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Study of
V/STOL Aircraft Implementation
Volume II: Appendices

Prepared by
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Air Transportation Group

November 1972

Prepared for ADVANCED CONCEPTS AND MISSIONS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Moffet Field, California 94035

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STUDY OF

V/STOL AIRCRAFT IMPLEMENTATION
VOLUME II: APPENDICES

Approved by

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General Manager
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FOREWORD

This report on the study of V/STOL aircraft implementation is published in two volumes. Volume I presents a summary of the findings in eight areas:

- Introduction
- Summary of Study Results
- Short Haul Transportation Needs
- Aircraft Technology
- Aircraft Production Estimates
- Airport and Air Traffic Control Requirements
- Implementation Costs and Funding
- Implementation Action

The present document, Volume II, is an appendix containing the essential supporting reference data and methodology.

APPENDIX A

SHORT HAUL AIR TRANSPORTATION REQUIREMENTS

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APPENDIX A

SHORT HAUL AIR TRANSPORTATION REQUIREMENTS

This appendix comprises two sections, the first characterizing the existing high density short haul market and the second the predicted market in 1980 and 1990. Each section contains supporting discussion, detailed data and figures judged to be too voluminous for inclusion in Volume I, the summary report.

A.1 CHARACTERISTICS OF THE EXISTING HIGH DENSITY SHORT HAUL MARKET

a. Existing Travel Demand

The high density short haul market was defined as one in which air traffic between all city pairs in 1970 satisfied two criteria: travel by 100,000 or more annual origin and destination (O&D) air passengers and intercity air distances of less than 500 miles. In FY 1970 there were 193 city pairs with 100,000 or more O&D passengers. The percent distribution of passengers traveling between these city pairs as a function of trip distance is presented in Figure A-1. As shown, almost half (48%) of the O&D passengers travel less than 500 miles, while an additional 21% travel 500 to 1,000 miles. Figure A-2, which presents the distribution of city pairs as a function of distance, indicates there are 87 city pairs with intercity distances of less than 500 miles and 44 city pairs with distances of 500 to 1,000 miles between them. The 87 city pairs less than 500 miles apart account for 45% of all high density routes and are well representative of all geographical regions of the United States. Figure A-3, which is a plot of the percent of total O&D passengers in 50 mile increments, illustrates that the percent of O&D passengers diminishes rapidly for routes beyond 500 miles.

Table A-1 summarizes the high density short haul travel and total domestic air travel data by type of carrier while Table A-2 shows the FY 1970 ranking of the 87 city pairs that meet the high density short haul market definition. Table A-3 tabulates and ranks this high density short haul travel by geographical region, Table A-4 lists each of the city pairs by geographical region and, finally, Table A-5 ranks the 87 city pairs by intercity air trip distance.

To understand the operations in the existing high density short haul market an examination was made of each of the air hubs (cities with two or more high density short haul routes) to determine the mix and type of air carriers and the mix and type of aircraft in service on a seat available basis. This data is given (with the hubs listed alphabetically) in Table A-6 and the hub summary is given in Figures A-4 and A-5.

b. Comparison of Airline Operating Statistics and Costs

Pacific Southwest Airlines (PSA) is a recognized efficiently run California intrastate air carrier operating exclusively in the high density short haul market. It was selected as a convenient standard for comparing operating data with other domestic airlines carrying a similar number of passengers. In 1970, PSA--and three other airlines, Allegheny, Braniff and Continental--carried approximately 5 million passengers.

A tabulation was made of the operating, traffic and financial statistics for the four airlines. The PSA data was obtained from the PSA Financial Statements for the 12 months ending December 31, 1970[A-2] and from the PSA Annual Stockholder Report for 1970.[A-3] The information for the other three airlines was obtained from the CAB Air Carrier Traffic Statistics for the 12 months ending December 31, 1970,[A-4] the CAB Air Carrier Financial Statistics for the 12 months ending December 31, 1970[A-5] and the Annual Stockholders Report for Braniff, Continental and Allegheny for 1970.[A-6,7,8] These statistics are discussed in the following paragraphs.

(1) Operating Revenue

Line 13 of Table A-7 lists the fare per revenue passenger mile for each of the airlines. The comparison shows that PSA, operating at fare yields from 20% to 55% less than the other airlines, was able to earn an operating profit of 5.6% of total operating revenue. The review of the operating expenses that follows will identify the cost differentials that allow PSA to operate profitably at this lower fare per revenue passenger mile.

(2) Direct Operating Expense

The PSA direct operating cost matches the direct operating cost (for PSA's average seating capacity and average stage length) calculated using the ATA direct cost formula.[A-1] It was found, however, that the ATA direct cost formula predicts a higher direct cost for the short stage lengths (Allegheny) and a lower cost for the longer stage lengths (Braniff and Continental) than the airline's actual direct cost. The reason for this cost difference (10% to 30%) was not identified.

Line 26 of Table A-7 lists the total direct operating expense expressed in percent of total operating revenue. This shows PSA with the highest total direct expense of the four airlines, 53.9% of total operating revenue. An examination of the direct expense items on lines 22, 23, 24 and 25 of Table A-7 shows that PSA flight operations expense is equal to or lower than that of the other three airlines, the PSA maintenance direct expense is about equal to the maintenance direct expense of the other airlines and the PSA maintenance indirect expense is less than that of the other airlines. However, depreciation of flight equipment is a much higher expense for PSA. A review of reference material[A-3,6,7,8] reveals that PSA has the newest and most modern jet fleet which requires a larger depreciation expense.

Airlines sometimes express the direct operating cost in cents per available seat mile versus stage length in miles to account for large cost items such as fuel and crew salaries which vary both as a function of distance flown and aircraft seating capacity. Therefore, the cost for each airline in cents per available seat mile (Line 7, Table A-8) first was normalized to reflect a single class of service with PSA density seating and then was plotted (Figure A-6) against the average stage length flown (from

Line 11 Table A-7). The data points from the four airlines plot as a smooth curve (Figure A-6) showing that the PSA direct operating cost is consistent with the direct operating costs of the other airlines.

(3) Indirect Operating Expense

The total indirect operating expense for each of the four airlines is given on Line 33, Table A-7. The PSA indirect operating expense is 33% of the total operating revenue compared to 43-45% for each of the other airlines. Table A-8, Lines 8 through 12, itemizes the indirect operating expenses for each of the airlines in terms of cost in cents per available seat mile, cost in cents per revenue passenger mile, and cost in dollars per passenger. Because each airline offers different classes of service and consequently different seating densities the cost information in Table A-7 requires normalization to a standard seating configuration. After normalization, to a single class of service using PSA coach density seating, the indirect cost is presented in Table A-9 in two forms: cost in cents per available seat mile and cost in cents per revenue passenger mile. An item by item examination of these costs revealed the following:

- o Depreciation, Other: (Line 6, Table A-9) shows consistency at ≈.032 cents/available seat mile.
- o General and Administrative: (Line 5, Table A-9) shows consistency at ≈.30 cents/revenue passenger mile.
- o Promotion and Sales: (Line 4, Table A-9) shows that Allegheny, Braniff and Continental agree at ≈.30 cents/available seat mile while PSA has a cost of .22 cents/available seat mile. This can be explained as the difference in promotional sales and ticket counter costs between a market spread over many cities (average 39) over a large geographical area involving several states and a market that is dense with only 8 cities all within one state.
- o Passenger Service: (Line 2, Table A-9) shows that Allegheny, Braniff and Continental costs agree at ≈.57 cents/revenue passenger mile while PSA spends only .35 cents. The cost of serving meals could account for this cost differential. PSA is the only airline of the four that does not serve meals.
- o Aircraft Traffic and Service: (Line 3, Table A-9) shows a correlation when the costs are plotted against the number of airports served by each airline. This data is presented in Figure A-7.

These indirect cost parameters were then combined giving the following empirical formula for predicting the total indirect operating expense.

$$IOC = (.0063 + .0022 \text{ with meals}) \times RPM + (.0054 + .008\ F + C) \times ASM$$

where:

IOC:	Indirect Cost in Dollars/One-Way All Coach Jet Trip
RPM:	Revenue Passenger Miles = (Number of Passengers) (Stage Length)
F:	1 If not Dense Commuter Market 0 Otherwise
C:	Cost as a Function of Number of Airports in System; Value Read from Figure A-7
ASM:	Available Seat Miles = (Aircraft Capacity) (Stage Length)

Table A-10 is a comparison of the indirect operating cost per average trip for PSA, Allegheny, Braniff and Continental. The IOCs were calculated by: the initial IOC study based on the 1970 PSA data (Table A-11), the empirical method developed in the preceding paragraph, and the airline actual IOCs. Both the initial IOC and the empirical IOC agree for the average PSA trip. However, the initial IOCs are too high for stage lengths shorter than the PSA average stage lengths. Hence, the initial IOC method does not reflect sufficiently the variation of indirect operating cost with stage length. An examination of the Aerospace Cost Allocation in the initial IOC analysis (Table A-11) shows that all cost items circled with the broken lines could be reapportioned to available seat miles and to revenue passenger miles to reflect the variation of indirect operating costs with stage length. In addition, most of the indirect cost items do not appear sensitive to variations in either revenue or load factor. This suggests that the indirect costs should be apportioned to the system capacity (available seat miles) with a smaller portion assigned to load factor (revenue passenger miles). The indirect cost formula was revised with the new cost allocations shown in Table A-12. The last line of Table A-10 lists the revised IOCs calculated for the average stage lengths and average seating capacities of each of the four airlines. This revised IOC formula now gives good agreement as a function of airline stage length.

A.2 PREDICTION OF THE HIGH DENSITY SHORT HAUL MARKET IN 1980 AND 1990

The methodology used to predict the short haul demand in 1980 and 1990 is described in the main body of the report. This section includes detailed discussions of the models and data used in the prediction of demand.

a. The Intercity Travel Demand Model

The Intercity Travel Demand Model previously developed by Aerospace[A-9] was used to predict total travel demand because it has proved to be more accurate than the conventional gravity model.

Actual travel demand for cities in the California and Midwest Corridors was plotted as a function of the associated population products. These data are indicated in Figure A-8. According to the conventional gravity model approach, for any given intercity distance, the slope of the line connecting the city pair data should be a constant on a log-log plot. It is seen from the data that the slope is not constant, but decreases as the population product and the total number of daily person trips increase. This is quite reasonable in that, as cities grow, the services available to any resident in his local area tend to increase, and thus his need to travel to a distant city to satisfy his needs is lessened, resulting in a reduced rate of growth in intercity trips.

It was determined that the slope of the data segments is a linear function of the total daily person trips and, using this relationship, a series of demand curves was constructed. These curves are shown together and with the general equation for the curves in Figure A-8.

Using the calibration constants shown, the fit of the Aerospace model to the California data was considerably better than that of the conventional gravity model, with errors generally under 10 percent for any city pair. Unlike the gravity model, the Aerospace model requires a single survey data point for each city pair which effectively takes into account non-population travel demand factors for that pair. City pairs which generate a large demand would be expected to have a calibration point on one of the upper curves while those with relatively less attractiveness would yield a calibration point on one of the lower curves.

Using the Aerospace model, potential demand for a future time period can be calculated from only the city pair population product and demand for a given year, and the forecast population product for the desired year. Total travel demand for 1980 and 1990 was calculated in this way for each of the 87 city pairs comprising the high density short haul market.

b. Prediction of Modal Splits

(1) Current Air Modal Splits

Current air modal splits as a function of intercity distances are presented in Figures A-9 to A-12 for each of the four standard census regions. These were derived from the 1967 Census of Transportation data tape and used to calculate the current air modal split for each of the 87 city pairs in the short haul market.

(2) Load Factor Considerations

Recent air carrier and CAB statistics were used to determine the load factors obtainable in competition and non-competition markets. The domestic trunks which typically serve long haul high density markets had a five year adjusted load factor of 55% in 1969 as shown in Table A-13. PSA achieved a system load factor of 50.2% in 1970, when overcapacity existed throughout the airline industry. Taken together, these facts indicate that a 55% load factor is both reasonable and achievable in a short haul high density market. The load factor achievable in a non-competition market was determined by considering the 1967 load factor of 62% experienced on routes served by one carrier. Assuming optimum scheduling, a 65% load factor was chosen as characteristic of the non-competition market.

(3) Potential Air Modal Split Growth

Minimum and maximum short haul markets in 1980 and 1990 were estimated based on potential air passenger capture (air modal split) possible through improved air service. The minimum passenger growth case is derived from the Pacific Southwest Region (California Corridor), one of the regions in the U.S. that currently has excellent short haul air service. This region has many air service paths between cities, high frequency of service, high density aircraft seating, and low existing air fares. Thus, it will be more difficult to offer an improved service that can increase the percent of the total travel demand that will travel by air. The North Central Region (Midwest Triangle) was chosen to be indicative of a market with maximum growth potential. This region has few service paths between cities, low density aircraft seating and relatively high (CAB) fare levels. Here, there is an opportunity to select more convenient airport locations, add service paths and increase seating density so as reduce fares and create a large increase in air passenger demand.

In addition, both types of market growth (minimum and maximum) were examined to determine the impact on air passenger demand if fares were established to reflect the costs of operating at either the 55% or 65% average passenger load factor noted above as being representative of competitive and non-competitive markets. The 55% load factor is representative of two or more airlines operating in competition on a route, while the 65% load factor is representative of a single airline operating on a route (non-competition market).

The range of air modal splits resulting from these four types of short haul air market growth is shown in Figure A-13. Curve (A) represents the maximum potential air passenger demand created by a maximum growth market achieved with the lower fare obtained by operating at a 65% (non-competitive) load factor. The next highest demand, represented by curve (B), is again that in a maximum growth market with the airlines operating at a higher fare based on the increase in costs associated with operating at a 55%

(competitive) load factor. Curves Ⓒ and Ⓓ represent the minimum growth market air passenger demand again obtained by utilizing fare levels based on costs of operating at 55% and 65% load factors, respectively.

(4) Potential V/STOL Demand

Table A-14 contains the current and predicted populations for the cities comprising the 87 city pairs. The predicted travel demand is presented in Table A-15 for all modes of transportation and for air service for each of the city pairs.

(5) V/STOL Market Shares in 1990

A comparison was made of VTOL and STOL market shares for three additional city pairs simulated by the modal split program. The market shares for each of the intercity modes of transportation (air, bus and rail, auto) are shown for Los Angeles-San Francisco, Chicago-Cleveland, and Chicago-Detroit in Figures A-14, A-15 and A-16, respectively.

The left-hand side of Figure A-14 shows the calibration data for Los Angeles-San Francisco for 1970 where an existing 13 service path CTOL system charges a fare of $16.50. The figure shows that 42% of the travel is by air, 3% by bus and rail, and 55% by auto.

The center of Figure A-14 illustrates the Los Angeles-San Francisco percentages of travel by each travel mode in 1980 with the addition of a six-path non-CBD STOL service. The CTOL fare remains $16.50 (dotted line) while the STOL fare is varied between $14 and $22. At a fare of $22, STOL service captures only 13% of the total travel demand while at a fare of $14 it captures 47%. At the lower fare, most of the additional travel demand is captured from the CTOL service.

The right-hand side of Figure A-14 depicts the Los Angeles-San Francisco travel in 1990 with the CTOL and STOL service the same as in 1980 but with the addition of a single path CBD to CBD VTOL system. With STOL and CTOL fares fixed at $16.50 the VTOL fare was varied. At a fare of $22, VTOL captures only 4% of the total travel demand while at a fare of $16.50 it captures 18% of the total demand leaving 8% of the travel by CTOL, 22% by STOL, 50% by car and the balance (3%) by bus and rail.

