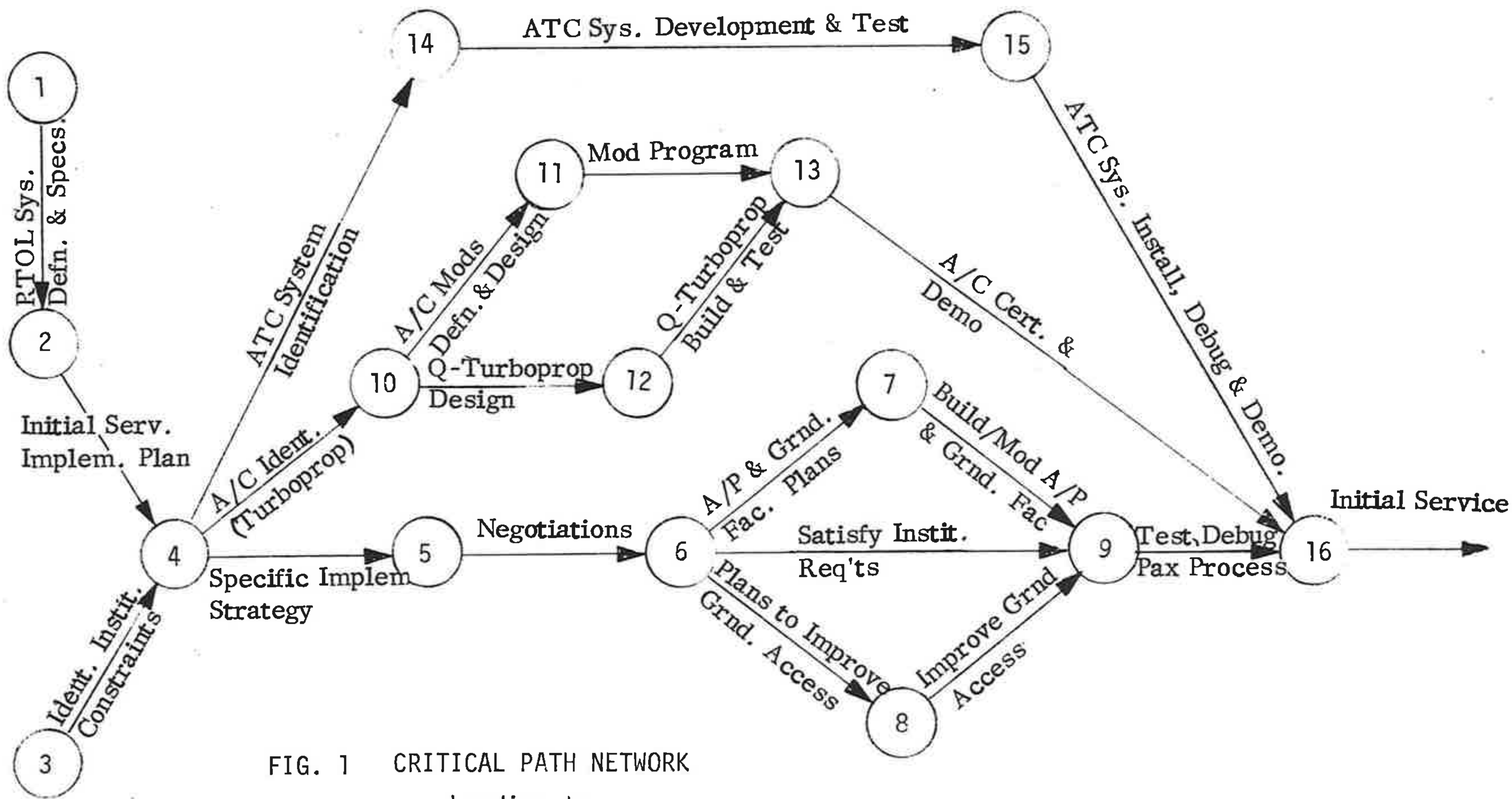


FIG. 1 CRITICAL PATH NETWORK
Leading to
INITIAL RTOL SERVICE

However, the ways in which these relate to RTOL need to be determined with special emphasis on program impacts caused by changes in constraints. Because it is planned to operate the initial RTOL system within the existing civil aviation framework as much as possible no significant changes to the institutional structure is anticipated but it is necessary to understand the structure in order to work within it.