Figures A-15 and A-16 show the same analysis for Chicago-Cleveland and Chicago-Detroit.

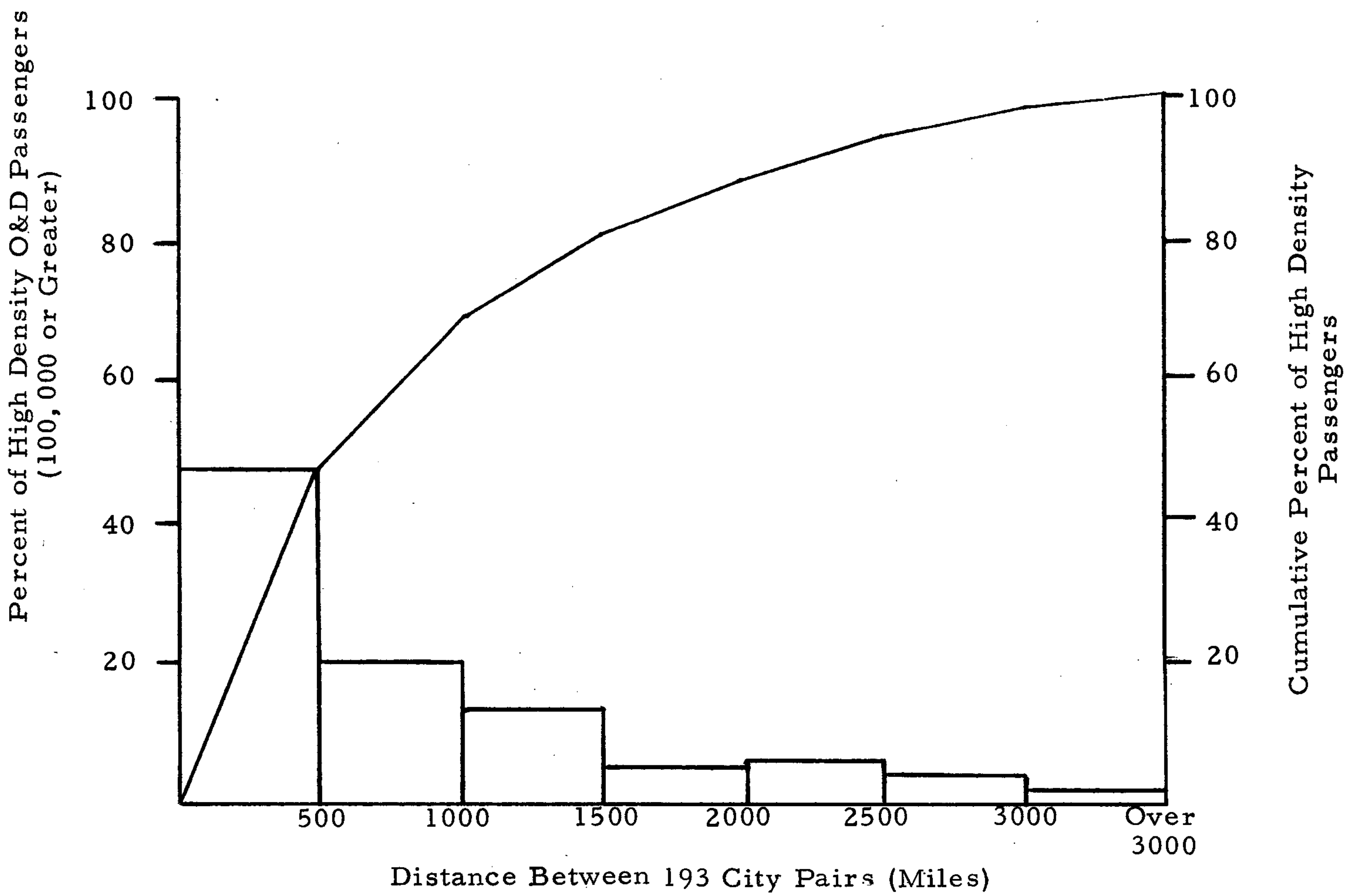

Figure A-1. Distribution of High Density O&D Passengers by Distance

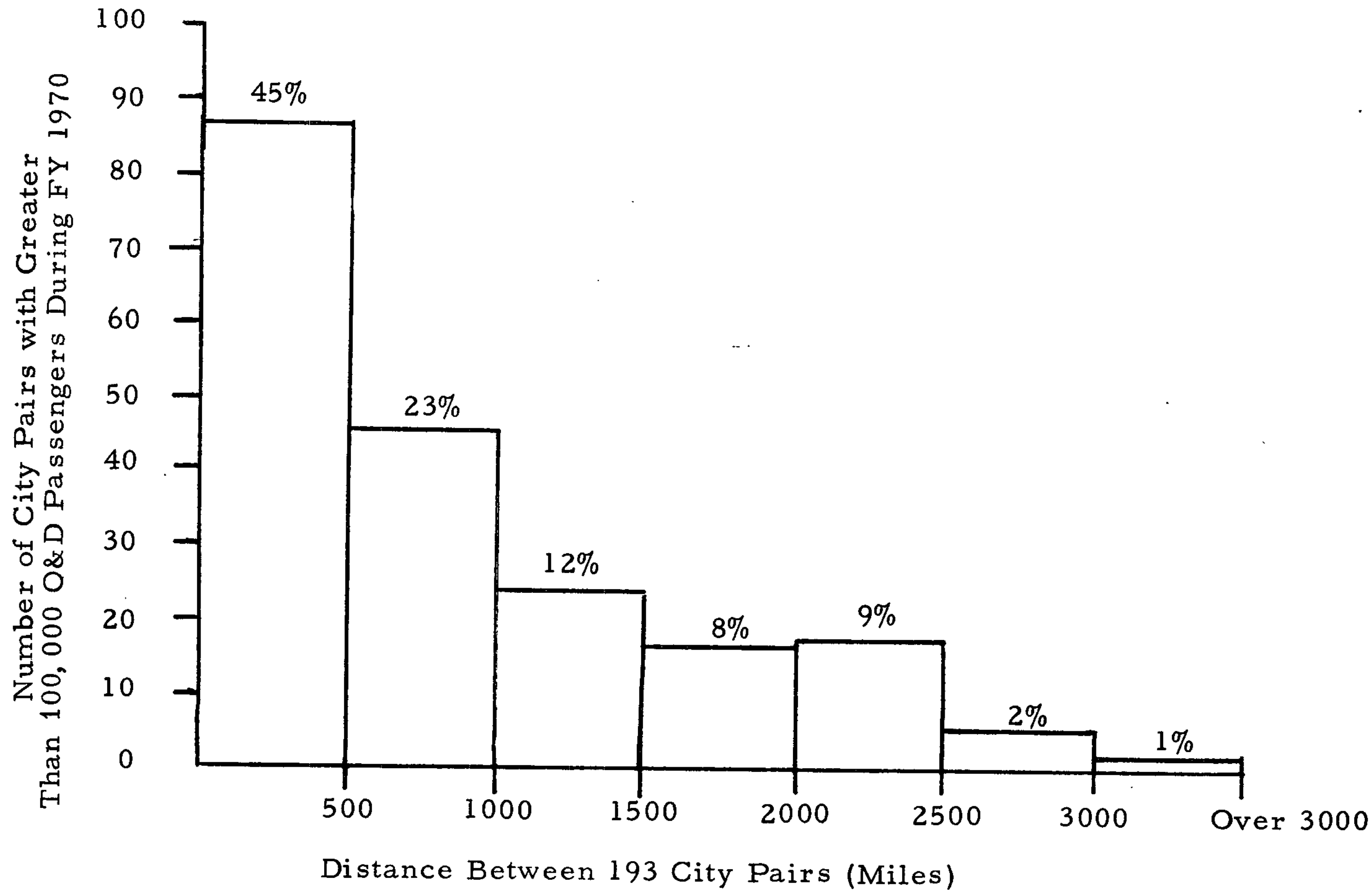

Figure A-2. Distribution of High Density City Pairs by Distance

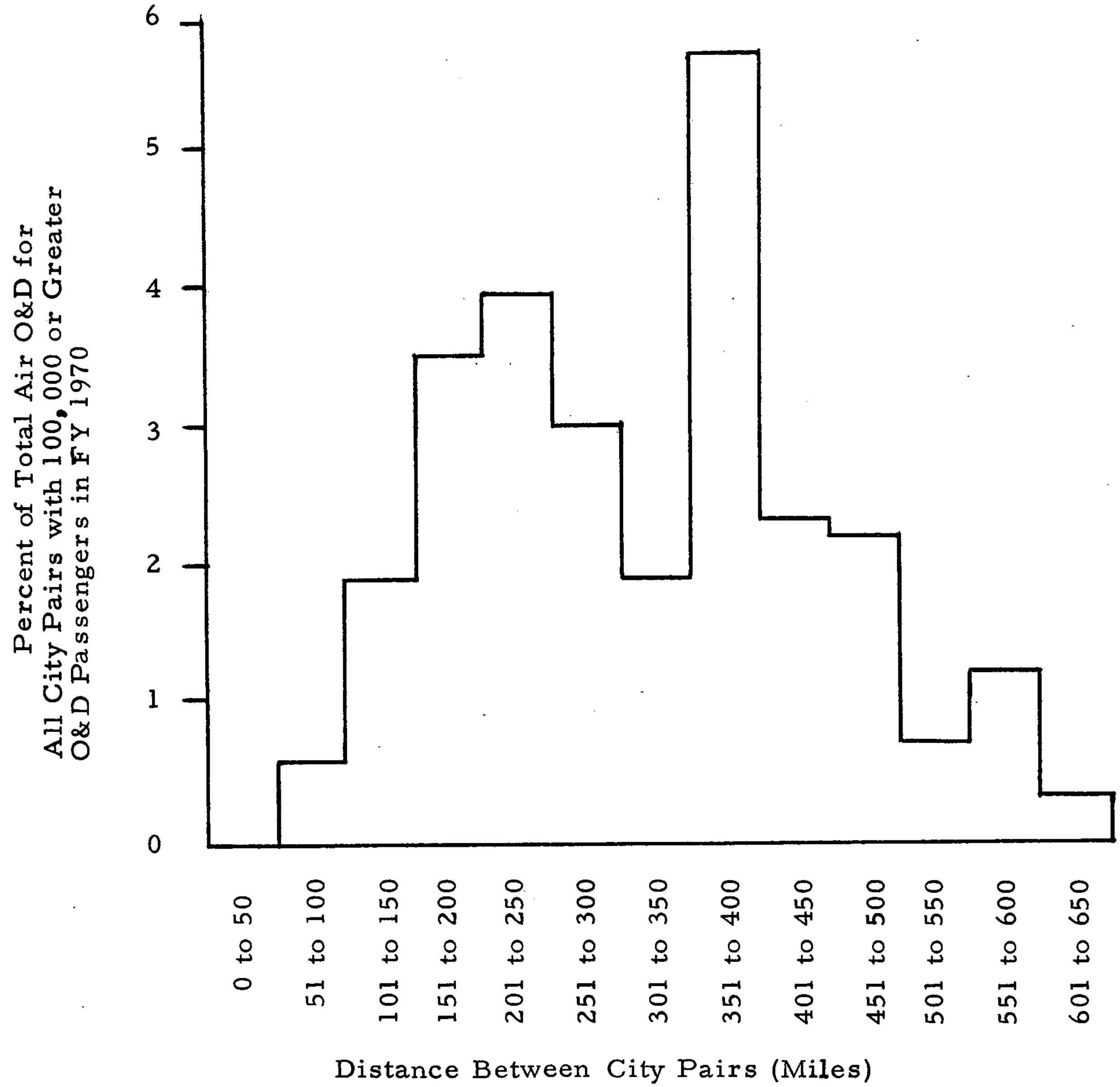

Figure A-3. Percent of Total O&D Passengers in FY 1970 Versus Distance Between City Pairs

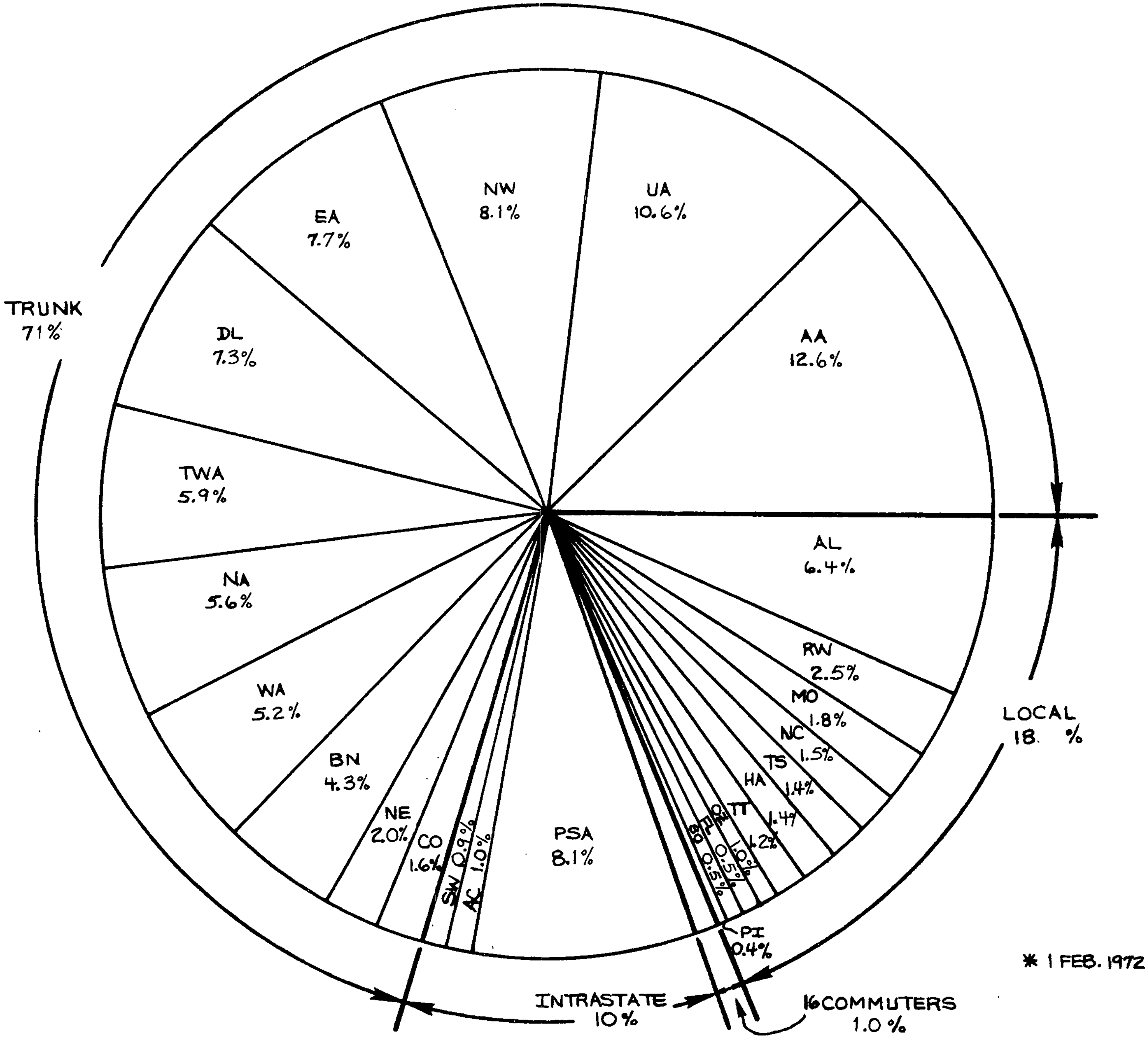

Figure A-4. United States Total Seats Available by Air Carrier for all 87 High Density Short Haul City Pairs

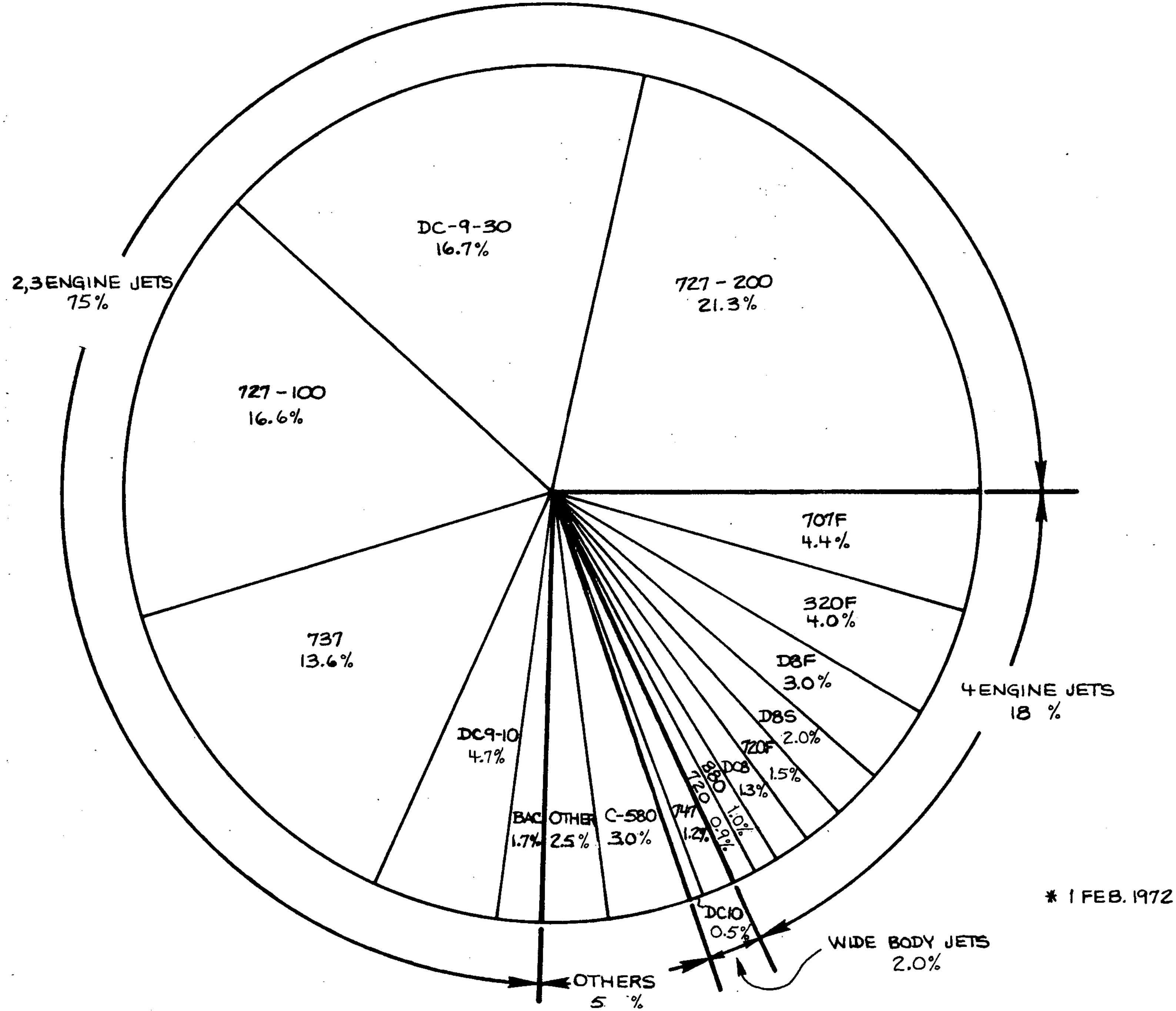

Figure A-5. United States Total Seats Available by Aircraft for all 87 High Density Short Haul City Pairs

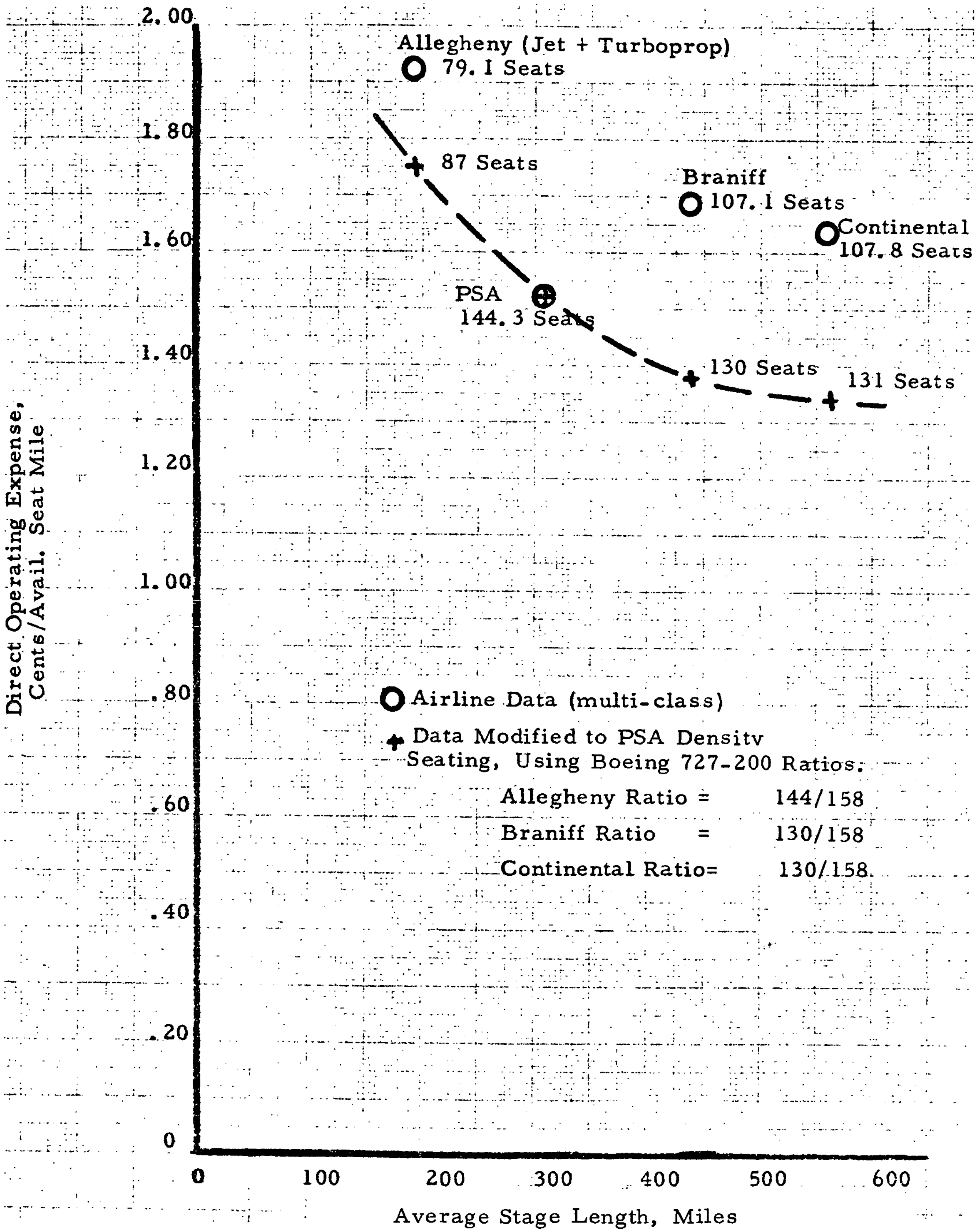

Figure A-6. Total Direct Operating Cost vs Stage Length

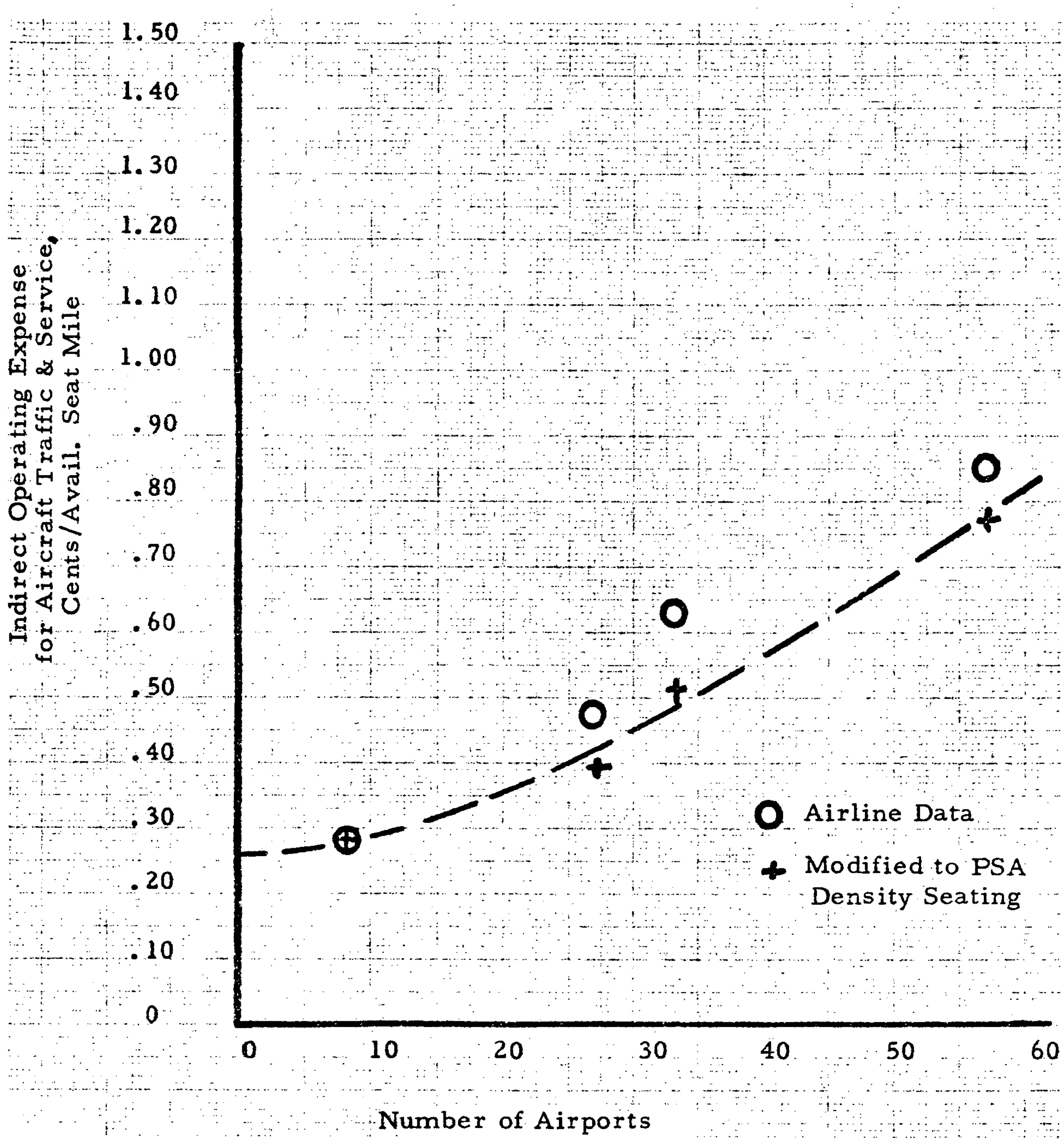

Figure A-7. Indirect Operating Expense for Aircraft Traffic & Service Expense vs Number of Airports Served

- UNLIKE GRAVITY MODEL REQUIRES SINGLE SURVEY DATA POINT FOR EACH CITY-PAIR INVESTIGATED
- ALL NON-POPULATION TRAVEL DEMAND FACTORS ASSUMED TO BE ACCOUNTED FOR IN SURVEY DATA POINT
- SUBSEQUENT CHANGES IN TRAVEL DEMAND, RELATIVE TO SURVEY DATA POINT, RELATED TO POPULATION GROWTH