- Node 4 - This is a key decision point because: 1) enough knowledge now exists to decide if the concept warrants the investment of additional resources and 2) follow-on activities involve rather significant committments.
- Link 4-5: "Specific Implementation Plan"

  Here the participants are identified and strategies developed to make the program most saliable to each. The key strategy is that one designed to convince communities with airports that RTOL service will benefit them.
- Link 5-6: "Negotiations"

  The key link in this or any other network leading to improved transportation at what appears to be community expense in terms of noise, pollution and/or non-productive use of real estate. If this link fails, the program fails. The general strategy proposed here involves negotiations with all participants at once (airlines, CAB, FAA, communities, general aviation, etc.) and that differences be mutually resolved (if possible). Guarantees for such as : noise limitations, pollution limitations and so on, could be made with stipulations that the capability to meet these limits would have to be demonstrated prior to the start of operations.

- Links 4-10, 10-11, 10-12, 11-13, 12-13, and 13-16 relate to RTOL aircraft development. It was decided to use an existing turboprop for the initial service because there are a number capable of flying the desired profile and because a quiet turboprop meeting the 95 EPNdB limit can be more quickly developed than a pure jet. Included in the certification and demonstration phase would be verification that guarantees made under negotiations were met.
- Links 4-14, 14-15 and 15-16 concern the development and installation of appropriate ATC systems if required.
- Links 6-7 and 7-9 concern airport and ground facilities definition, planning and development.

  As negotiations concerning specific airports are completed, work can begin on any modifications necessary to make it suitable for RTOL. Included in this are modifications to airports such as changes to runway configurations, lights, parking and storage, egc. and the installation of appropriate ATC equipment. Also, there is the modification or construction of terminal facilities.
- Links 6-8 and 8-9 are activities leading to improved ground access to RTOL terminals.

  Inherent in the RTOL concept is the idea that by dispersing short-haul service total travel times can be significantly reduced. This will be true only if there is adequate ground access.
- Link 9-16: "Testing and Debugging the Passenger Processing System"

  This, like the aircraft and ATC checkout programs, verifies that the system will work as promised and will decrease the probability of lost demand due to operating glitches.

Second Generation (Jet) RTOL Service Network (Fig. 2)

This network builds on the experience gained in starting the initial service (shown dotted, for detail see Fig. 1).

- Link 4-20: "Systems Analysis and Concepts."

  An expansion of earlier analyses, this task strives to come up with the optimum possible RTOL system within the total transportation complex. The resulting set of parameters will guide all the follow-on activities.

  The resource requirements for this front-end work are small. It would therefore involve only a slight risk of loss to begin this and follow-on planning activities before the initial service system has proven itself.

- Link 6-20: "Negotiations Experience"

  This link ties the experience gained during the negotiation portion of the initial service.

- Link 20-21 and 21-23: "Institutional Problems"

  Contrary to the decision in the initial service network to work within the institutional system, this program determines where changes are necessary and develops a strategy to make them happen.

- Link 20-22 and 22-23: "System Definition"

  Here specific system elements are conceived and analyzed in order to give more detail to the general concept. The latter part of this effort concentrates on a specific system definition in terms of aircraft, airports and related elements.

- Link 17-23: "Experience"

  As much operating experience as possible is applied to work done to date and readied for application to future activities.