$$T_1 = \left[C \left(\log (PP_1) - \log (PP_0) \right) + T_0^K \right]^{1/K}$$

WHERE: THE CALIBRATION CONSTANTS $C = 15.3417$ AND $K = 0.328$

AND PP_0 = SURVEY DATA POINT POPULATION PRODUCT

T_0 = SURVEY DATA POINT DAILY PERSON TRIPS

PP_1 = PROJECTED POPULATION PRODUCT FOR YEAR OF INTEREST

T_1 = DERIVED DAILY PERSON TRIPS FOR YEAR OF INTEREST

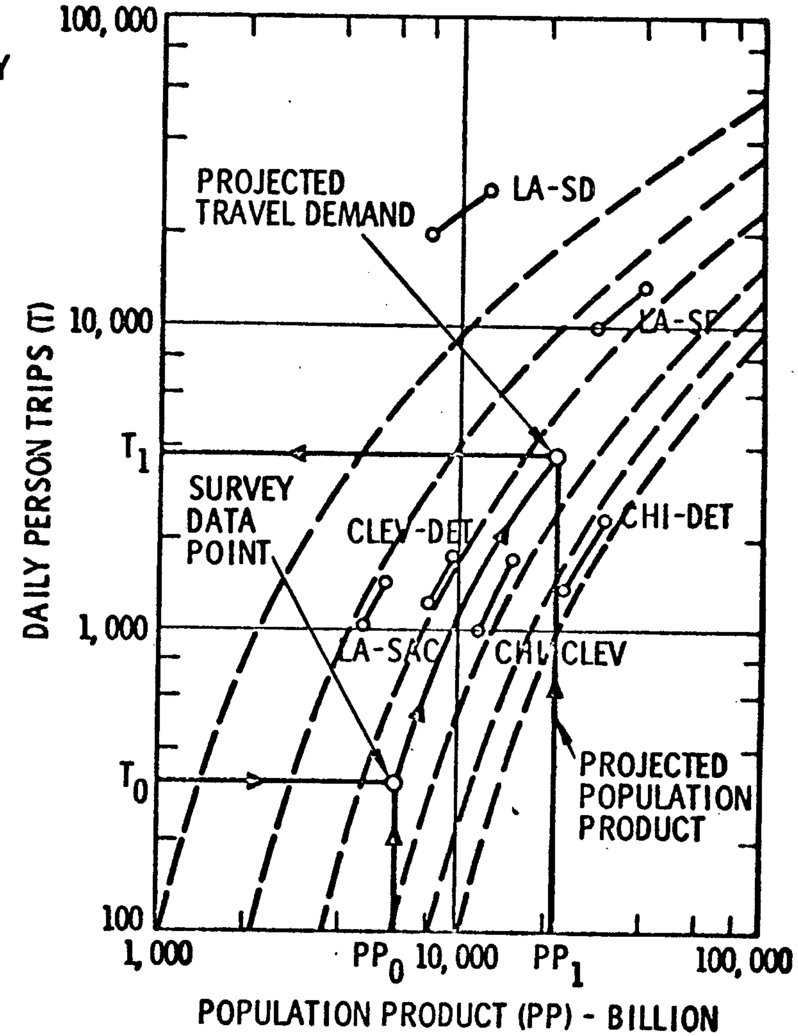

Figure A-8 Intercity Travel Demand Model Application

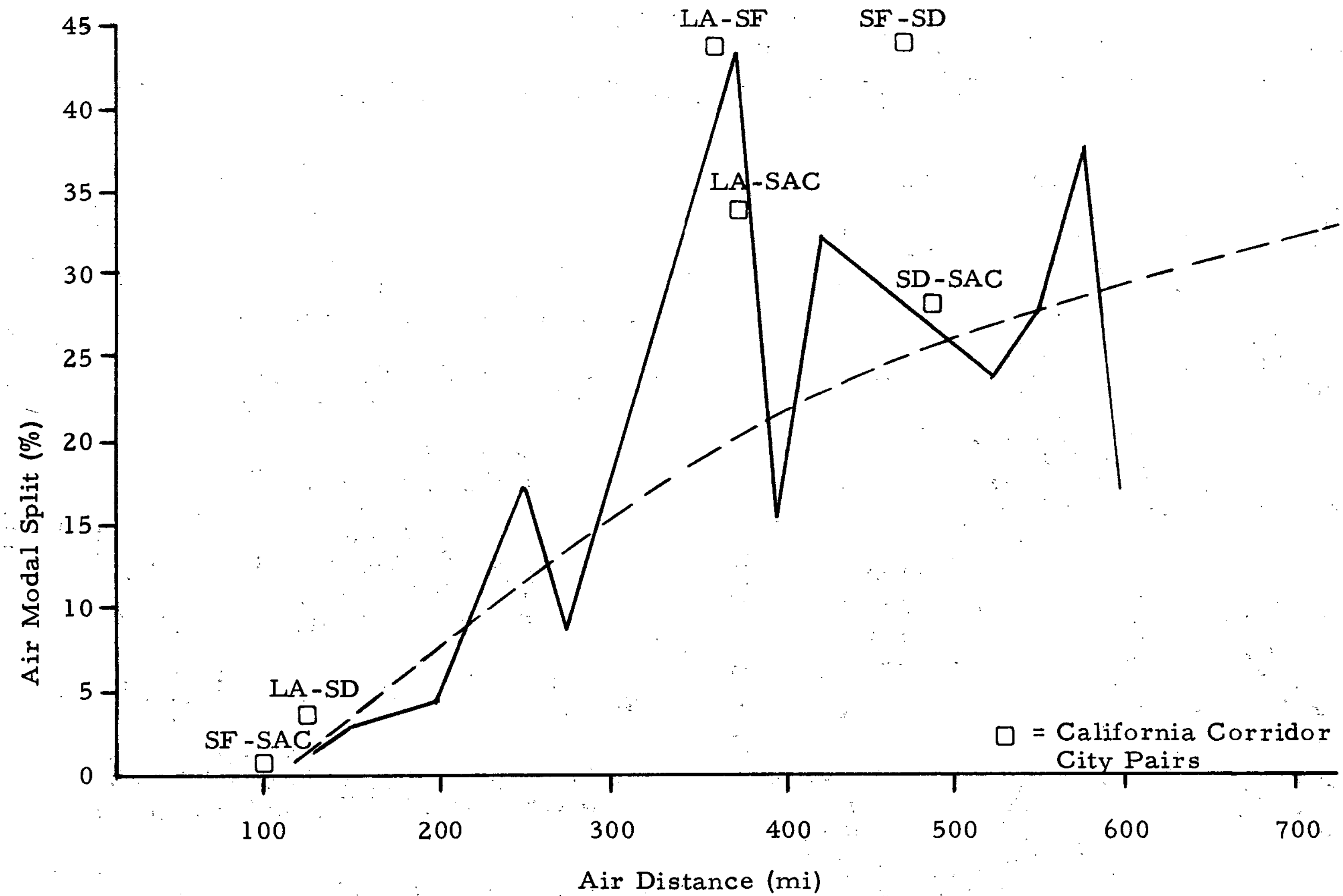

Figure A-9. Air Modal Split - West Region

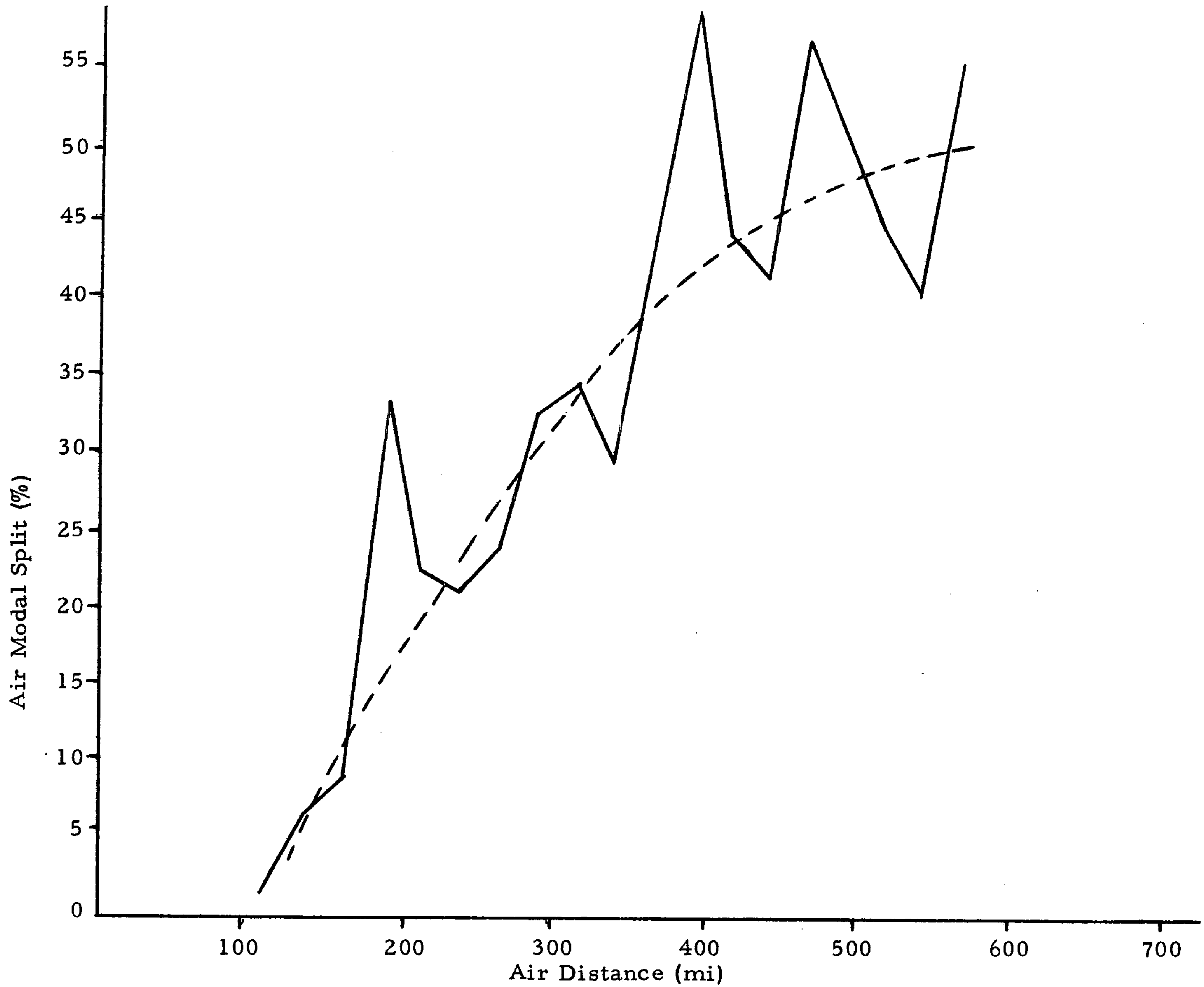

Figure A-10. Air Modal Split - Northeast Region

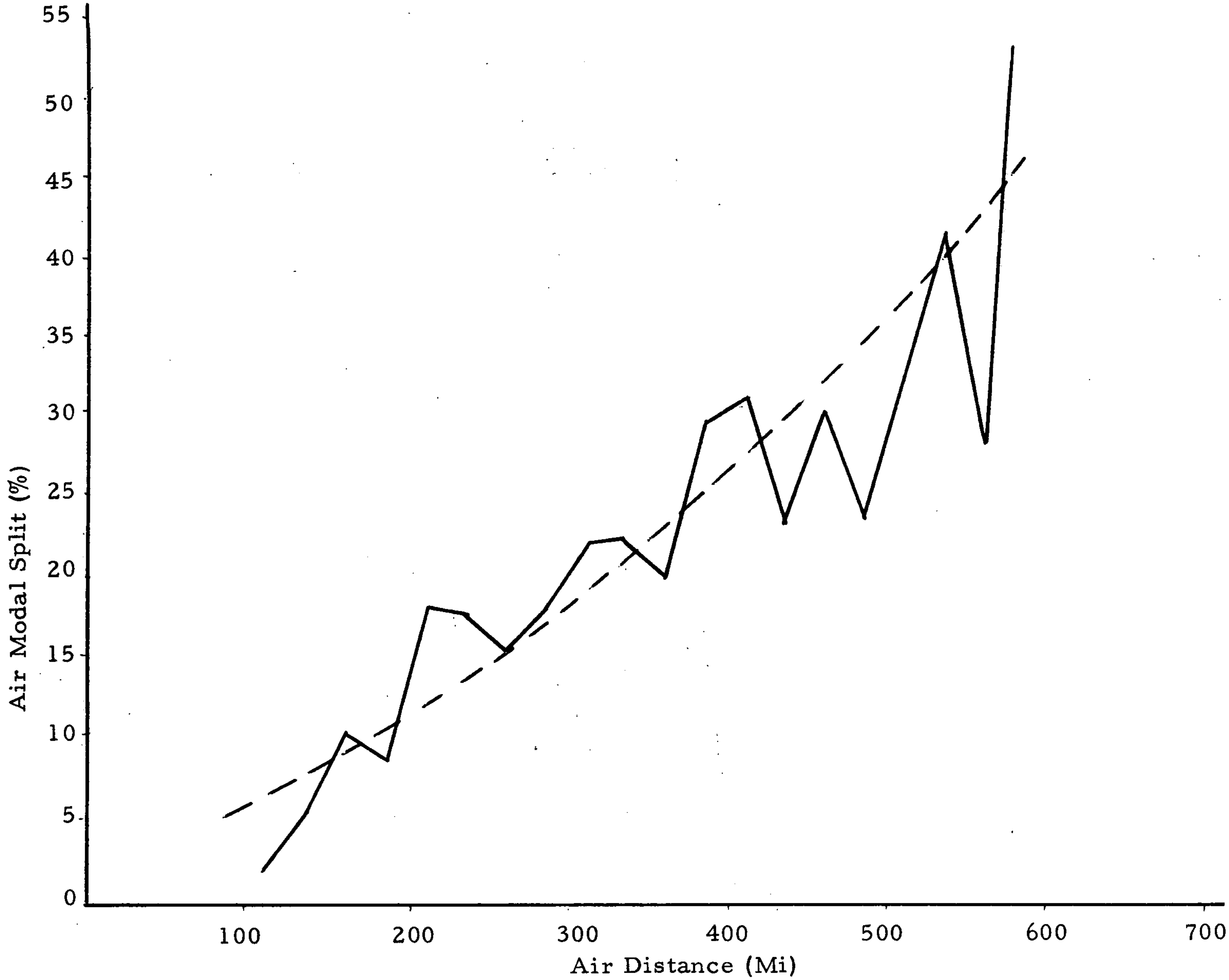

Figure A-11. Air Modal Split - South Region

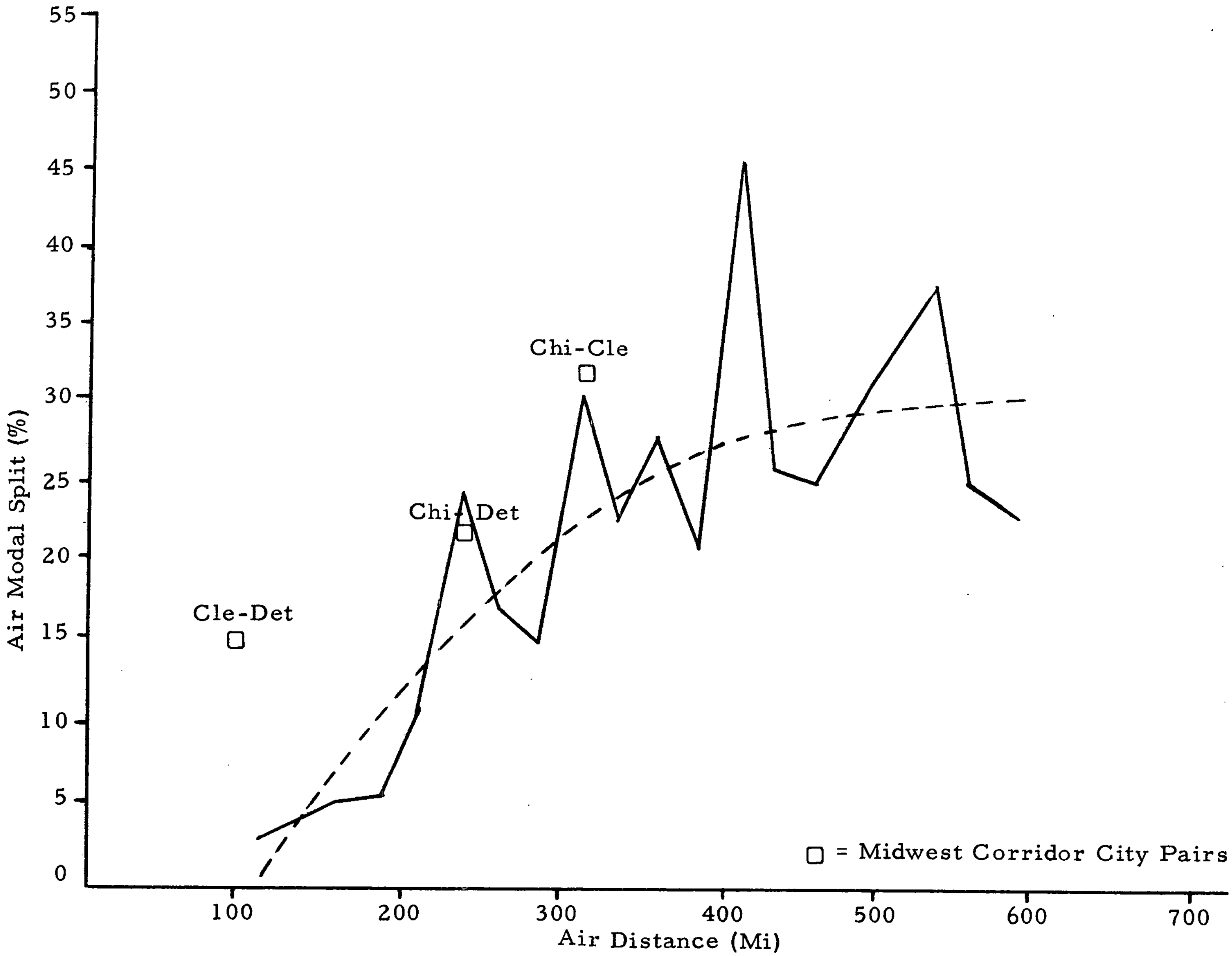

Figure A-12. Air Modal Split - North Central Region

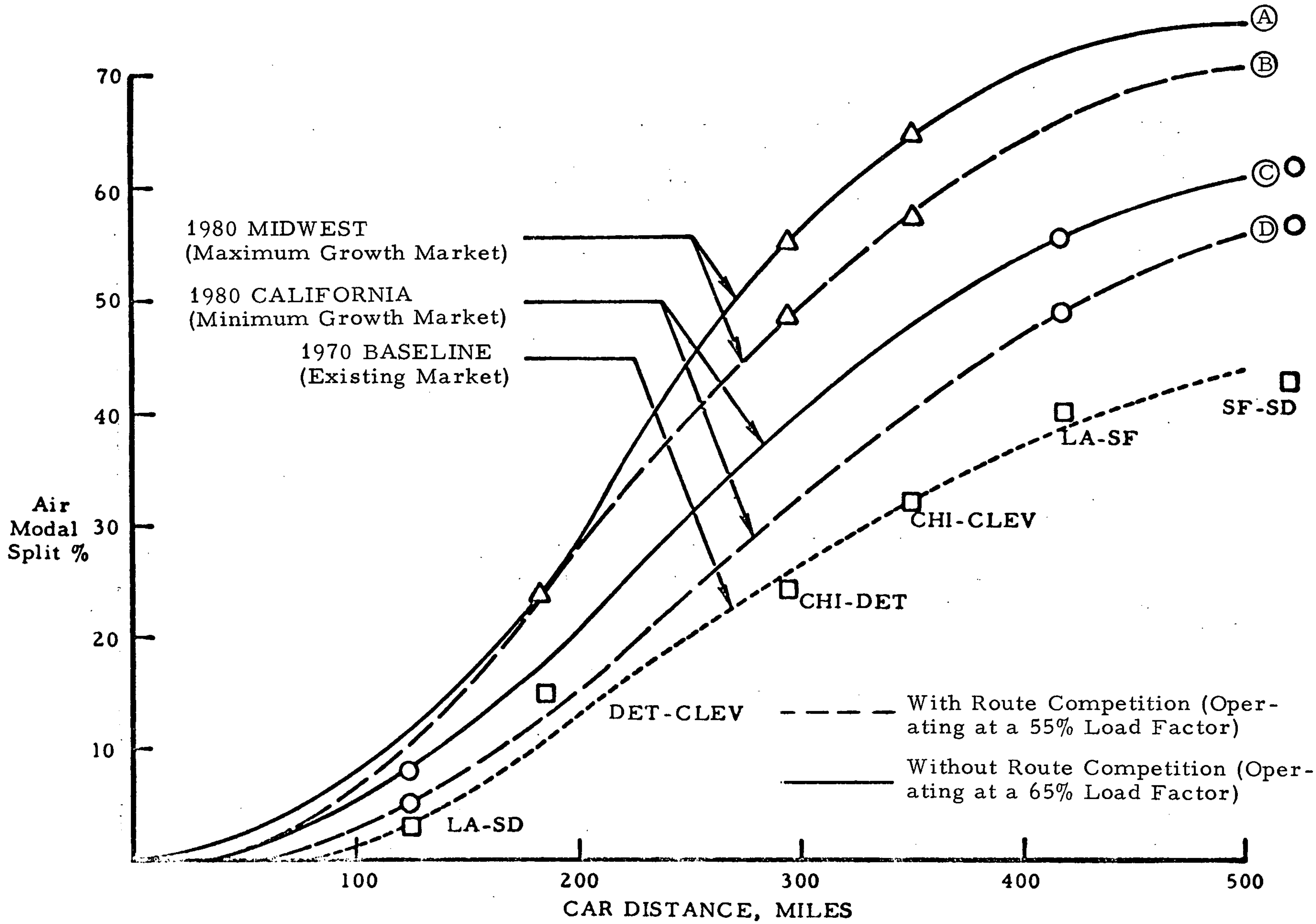

Figure A-13 Air Modal Splits

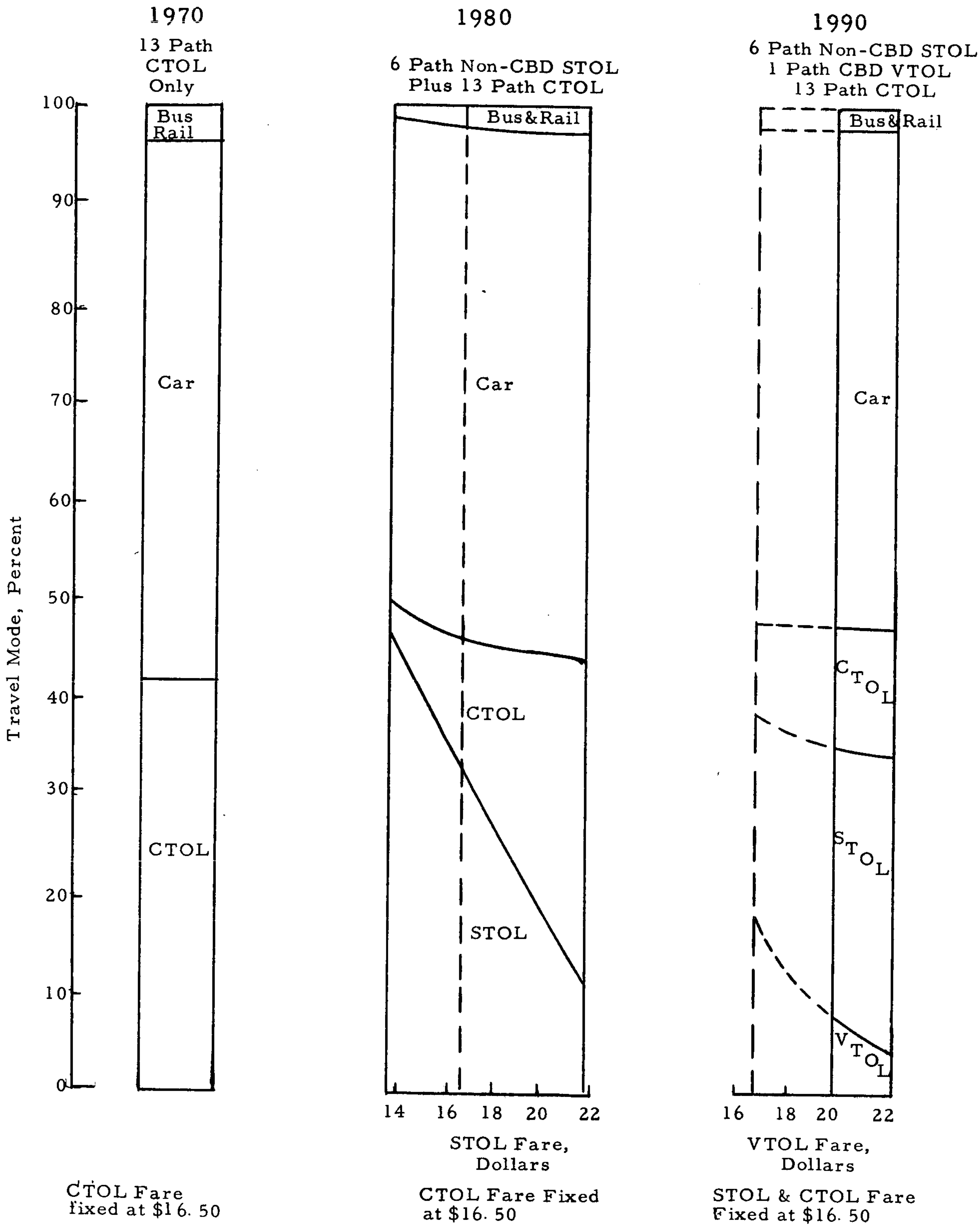

Figure A-14. Comparison of VTOL and STOL Market Shares, Los Angeles - San Francisco