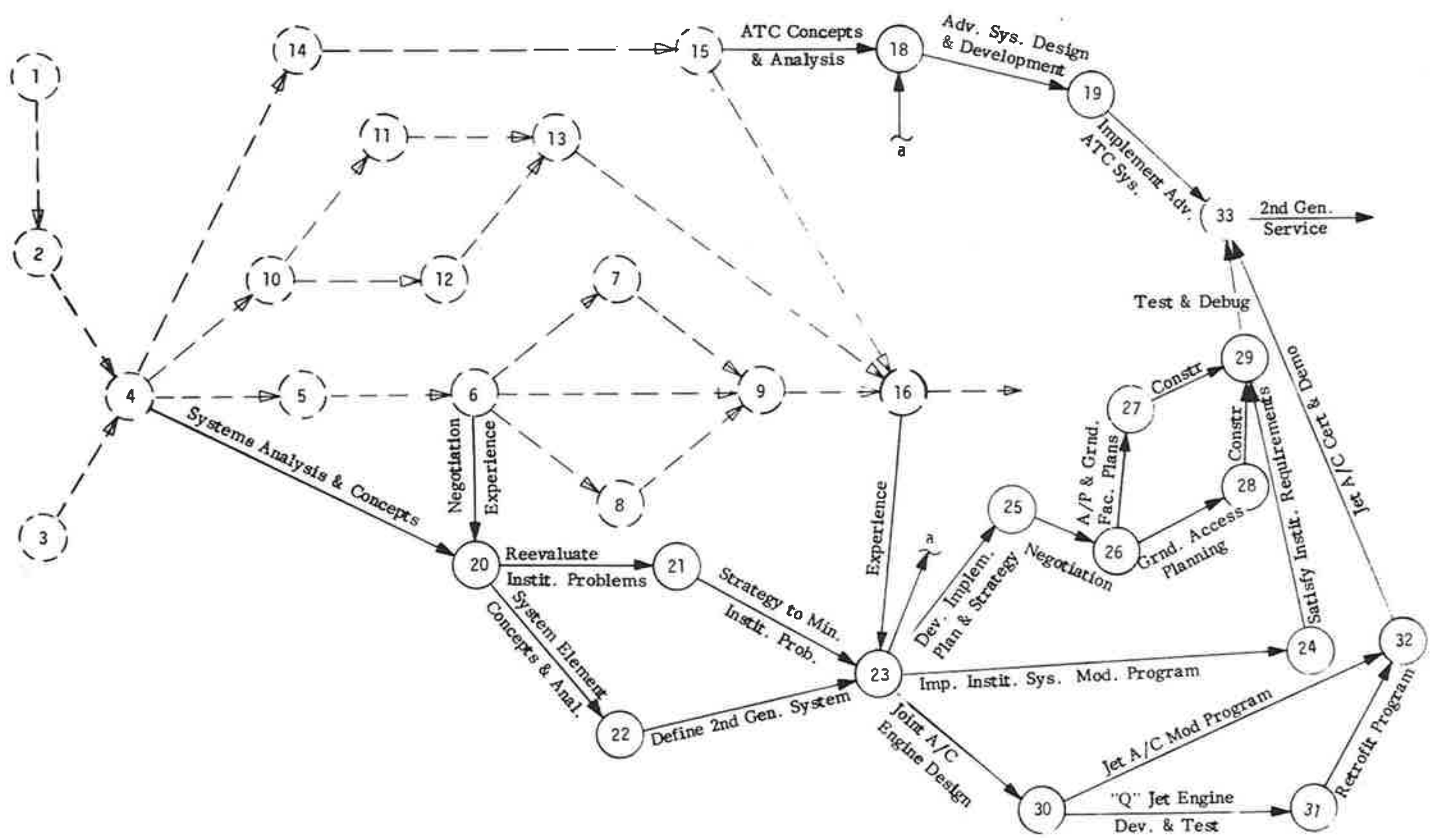


Figure 2. Network Leading to Second Generation (Jet) RTOL Service

- Node 23: A key decision point since follow-on activities require significant resource committments.
- Link 23-30, 30-32, 30-31, 31-32 and 32-33: "Aircraft and Engine Development Program"