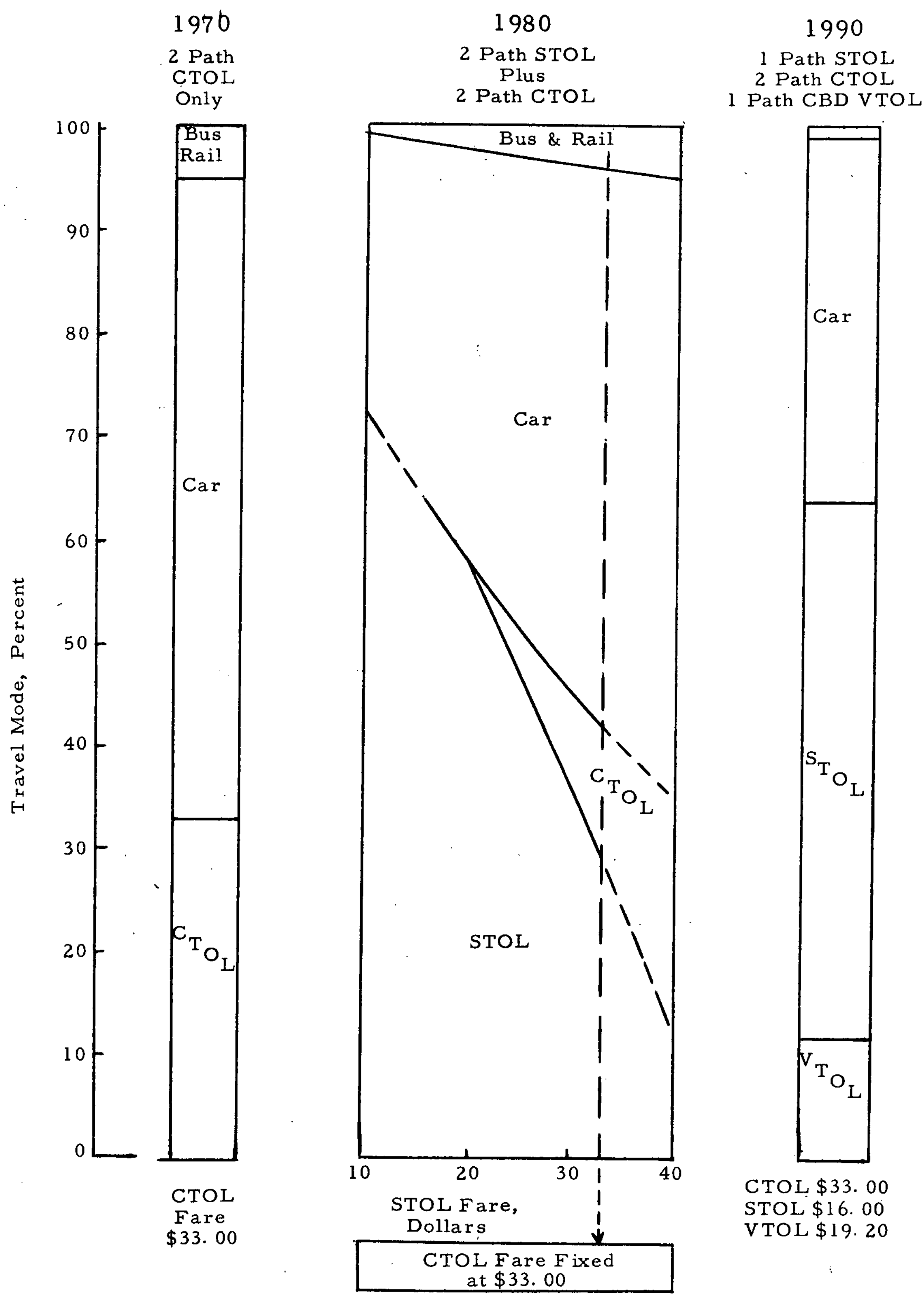

Figure A-15 Comparison of VTOL and STOL Market Shares, Chicago-Cleveland

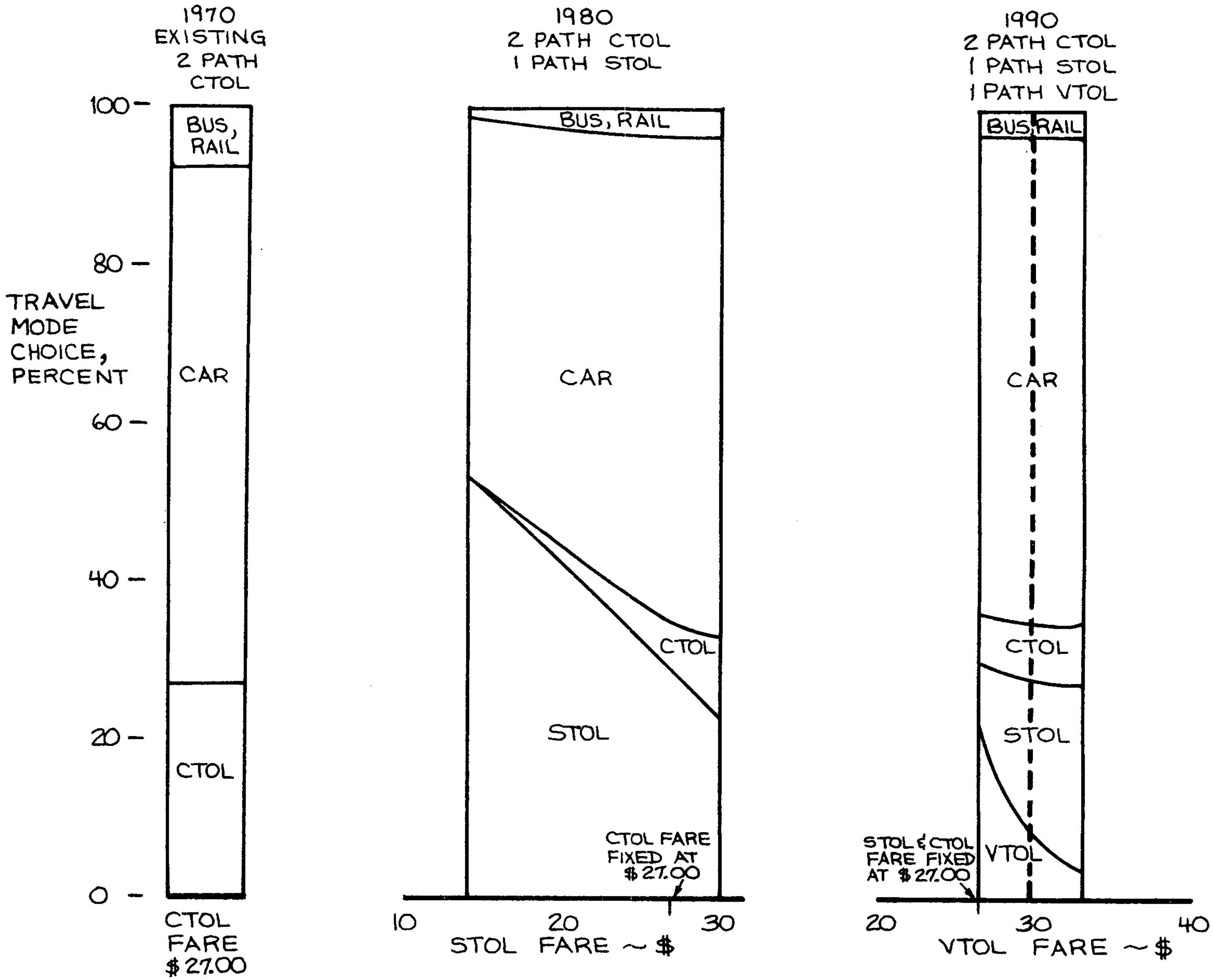

Figure A-16. Comparison of VTOL and STOL Market Shares, Chicago-Detroit

Table A-1. United States Domestic Air Passengers, Origin & Destination for FY 1970

CAB Trunk Plus Local Air Passengers, Unduplicated Origin & Destination		110,708,000
CAB Commuter Air Carriers Air Passengers, Unduplicated Origin & Destination[2,4]		4,270,000
PUC Intrastate Air Passengers, Unduplicated Origin & Destination[3,4]		5,889,000
	Total	120,292,000
Total Air Passengers with City Pair O&D 100,000 or Greater and Distances Between City Pairs 0 to 500 Miles[1,2,3,4]		30,180,000

1. Origin-Destination Survey of Airline Passenger Traffic, Domestic, 2nd Quarter of 1970, Volumes III-2-1 through III-2-7, Compiled by Civil Aeronautics Board, Published by the Air Transport Association of America.