  A quiet, jet RTOL is necessary to compete effectively with CTOLs in the 250-500 mile range making it a requirement for second generation service. The critical element is the quiet jet engine since a number of existing jet craft can approximate the desired profile.
- Link 23-24 and 24-29: "Institutional Requirements"

  The first part of this effort involves causing to institutional system to change to the previously defined configuration. The latter part involves satisfying the modified system within this link or where appropriate in parallel activities.
- Link 23-25: "Develop Implementation Plan and Strategy"

  As in the initial service network, this means getting ready for negotiations.
- Link 25-26: "Negotiation"

  While still a critical activity, the success of these negotiations is not a go-no go determinant since the basic network still exists.
- Links 26-27, 26-28, 27-29, 28-29 and 29-30 apply to groundside preparation and testing much as described for the initial service. The difference is in the scope - much better ground access and facilities would be developed where necessary. Also, new airports might be built (if only to provide a home for displaced general aviators).

- Links 15-18, 18-19 and 19-33: "ATC System Development"

  A continuation of the earlier ATC development program. This would guarantee that the RTOL ATC system would be kept up to the state of the art of, in consonance with, the total system.

- Node 33: At this point in time all elements of the second generation RTOL system would be ready for operation. However, this does not need to be a step function - a gradual transition from turboprop to jet service in an expanding network is not only more likely but is prefereable.

CRITICAL PATH ANALYSIS

Figures 3 and 4 show the two networks with estimated times to accomplish each link. Critical path times to initiation of service are:

For initial service, 3-3/4 years

For second generation service, 10 years

INITIAL RTOL SERVICE CRITICAL PATH

As figure 3 shows, there are three major parallel paths with smaller parallel activities on two of these. Table 1 summarizes this information.

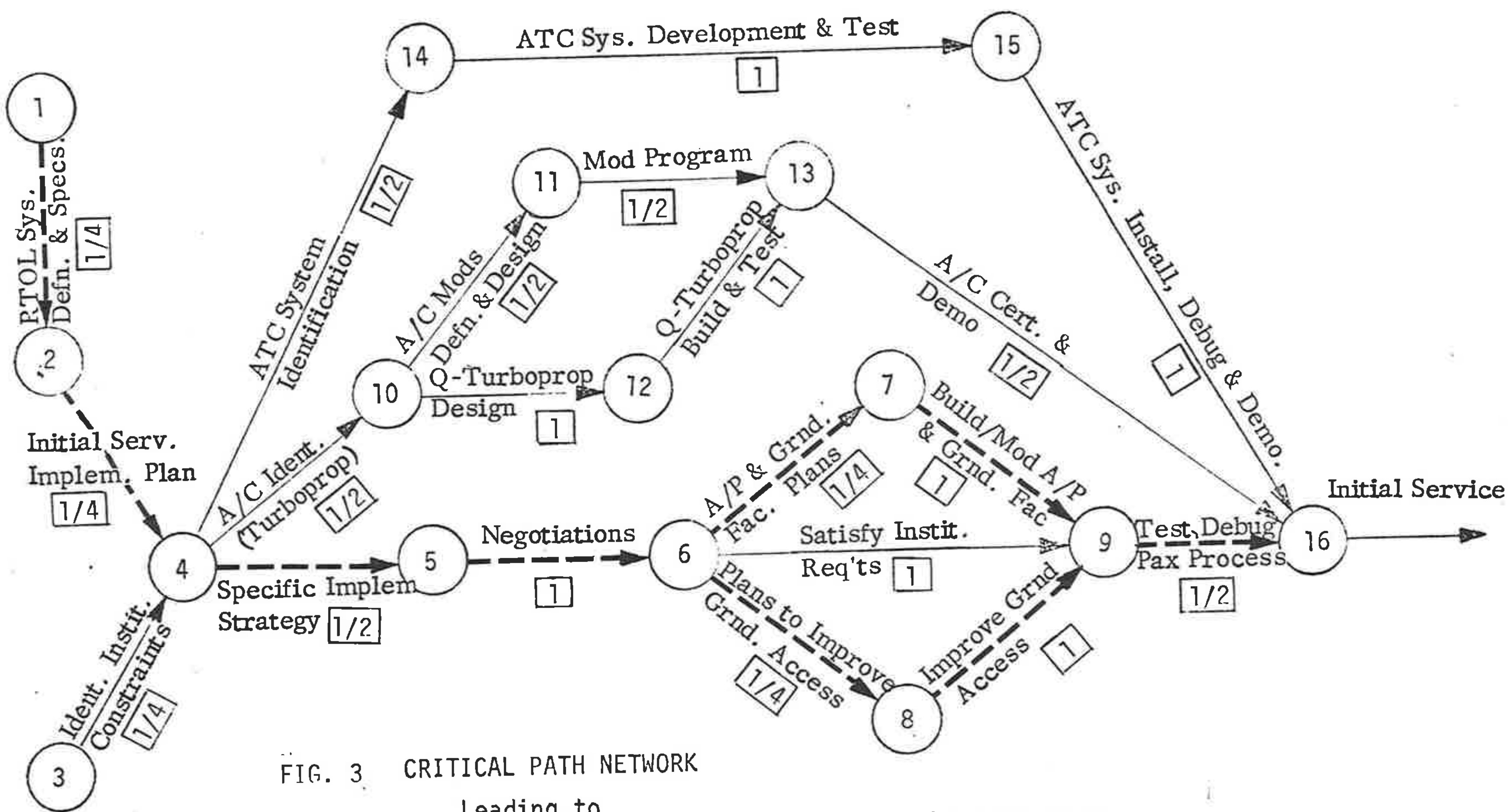


FIG. 3 CRITICAL PATH NETWORK
Leading to
INITIAL RTOL SERVICE

CRITICAL PATH ━ ━ ━ ━ ━

Looking at slack times:

- ATC development and implementation program has 3/4 years slack making it possible to hold off committing resources until it is known if the initial system will be implemented.
- The quiet-turboprop development program has marginal slack - it could easily become the critical path effort.
- The effort to satisfy institutional requirements can be stretched from 1 to 1-1/4 years without affecting the critical path.

SECOND GENERATION RTOL SERVICE CRITICAL PATH

Table 2 is a summary of the paths shown for the second generation network in Figure 4. Paths through initial service network to Second Generation activities are based on longest time from node 1 to the interfering node.

Path	Time to Accomplish	Slack Time
1 - 4 - 20	1-1/2	1/2*
1 - 6 - 20	2	0
20 - 21 - 23	1	1/2*
20 - 22 - 23	1-1/2	3/4
1 - 16 - 23	4-1/4	0
1 - 15 - 18	3	1-1/4
1 - 16 - 23 - 18	4-1/4	0
23 - 18 - 19 - 33	3	2-1/2
23 - 25 - 26 - 27 - or 28 - 29 - 33	4-1/2	1
23 - 24 - 29 - 33	3-1/2	1*
23 - 30 - 32 - 33	2	3-1/2
23 - 30 - 31 - 32 - 33*	5-1/2	
CRITICAL PATH		
1 - 16 - 23 - 30 - 31 - 32 - 33	9-3/4	

*Slack within a particular alternative.

Looking at slack times:

- There are no significant slacks up to node 23
- In the ATC program there is a maximum of three years slack from node 15, the departure point from the initial service network, to node 33, the start of second generation service. Therefore, unless the critical path is reduced by this amount, ATC will not be a pacing activity.
- The quiet jet engine development program lengthens the critical path by one year. If it can be reduced, then the path includes links 23 - 25 - 26 - 27 or 28 - 29, (involving the negotiation program and ground facility preparation. Reducing the critical path another year would make institutional factors program time critical. The net effect would be to reduce program length from ten to eight years.