2. Commuter Air Carrier Traffic Year Ended December 31, 1970, Civil Aeronautics Board, September 1971.

3. California Public Utility Commission Reports for 1970.

4. Official Airline Guides for 1970.

Table A-2. United States Domestic City Pair Air Passengers O&D for 1970, for all City Pairs Less Than 500 Statute Miles Apart (Arranged in Descending Order of Passenger Traffic)

City Pair Rank	City Pairs (Less Than 500 Miles Apart)	Non-Stop Mileage	Total Air Passengers/Yr Origin & Destination: CAB Trunk & Local	CAB Commuter	PUC Commuter	Total
1	Los Angeles Metro, Ca.-San Francisco Metro, Ca.	354	1,023,050		4,039,713	5,062,763
	A. Los Angeles, Ca.-San Francisco, Ca.		1,015,150		1,005,880	2,021,030
	B. Los Angeles, Ca.-Oakland, Ca.		96,080		638,513	734,593
	C. Los Angeles, Ca.-San Jose, Ca.		27,900		621,958	649,858
	D. Burbank, Ca.-San Francisco, Ca.		280		396,598	396,878
	E. Santa Ana, Ca.-San Francisco, Ca.		100		274,617	274,717
	F. Burbank, Ca.-San Jose, Ca.		30		248,538	248,768
	G. Ontario, Ca.-San Francisco, Ca.		60,330		157,153	217,483
	H. Burbank, Ca.-Oakland, Ca.		--		204,983	205,109
	I. Santa Ana, Ca.-San Jose, Ca.		150		186,612	186,762
	J. Santa Ana, Ca.-Oakland, Ca.		--		145,268	145,268
	K. Ontario, Ca.-San Jose, Ca.		110		84,221	84,331
	L. Ontario, Ca.-Oakland, Ca.		2,070		71,553	73,623
	M. Long Beach, Ca.-San Francisco, Ca.		61,350		3,137	64,487
	N. Long Beach, Ca.-Oakland, Ca.		10		--	10
2	Boston, Mass.-New York, N.Y./Newark, N.J.	190	2,201,880	9,150		2,211,030
3	New York, N.Y./Newark, N.J.-Washington, D.C.	216	1,768,770	24,961		1,793,731
4	Los Angeles Metro, Ca.-San Diego Metro, Ca.	102	162,480		778,085	940,565
	A. San Diego, Ca.-Los Angeles, Ca.		160,420		578,246	738,686
	B. San Diego, Ca.-Burbank, Ca.		--		182,347	182,347
	C. San Diego, Ca.-Ontario, Ca.		2,610		17,369	19,979
	D. San Diego, Ca.-Long Beach, Ca.		8,500		123	8,623
	E. San Diego, Ca.-Santa Ana, Ca.		1,750		--	1,750

Table A-2 (Continued)

City Pair Rank	City Pairs (Less Than 500 Miles Apart)	Non-Stop Mileage	Total Air Passenger/Yr Origin & Destination: CAB Trunk & Local	CAB Commuter	PUC Commuter	Total
5	Las Vegas, Nev.-Los Angeles Metro, Ca.	226	880,218			880,218
	A. Las Vegas, Nev.-Los Angeles, Ca.		653,338		--	653,338
	B. Las Vegas, Nev.-Burbank, Ca.		90,850		--	90,850
	C. Las Vegas, Nev.-Santa Ana, Ca.		77,820		--	77,820
	D. Las Vegas, Nev.-Ontario, Ca.		46,560		--	46,560
	E. Las Vegas, Nev.-Long Beach, Ca.		11,650			11,650
6	Detroit & Ann Arbor, Mich.-New York, N.Y./Newark, N.J.	489	858,280			858,280
7	San Diego Metro, Cal.-San Francisco Metro, Cal.	456	94,010		574,414	668,424
	A. San Diego, Cal.-San Francisco, Cal.		83,800		345,268	429,068
	B. San Diego, Cal.-San Jose, Cal.		1,820		93,307	95,127
	C. San Diego, Cal.-Oakland, Cal.		8,390		135,839	144,229
8	New York, N.Y./Newark, N.J.-Pittsburgh, Pa.	330	667,830			667,830
9	Los Angeles Metro, Ca.-Sacramento Metro, Ca.	380	221,600		431,800	653,400
	A. Sacramento, Ca.-Los Angeles, Ca.		189,310		370,400	559,710
	B. Sacramento, Ca.-Burbank, Ca.		40		51,700	51,740
	C. Sacramento, Ca.-Ontario, Ca.		32,250		9,700	41,950
10	Cleveland, Ohio-New York, N.Y./Newark, N.J.	410	649,990			649,990
11	Chicago, Ill.-Detroit & Ann Arbor, Mich.	238	552,777	20,246		573,023
12	Chicago, Ill.-Minneapolis/St. Paul, Minn.	345	559,220	12,468		571,688
13	Boston, Mass.-Washington, D.C.	406	542,870			542,870
14	Buffalo & Niagra Falls, N.Y.-New York, N.Y./Newark, N.J.	289	531,140			531,140
15	Chicago, Ill.-St. Louis, Mo.	256	441,890			441,890
16	Los Angeles Metro, Cal.-Phoenix, Ariz.	358	407,700			407,700
	A. Phoenix, Ariz.-Los Angeles, Ca.		335,230			335,230
	B. Phoenix, Ariz.-Santa Ana, Ca.		38,480			38,480
	C. Phoenix, Ariz.-Ontario, Ca.		27,700			27,700
	D. Phoenix, Ariz.-Burbank, Ca.		5,860			5,860
	E. Phoenix, Ariz.-Riverside, Ca.		360			360
	F. Phoenix, Ariz.-Long Beach, Ca.		70			70

Table A-2 (Continued)

City Pair Rank	City Pairs (Less Than 500 Miles Apart)	Non-Stop Mileage	Total Air Passengers/Yr Origin & Destination: CAB Trunk & Local	CAB Commuter	PUC Commuter	Total
17	New York, N. Y./Newark, N. J.-Rochester, N. Y.	252	398,440			398,440
18	Boston, Mass.-Philadelphia, Pa./Camden, N. J.	274	396,650			396,650
19	Chicago, Ill.-Cleveland, Ohio	311	377,410			377,410
20	Honolulu, Hawaii-Lihue, Kauai, Hawaii	101	361,470			361,470
21	Dallas & Ft. Worth, Tex.-Houston, Tex.	223	352,950			352,950
22	New York, N. Y./Newark, N. J.-Syracuse, N. Y.	197	342,600			342,600
23	Hilo, Hawaii-Honolulu, Hawaii	216	340,820			340,820
24	Philadelphia, Pa./Camden, N. J.-Pittsburgh, Pa.	274	307,430			307,430
25	Honolulu, Hawaii-Kahului, Maui, Hawaii	100	293,980			293,980
26	Chicago, Ill.-Kansas City, Mo.	407	293,920			293,920
27	Chicago, Ill.-Pittsburgh, Pa.	403	276,610			276,610
28	Baltimore, Md.-New York, N. Y./Newark, N. J.	180	267,940			267,940
29	Columbus, Ohio-New York, N. Y./Newark, N. J.	472	235,480			235,480
30	Detroit & Ann Arbor, Michi.-Washington, D. C.	391	232,660			232,660
31	Miami, Fla.-Tampa & St. Petersburg/Clearwater & Lakeland, Fla.	199	192,000	28,391		220,391
32	Detroit & Ann Arbor, Mich.-Philadelphia, Pa./Camden, N. J.	452	218,220			218,220
33	Las Vegas, Nev.-San Francisco Metro, Ca.	419	214,680			214,680
	A. Las Vegas, Nev.-San Francisco, Ca.		162,890		--	162,890
	B. Las Vegas, Nev.-San Jose, Ca.		38,730		--	38,730
	C. Las Vegas, Nev.-Oakland, Ca.		13,060		--	13,060
34	Reno, Nev. -San Francisco Metro, Ca.	187	209,070	5,047		214,117
	A. Reno, Nev.-San Francisco, Ca.		160,270		--	160,270
	B. Reno, Nev.-Oakland, Ca.		26,990		--	26,990
	C. Reno, Nev.-San Jose, Ca.		21,810		--	21,810

Table A-2 (Continued)

City Pair Rank	City Pairs (Less Than 500 Miles Apart)	Non-Stop Mileage	Total Air Passengers/Yr Origin & Destination: CAB Trunk & Local	CAB Commuter	PUC Commuter	Total
35	Chicago, Ill.-Indianapolis, Ind.	168	186,660	25,495		212,155
36	Portland, Ore.-Seattle, Wash.	132	198,430			198,430
37	Houston, Tex.-New Orleans, La.	303	193,600			193,600
38	Chicago, Ill.-Cincinnati	254	192,830			192,830
39	New York, N. Y./Newark, N. J.-Providence, R. I.	149	192,790			192,790
40	Kansas City, Mo.-St. Louis, Mo.	230	176,780	2,800		179,580
41	Seattle, Wash.-Spokane, Wash.	223	174,930			174,930
42	Cleveland, Ohio-Detroit & Ann Arbor, Mich.	93	97,720	73,304		171,024
43	Philadelphia, Pa./Camden, N. J.-Washington, D. C.	133	136,380	33,925		170,305
44	Pittsburgh, Pa.-Washington, D. C.	194	168,590			168,590
45	Cleveland, Ohio-Philadelphia, Pa./Camden, N. J.	366	167,990			167,990
46	Albany, N. Y.-New York, N. Y./Newark, N. J.	138	159,550	7,296		166,846
47	Cleveland, Ohio-Washington, D. C.	298	164,230			164,230
48	Chicago, Ill.-Columbus, Ohio	287	161,300			161,300
49	New York, N. Y./Newark, N. J.-Raleigh/Durham, N. C.	425	156,560			156,560
50	Dallas & Ft. Worth, Tex.-San Antonio, Tex.	254	156,450			156,450
51	New York, N. Y./Newark, N. J.-Philadelphia, Pa.	84	94,900	61,475		156,375
52	Hartford/Springfield/Westfield, Conn.-New York, N. Y.	106	126,470	24,805		151,275
53	Greensboro/High Pt., N. C.-New York, N. Y./Camden, N. J.	456	149,460			149,460
54	New York, N. Y./Newark, N. J.-Norfolk, Va.	292	147,580			147,580
55	Atlanta, Ga.-Jacksonville, Fla.	275	122,650	20,200		142,850

Table A-2 (Continued)

City Pair Rank	City Pairs (Less Than 500 Miles Apart)	Non-Stop Mileage	Total Air Passengers/Yr Origin & Destination: CAB Trunk & Local	CAB Commuter	PUC Commuter	Total
56	Los Angeles Metro, Ca.-Tucson, Ariz.	439	139,440			139,440
	A. Tucson, Ariz.-Los Angeles, Ca.		86,300		--	86,300
	B. Tucson, Ariz.-Santa Ana, Ca.		6,700		--	6,700
	C. Tucson, Ariz.-Ontario, Ca.		3,570		--	3,570
	D. Tucson, Ariz.-Burbank, Ca.		380		--	380
	E. Tucson, Ariz.-Riverside, Ca.		140		--	140
57	Dallas & Ft. Worth, Tex.-New Orleans, La.	423	137,650			137,650
58	Chicago, Ill.-Louisville, Ky.	277	136,850			136,850
59	Honolulu, Hawaii-Kailua-Kona, Hawaii	170	136,830			136,830
60	Boston, Mass.-Pittsburgh, Pa.	496	134,860			134,860
61	Baltimore, Md.-Boston, Mass.	370	133,760			133,760
62	Chicago, Ill.-Dayton, Ohio	231	132,320			132,320
63	Los Angeles, Ca.-Salinas/Monterey, Ca.	273	130,480			130,480
64	Atlanta, Ga.-Tampa & St. Petersburgh/Clearwater & Lakeland, Fla.	409	121,860	5,663		127,523
65	Detroit & Ann Arbor, Mich.-Milwaukee, Wisc.	244	122,200	5,164		
66	Denver, Colo.-Salt Lake City, Utah	382	122,020	1,428		123,448
67	Detroit & Ann Arbor, Mich.-St. Louis, Mo.	451	123,390			123,390
68	Chicago, Ill.-Omaha, Neb.	423	123,390			123,390
69	Chicago, Ill.-Memphis, Tenn.	485	123,310			123,310
70	Hartford/Springfield/Westfield, Conn.-Washington, D. C.	319	120,520			120,520
71	Chicago, Ill.-Des Moines, Iowa	306	117,520			117,520
72	Dallas & Ft. Worth, Tex.-Oklahoma City, Okla.	185	116,390			116,390
73	Norfolk, Va.-Washington, D. C.	149	116,360			116,360

Table A-2 (Continued)

City Pair Rank	City Pairs (Less Than 500 Miles Apart)	Non-Stop Mileage	Total Air Passengers/Yr Origin & Destination: CAB Trunk & Local	CAB Commuter	PUC Commuter	Total
74	New York, N. Y./Newark, N. J.-Richmond, Va.	287	116,170			116,170
75	Milwaukee, Wisc.-Minneapolis/St. Paul, Minn.	298	111,170	4,870		116,040
76	Detroit & Ann Arbor, Mich.-Pittsburgh, Pa.	197	115,410			115,410
77	Jacksonville, Fla.-Miami, Fla.	330	102,600	12,203		114,803
78	Sacramento, Ca.-San Francisco Metro, Ca.	74	47,290		64,700	111,990
	A. Sacramento, Ca.-San Francisco, Ca.		1,190		64,700	65,890
	B. Sacramento, Ca.-San Jose, Ca.		45,460		--	45,460
	C. Sacramento, Ca.-Oakland, Ca.		640		--	640
79	Fresno, Ca.-Los Angeles, Ca.	213	107,180			107,180
80	Buffalo & Niagara Falls, N. Y.-Chicago, Ill.	467	106,590			106,590
81	Fresno, Ca.-San Francisco, Ca.	164	104,370			104,370
82	Boston, Mass.-Buffalo & Niagara Falls, N. Y.	396	103,770			103,770
83	Detroit & Ann Arbor, Mich.-Indianapolis, Inc.	241	91,380	11,150		102,530
84	Buffalo & Niagara Falls, N. Y.-Philadelphia, Pa./Camden, N. J.	282	101,610			101,610
85	Dallas & Ft. Worth, Tex.-Kansas City, Mo.	448	101,400			101,400
86	Atlanta, Ga.-Memphis, Tenn.	332	100,640			100,640
87	Austin, Tex.-Dallas & Ft. Worth, Tex.	187	100,370			100,370
	87 City-Pair Totals		23,900,985	390,041	5,888,712	30,179,738

Table A-3. 1970 Geographical Region Summary of United States Domestic Origin & Destination City Pair Air Passengers for all City Pairs With 100, 000 or Greater O&D Air Passengers and City Pairs Separated Less than 500 Miles

Regional Rank	Region	Number of City Pairs	Number of Cities	Total Air Passengers/Yr Origin & Destination	Percent
1a	North East (North South)	17	12	6, 990,223	23.2
1b	North East (East West)	16	11	5, 283, 120	17.5
2	Pacific South West	13	10	9, 634,367	31.9
3	North Central	22	18	4, 776, 144	15.9
4	South Central	7	7	1, 158,810	3.9
5	Hawaiian	4	5	1, 133, 330	3.7
6	South East	5	5	706, 207	2.3
7	Pacific North West	2	3	373, 360	1.2
8	Rocky Mountain	1	2	123, 448	.4
	Total	87	6	30,179, 738	100.0%

Table A-4. Geographical Region Tabulation of United States Domestic City Pair Air Passengers, Origin & Destination for 1970, For all City Pairs with 100, 000 or Greater Air Passengers Less Than 500 Statute Miles Apart

Hawaiian Region

Regional City-Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	20	Honolulu, Hawaii - Lihue, Hawaii	361,700	101
2	23	Honolulu, Hawaii - Hilo, Hawaii	340,820	216
3	25	Honolulu, Hawaii - Kahului, Hawaii	293,980	100
4	50	Honolulu, Hawaii - Kailua, Kona, Hawaii	136,830	170
		Hawaii Total	1,133,330	

Table A-4 (Continued)

South East Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	31	Miami, Fla. - Tampa Metro, Fla.	220,391	199
2	55	Atlanta, Ga. - Jacksonville, Fla.	142,850	275
3	65	Atlanta, Ga. - Tampa Metro, Fla.	127,523	409
4	77	Miami, Fla. - Jacksonville, Fla.	114,803	330
5	86	Atlanta, Ga. - Memphis, Tenn.	100,640	332
		South East Total	706,207	

Table A-4 (Continued)

Pacific Northwest Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	36	Seattle, Wash. - Portland, Ore.	198,430	132
2	41	Seattle, Wash. - Spokane, Wash.	174,930	223
		Pacific Northwest Total	373,360	

Table A-4 (Continued)

Pacific Southwest

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	1	Los Angeles Metro - San Francisco Metro	5,062,736	354
2	4	Los Angeles Metro - San Diego, Cal.	940,565	102
3	5	Los Angeles Metro - Las Vegas, Nev.	880,218	226
4	7	San Francisco Metro - San Diego, Cal.	668,424	456
5	9	Los Angeles Metro - Sacramento, Cal.	653,338	380
6	16	Los Angeles Metro - Phoenix, Ariz.	407,700	358
7	33	San Francisco Metro - Las Vegas, Nev.	214,680	419
8	34	San Francisco Metro - Reno, Nev.	214,117	187
9	56	Los Angeles Metro - Tucson, Ariz.	139,440	439
10	63	Los Angeles Metro - Salinas/Monterey, Cal.	130,480	273
11	78	San Francisco Metro-Sacramento, Cal.	111,119	74
12	79	Los Angeles Metro - Fresno, Cal.	107,180	213
13	81	San Francisco Metro - Fresno, Cal.	104,370	164
		Pacific Southwest Total	9,634,367	

Table A-4 (Continued)

North Central Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	11	Chicago, Ill. - Detroit, Mich.	573,023	238
2	12	Chicago, Ill. - Minneapolis, Minn.	571,688	345
3	15	Chicago, Ill. - St. Louis, Mo.	441,890	256
4	19	Chicago, Ill. - Cleveland, Ohio	377,410	311
5	26	Chicago, Ill. - Kansas City, Kan.	293,920	407
6	27	Chicago, Ill - Pittsburgh, Penn.	276,610	403
7	35	Chicago, Ill. - Indianapolis, Ind.	212,155	168
8	38	Chicago, Ill. - Cincinnati, Ohio	192,830	254
9	40	St. Louis, Mo. - Kansas City, Kan.	179,580	230
10	42	Detroit, Mich. - Cleveland, Ohio	171,024	93
11	48	Chicago, Ill. - Columbus, Ohio	161,300	287
12	58	Chicago, Ill. - Louisville, Ken.	136,850	277
13	62	Chicago, Ill. - Dayton, Ohio	132,320	231
14	64	Detroit, Mich. - Milwaukee, Wisc.	127,364	244

Table A-4 (Continued)

North Central Region (continued)

Regional City-Pair Rank	United States City-Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
15	67	St. Louis, Mo. - Detroit, Mich.	123,390	451
16	68	Chicago, Ill. - Omaha, Neb.	123,390	423
17	69	Chicago, Ill. - Memphis, Tenn.	123,310	485
18	71	Chicago, Ill. - Des Moines, Iowa	117,520	306
19	75	Minneapolis, Minn. - Milwaukee, Wisc.	116,040	298
20	76	Detroit, Mich. - Pittsburgh, Penn.	115,410	197
21	80	Chicago, Ill. - Buffalo, N. Y.	106,590	467
22	83	Detroit, Mich. - Indianapolis, Ind.	102,530	241
		North Central Total	4,776,144	

Table A-4 (Continued)

South Central Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	21	Dallas/Ft. Worth, Tex. - Houston, Tex.	352,950	223
2	37	Houston, Tex. - New Orleans, La.	193,600	303
3	50	Dallas/Ft. Worth, Tex. - San Antonio, Tex.	156,450	254
4	57	Dallas/Ft. Worth, Tex. - New Orleans, La.	137,650	423
5	72	Dallas/Ft. Worth, Tex. - Oklahoma City, Okla.	116,390	185
6	85	Dallas/Ft. Worth, Tex.-Kansas City, Mo.	101,400	448
7	87	Dallas/Ft. Worth, Tex.-Austin, Tex.	100,370	187
		South Central Total	1,158,810	

Table A-4 (Continued)

Rocky Mountain Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	66	Salt Lake City, Utah - Denver, Colo.	123,448	382
		Rocky Mountain Total	123,448	

Table A-4 (Continued)

North East (North South) Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	2	New York Metro - Boston Metro	2,211,030	190
2	3	New York Metro - Washington, D. C.	1,793,731	216
3	13	Boston, Mass. - Washington, D. C.	542,870	406
4	18	Boston, Mass. - Philadelphia, Penn.	396,650	274
5	28	New York Metro - Baltimore, Md.	267,940	180
6	39	New York Metro - Providence, R. I.	192,790	149
7	43	Washington, D. C. - Philadelphia, Penn.	170,300	133
8	46	New York Metro - Albany, N. Y.	166,846	138
9	49	New York Metro - Raleigh/Durham, N. C.	156,560	425
10	51	New York Metro - Philadelphia, Penn.	156,375	84
11	52	New York Metro - Hartford/Springfield/ Westfield	151,275	106
12	53	New York Metro - Greensboro, N. C.	149,460	456

Table A-4 (Continued)

North East (North South) Region (continued)

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
13	54	New York Metro - Norfolk, Va.	147,580	292
14	61	Boston, Mass. - Baltimore, Md.	133,760	370
15	70	Washington, D. C. - Hartford/Springfield/ Westfield	120,526	319
16	73	Washington, D. C. - Norfolk, Va.	116,360	149
17	74	New York Metro - Richmond, Va.	116,170	287
		North East North South Total	6,990,223	

Table A-4 (Continued)

North East (East West) Region

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
1	6	New York Metro - Detroit/Ann Arbor, Mich.	858,280	489
2	8	New York Metro - Pittsburgh, Penn.	667,830	330
3	10	New York Metro - Cleveland, Ohio	649,990	410
4	14	New York Metro - Buffalo/Niagara Falls, N. Y.	531,140	289
5	17	New York Metro - Rochester, N. Y.	398,440	252
6	22	New York Metro - Syracuse, N. Y.	342,600	197
7	24	Philadelphia, Penn. - Pittsburgh, Penn.	307,430	274
8	29	New York Metro - Columbus, Ohio	235,480	472
9	30	Washington, D. C. - Detroit/Ann Arbor, Mich.	232,660	391
10	32	Philadelphia, Penn. - Detroit/Ann Arbor, Mich.	218,220	452
11	44	Washington, D. C. - Pittsburgh, Penn.	168,590	194
12	45	Philadelphia, Penn. - Cleveland, Ohio	167,990	366

Table A-4 (Continued)

North East (East West) Region (continued)

Regional City Pair Rank	United States City Pair Rank	City Pairs (Less Than 500 Miles)	Total Air Passengers/Yr Origin & Destination	Nonstop Mileage
13	47	Washington, D. C. - Cleveland, Ohio	164,230	298
14	60	Boston, Mass. - Pittsburgh, Penn.	134,860	496
15	82	Boston, Mass. - Buffalo/Niagara Falls, N. Y.	103,770	396
16	84	Philadelphia, Penn. - Buffalo/Niagara Falls, NY	101,610	282
		North East East West Total	5,283,120	

Table A-5. United States Domestic City Pair Air Passengers, Origin & Destination for 1970, for All City Pairs Less than 500 Statute Miles Apart with 100,000 or More Passengers (City Pairs Arranged in Ascending Order of Non-Stop Mileage)

50-100 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
78	Sacramento, Cal.-San Francisco Metro, Cal.	74	111,990	.09	.09
51	New York, N. Y./Newark, N. J.-Philadelphia, Penn.	84	156,375	.13	.22
42	Cleveland, Ohio-Detroit, Michigan	93	171,024	.14	.36
25	Honolulu, Hawaii-Kahului, Maui, Hawaii	100	293,980	.24	.61
	4 City-Pair Subtotals		733,369	.61	.61

101-150 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
20	Honolulu, Hawaii-Lihue, Kauai, Hawaii	101	361,470	.30	.91
4	Los Angeles Metro, Cal.-San Diego, Cal.	102	940,565	.78	1.69
51	Hartford/Springfield/Westfield, Conn.-N. Y., N. Y.	106	151,275	.13	1.82
36	Portland, Oregon-Seattle, Washington	132	198,430	.16	1.98
43	Philadelphia, Pa./Camden, N. J.-Washington, D. C.	133	170,305	.14	2.12
46	Albany, N. Y.-New York, N. Y./Newark, N. J.	138	166,846	.14	2.26
39	New York, N. Y./Newark, N. J.-Providence, R. I.	149	192,790	.16	2.42
73	Norfolk, Va.-Washington, D. C.	149	116,360	.10	2.51
	8 City-Pair Subtotals		2,298,041	1.91	2.51

151-200 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
81	Fresno, Cal.-San Francisco, Cal.	164	104,370	.09	2.60
35	Chicago, Ill.-Indianapolis, Ind.	168	212,155	.18	2.78
59	Honolulu, Hawaii-Kailua, Kona, Hawaii	170	136,830	.11	2.89
28	Baltimore, Md.-New York, N. Y./Newark, N. J.	180	267,940	.22	3.11
72	Dallas, Ft. Worth, Tex.-Oklahoma City, Okla.	185	116,390	.10	3.21
34	Reno, Nev.-San Francisco Metro, Cal.	187	214,117	.18	3.38
87	Austin, Texas-Fort Worth, Texas	187	100,370	.08	3.47

Table A-5 (Continued)

151-200 Miles (Continued)

City Pair Rank	City Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
2	Boston, Mass.-N. Y., N. Y./Newark, N. J.	190	2,211,030	1.84	5.30
44	Pittsburgh, Pa.-Washington, D. C.	194	168,590	.14	5.45
22	New York, N. Y./Newark, N. J.-Syracuse, N. J.	197	342,600	.29	5.73
76	Detroit/Ann Arbor, Mich.-Pittsburgh, Pa.	197	115,410	.10	5.83
31	Miami, Fla.-Tampa/St. Petersburg, Fla.	199	220,391	.18	6.01
	12 City-Pair Subtotals		4,210,193	3.50	6.01

201-250 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
79	Fresno, Cal.-Los Angeles, Cal.	213	107,180	.09	6.10
3	New York/Newark, N. J.-Washington, D. C.	216	1,793,731	1.49	7.59
23	Hilo, Hawaii-Honolulu, Hawaii	216	340,820	.28	7.87
21	Dallas/Ft. Worth, Tex.-Houston, Tex.	223	352,950	.29	8.16
41	Seattle, Wash.-Spokane, Wash.	223	174,930	.15	8.31
5	Las Vegas, Nev.-Los Angeles Metro, Cal.	226	880,218	.73	9.04
40	Kansas City, Mo.-St. Louis, Mo.	230	179,580	.15	9.19
62	Chicago, Ill.-Dayton, Ohio	231	132,320	.11	9.30
11	Chicago, Ill.-Detroit/Ann Arbor, Mich.	238	573,023	.48	9.77
83	Detroit/Ann Arbor, Mich.-Indianapolis, Ind.	241	102,530	.09	9.86
65	Detroit/Ann Arbor, Mich.-Milwaukee, Wis.	244	127,364	.11	9.96
	11 City-Pair Subtotals		4,764,646	3.95	9.96

251-300 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
17	New York, N. Y./Newark, N. J./Rochester, N. Y.	252	398,440	.33	10.29
38	Chicago, Ill.-Cincinnati, Ohio	254	192,830	.16	10.45
50	Dallas/Ft. Worth, Tex.-San Antonio, Tex.	254	156,450	.13	10.58
15	Chicago, Ill.-St. Louis, Mo.	256	441,890	.37	10.95
63	Los Angeles Metro, Cal.-Salinas/Monterey, Cal.	273	130,480	.11	11.06
17	Boston, Mass.-Philadelphia, Pa./Camden, N. J.	274	396,650	.33	11.39
24	Philadelphia, Pa./Camden, N. J.-Pittsburgh, Pa.	274	307,430	.26	11.64

Table A-5 (Continued)

251-300 Miles (Continued)

City Pair Rank	City Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
55	Atlanta, Ga.-Jacksonville, Fla.	275	142,850	.12	11.76
58	Chicago, Ill.-Louisville, Ken.	277	136,850	.11	11.87
84	Buffalo/Niagara Falls, N. Y.-Philadelphia, Pa./ Camden, N. J.	282	101,610	.08	11.96
48	Chicago, Ill.-Columbus, Ohio	287	161,300	.13	12.09
74	New York, N. Y./Newark, N. J.-Richmond, Va.	287	116,170	.10	12.18
14	Buffalo, N. Y.-New York, N. Y./Newark, N. J.	289	531,140	.44	12.63
54	New York, N. Y./Newark, N. J.-Norfolk, Va.	292	147,580	.12	12.75
47	Cleveland, Ohio-Washington, D. C.	298	164,230	.14	12.88
75	Milwaukee, Wisc.-Minneapolis/St. Paul, Minn.	298	116,040	.10	12.98
	16 City-Pair Subtotals		3,641,940	3.02	12.98

301-350 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
37	Houston, Tex.-New Orleans, La.	303	193,600	.16	13.14
71	Chicago, Ill-Des Moines, Iowa	306	117,520	.10	13.24
19	Chicago, Ill-Cleveland, Ohio	311	377,410	.31	13.55
70	Hartford/Springfield, Conn.-Washington, D. C.	319	120,520	.10	13.65
8	New York/Newark, N. J.-Pittsburgh, Pa.	330	667,830	.56	14.21
77	Jacksonville, Fla.-Miami, Fla.	330	114,803	.10	14.31
86	Atlanta, Ga.-Memphis, Tenn.	332	100,640	.08	14.39
12	Chicago, Ill-Minneapolis/St. Paul, Minn.	345	571,688	.48	14.87
	8 City-Pair Subtotals		2,264,011	1.89	14.87

351-400 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
1	Los Angeles Metro, Cal.-San Francisco Metro, Cal.	354	5,062,763	4.21	19.08
16	Los Angeles Metro, Cal.-Phoenix, Ariz.	358	407,700	.34	19.42
45	Cleveland, Ohio-Philadelphia/Camden, N. J.	366	167,990	.14	19.56
61	Baltimore, Md.-Boston, Mass.	370	133,760	.11	19.67

Table A-5 (Continued)

351-400 Miles (Continued)

City Pair Rank	City Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
9	Los Angeles Metro, Cal.-Sacramento, Cal.	380	653,400	.54	20.21
66	Denver, Colo.-Salt Lake City, Utah	382	123,448	.10	20.31
30	Detroit/Ann Arbor, Mich.-Washington, D. C.	391	232,660	.19	20.50
82	Boston, Mass.-Buffalo/N. F., N. Y.	396	103,770	.09	20.59
	8 City-Pair Subtotals		6,885,491	5.72	20.59

401-450 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
27	Chicago, Ill.-Pittsburgh, Pa.	403	276,610	.23	20.82
13	Boston, Mass.-Washington, D. C.	406	542,870	.45	21.27
26	Chicago, Ill.-Kansas City, Mo.	407	293,920	.24	21.51
64	Atlanta, Ga.-Tampa/St. Pet., Fla.	409	127,523	.11	21.62
10	Cleveland, Ohio-New York/Newark, N. J.	410	649,990	.54	22.16
33	Las Vegas, Nev.-San Francisco Metro, Ca.	419	214,680	.18	22.34
57	Dallas/Ft. Worth, Tex.-New Orleans, La.	423	137,650	.11	22.45
68	Chicago, Ill.-Omaha, Neb.	423	123,390	.10	22.55
49	New York/Newark, N. J.-Raleigh/Durham, N. C.	425	156,560	.13	22.68
56	Los Angeles Metro, Ca.-Tucson, Ariz.	439	139,440	.12	22.80
85	Dallas/Ft. Worth, Tex.-Kansas City, Mo.	448	101,400	.08	22.88
	11 City-Pair Subtotals		2,764,033	2.29	22.88

451-500 Miles

City Pair Rank	City-Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
67	Detroit/Ann Arbor, Mich.-St. Louis, Mo.	451	123,390	.10	22.98
32	Detroit/Ann Arbor, Mich.-Phil./Camden, N. J.	452	218,220	.18	23.16
53	Greensboro/High Pt., N. C.-N. Y./Newark, N. J.	456	149,460	.12	23.28
80	Buffalo/Niagara Falls, N. Y.-Chicago, Ill.	467	106,590	.09	23.37

Table A-5 (Continued)

451-500 Miles (Continued)

City Pair Rank	City Pair	Non-Stop Mileage	Total Air Passengers Per Year, Origin & Destination	Percent of Total Air O&D Passengers Per Year	Cumulative Total Percent
7	San Diego Metro, Cal.-San Francisco Metro, Cal.	456	668,424	.56	23.93
29	Columbus, Ohio-New York/Newark, N. J.	472	235,480	.20	24.13
69	Chicago, Ill.-Memphis, Tenn.	485	123,310	.10	24.23
6	Detroit/Ann Arbor, Mich.-New York/Newark, N. J.	489	858,280	.71	24.94
60	Boston, Mass.-Pittsburgh, Penn.	496	134,860	.11	25.05
	9 City-Pair Subtotals		2,618,014	2.18	25.05
	87 City-Pair Totals		30,388,698	25.05	25.05

Table A-6. Mix and Type of Aircraft and Air Carrier in Service by Seats Available on all 87 High Density Short Haul Routes (By Air Hub for Cities with Two or More High Density Short Haul Routes)

Hub City	Type of Aircraft, Percent				Type of Carrier, Percent			
	Short & Medium Haul 2&3 Eng. Jet	Long Haul 4 Engine Jet	Wide Body Jet	Other	Trunk	Local	Intrastate	Commuter
Atlanta	57.2	34.4	5.0	3.4	94.0	6.0	--	--
Boston	89.1	8.9	--	2.0	49.5	50.5	--	--
Chicago	65.4	23.1	5.1	6.6	85.0	13.7	--	1.3
Dallas	79.4	15.3	--	5.4	66.4	19.6	14.0	--
Denver	85.7	10.7	--	3.6	70.7	29.3	--	--
Detroit	59.0	24.7	4.1	12.1	87.5	10.5	--	2.0
Honolulu	97.6	--	--	2.4	--	97.6	--	2.4
Houston	78.0	21.3	--	0.7	59.2	20.0	20.8	--
Kansas City	90.9	4.0	--	5.1	91.5	8.2	--	0.3
Los Angeles	80.5	18.6	--	0.9	52.7	8.8	38.5	--
Miami	52.1	30.5	13.6	3.8	97.7	--	--	2.3
New York	78.4	15.4	--	6.1	83.1	16.5	--	0.4
Philadelphia	70.9	22.1	--	7.0	66.4	33.2	--	0.4
San Francisco	84.8	12.1	--	3.3	41.2	5.7	52.2	0.9
Seattle	58.3	37.4	--	4.3	84.9	13.1	--	2.0
Washington, D.C.	78.4	12.6	--	9.1	81.3	18.5	--	0.2
Hub City Total	75.0	18.0	2.0	5.0	71.0	18.0	10.0	1.0

Table A-7. Comparison of Operating, Traffic, and Financial Statistics for Airlines with Approximately 5 Million Passengers in Year Ending 31 December 1970

		Braniff 1970 Domestic			Continental 1970			Allegheny 1970			PSA 1970, Airline Only		
1	Traffic Statistics (000)												
2	Revenue Passengers	5700			5070			5917			5162		
3	Revenue Passenger Miles (RPM)	3,375,320			4,433,901			1,682,840			1,585,392		
4	Available Seat Miles (ASM)	7,278,961			8,668,211			3,897,075			3,150,000		
5	Revenue Passenger Load Factor	46.4%			51.2%			43.2%			50.2%		
6	Operating Statistics												
7	Number of Aircraft in Service, Avg	63			62			68			25		
8	Number of Airports Served	33			27			57			8		
9	Number of Employees	Not Available			8329			4876			2300		
10	Average Passenger Trip Length	593			873			294			307		
11	Average Stage Length	435			559			190			228		
12	Average Available Seats/Aircraft	107.1			107.8			79.1			144.3		
13	Fare Per Revenue Passenger Mile	6.2¢			5.5¢			8.4¢			4.6¢		
14	Financial Statistics (000)												
15	Operating Revenues	Amount, $		Percent	Amount, $		Percent	Amount, $		Percent	Amount, $		Percent
16	Passenger	209,575		89.6	242,579		84.1	141,812		91.5	72,950		97.7
17	Other Transport	23,479		10.1	47,798		16.4	10,313		6.7	1,018		1.3
18	Incidental & Subsidy	678		.3	(1,011)		(.5)	2,512		1.8	715		1.0
19	TOTAL OPERATING REVENUE	233,732	100.0	100.0	289,366	100.0	100.0	154,635	100.0	100.0	74,694	100.0	100.0
20	Operating Expenses												
21	Direct Expenses	Amount		Percent	Amount		Percent	Amount		Percent	Amount		Percent
22	Flight Operations	73,937		60.3	73,466		51.2	46,731		58.3	19,778		49.3
23	Maintenance, Direct	22,739		18.6	27,613		19.2	14,121		18.9	8,226		20.4
24	Maintenance, Indirect	10,690		8.7	17,095		11.9	9,785		13.0	1,639		4.1
25	Depreciation, Flt. Equip.	15,203		12.4	25,383		17.7	7,367		9.8	10,579		26.2
26	TOTAL DIRECT EXPENSE	122,569	52.4	100.0	143,557	49.6	100.0	78,004	50.5	100.0	40,222	53.9	100.0
27	Indirect Expenses												
28	Passenger Service	21,473		20.4	33,370		26.9	10,206		15.4	5,509		22.4
29	Aircraft & Travel Service	45,062		42.8	40,349		32.4	33,093		50.0	7,503		30.5
30	Promotion & Sales	25,291		24.0	30,829		24.9	13,834		20.9	5,943		24.1
31	General & Administration	10,820		10.3	15,115		12.2	7,095		10.7	4,755		19.3
32	Depreciation, Other	2,617		2.5	4,423		3.6	1,290		2.0	925		3.7
33	TOTAL INDIRECT EXPENSE	105,263	45.1	100.0	124,086	42.9	100.0	65,518	42.4	100.0	24,635	33.0	100.0
34	TOTAL OPERATING EXPENSE	227,832			267,643			143,522			64,857		
35	NET OPERATING INCOME	5,900			21,723			11,113			9,827		
36	Other Expenses												
37	Non Op. Income (000) & Exp.	(270)		(1.9)	(359)		(2.2)	571		5.4	0		0.0
38	Interest Expense	10,929		72.8	15,338		93.0	8,369		79.1	5,612		100.0
39	Amortization of Develop.	4,378		29.1	1,519		9.2	1,645		15.5	0		0.0
40	TOTAL OTHER EXPENSES	15,037	6.4	100.0	16,498	5.7	100.0	10,585	6.8	100.0	5,612	7.5	100.0
41	TOTAL EXPENSE	242,869			284,141			154,107			70,469		
42	OPERATING PROFIT BEFORE TAXES	(9,136)	(3.9)		5,225	1.8		528	0.3		4,215	5.6	

Table A-8. Comparison of Operating Expenses for Airlines with Approximately 5 Million Passengers in Year Ending 31 December 1970

		Cost in Cents/Available Seat Mile					Cost in Cents/Revenue Passenger Mile					Cost in Dollars/Passenger				
		Braniff	Continental	Allegheny	PSA	PSA Mod.	Braniff	Continental	Allegheny	PSA	PSA Mod.	Braniff	Continental	Allegheny	PSA	PSA Mod.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Operating Expenses					*					*					*
2	Direct Expenses															
3	Flight Operations	1.01	.85	1.20	.75	.91										
4	Maintenance, Direct	.31	.32	.36	.31	.38										
5	Maintenance, Indirect	.15	.20	.25	.06	.07										
6	Depreciation, Flt. Equip.	.21	.28	.19	.40	.49										
7	Total Direct Expense	1.68	1.63	2.00	1.52	1.85										
8	Indirect Expenses															
9	Passenger Service	.30	.38	.26	.21	.26	.64	.75	.61	.35	.43	3.76	6.58	1.75	1.07	1.30
10	Aircraft Traffic & Service	.62	.47	.85	.28	.34	1.34	.91	1.96	.47	.57	7.91	7.94	5.59	1.45	1.76
11	Promotion & Sales	.35	.36	.35	.22	.27	.75	.70	.82	.38	.46	4.44	6.08	2.34	1.15	1.40
12	General & Administration	.15	.17	.18	.18	.25	.32	.34	.42	.30	.37	1.90	2.98	1.20	0.92	1.12
13	Depreciation, Other	.04	.05	.03	.03	.04	.08	.10	.08	.06	.07	0.46	0.87	0.22	0.18	.22
14	Total Indirect Expense	1.46	1.43	1.68	.92	1.12	3.12	2.80	3.89	1.56	1.90	18.45	24.40	11.10	4.77	5.80
15	Total Operating Expenses	3.14	3.05	3.68	2.44	2.98										
16	Other Expenses															
17	Non-Operating Expense & Income	-	-	.01	-	-										
18	Interest Expense	.15	.18	.21	.21	.25										
19	Amortization of Development	.06	.02	.04	-	-										
20	Total Other Expense	.21	.20	.26	.21	.25										
21	Total Expense	3.37	3.25	3.95	2.65	3.23										

* PSA-Modified Converted to Trunk Airline Seat Density Using Ratio of Boeing 727-200 Seating As Used by PSA (158) and by Braniff (130).

Table A-9. Indirect Operating Costs for Single Class Service (PSA Density Seating)*

	Cost in Cents/Avail. Seat Mile					Cost in Cents/Revenue Pass. Mile				
	Braniff	Cont.	Allegh.	PSA	3-Avg.	Braniff	Cont.	Allegh.	PSA	3-Avg.
1. Direct Expenses										
2. Passenger Service	. 25	. 31	. 24	. 21	. 27	. 53	. 62	. 56	. 35	. 57
3. Aircraft Traffic & Service	. 51	. 39	. 78	. 28	. 56	1. 10	. 76	1. 79	. 47	1. 21
4. Promotion & Sales	. 29	. 30	. 32	. 22	. 30	. 62	. 58	. 75	. 38	. 65
5. General & Administrative	. 12	. 14	. 16	. 18	. 14	. 26	. 28	. 38	. 30	. 31
6. Depreciation, Other	. 03	. 04	. 03	. 03	. 03	. 08	. 07	. 06	. 06	. 07
7. Total Indirect Expense	1. 20	1. 18	1. 51	. 92	1. 30	2. 56	2. 30	3. 54	1. 56	2. 82

*Costs have been modified to adjust to PSA configuration seating by using Boeing 727-200 available seats for each airline divided by the PSA Boeing 727-200 available seats. The factors are:

Braniff = 130/158
Continental = 130/158
Allegheny = 144/158
PSA = 158/158

Table A-10. Indirect Operating Cost (IOC) Comparison

Airline	PSA	Allegheny		Braniff		Continental	
Aircraft Seats, Avg.	144	87		130		131	
Load Factor	.60	.43		.46		.52	
Avg. Stage Length	228	190		435		559	
Type Market	Dense	Dense	Spread	Dense	Spread	Dense	Spread
Number of Airports	8	8	57	8	33	8	27
Meals	No	No	Yes	No	Yes	No	Yes
IOCs in Dollars/Trip							
Actual IOC	306	---	255	---	650	---	860
Empirical IOC	305	133	245	406	678	617	870
Initial Study IOC	306	166	---	338	---	398	---
Revised Study IOC	306	159	---	396	---	604	---

Table A-11. Initial Indirect Operating Cost Analysis, PSA - CY 1970

Operating Statistics	
Average Passenger Trip	307.1109
Average Aircraft Size	144.319
Average Stage Length	227.7819
Assumed Load Factor	60%
Revenue Passenger Miles	2,642,320
ASM Per Trip	32,873.256

Operating Costs & Statistics	
RPM Per Departure	19,723.9577
Average No. Pass/Departure	86.5914
IOC CY 1970 (000)	$24,625.9

Aerospace Cost Allocation

	Percent of Total Cost	Number of Passengers %	Number of Passengers % of Total	Number of Departures %	Number of Departures % of Total	Aircraft Size %	Aircraft Size % of Total	Avail. Seat Miles %	Avail. Seat Miles % of Total
Passenger Service									
Stewardess Expense	12.77%	30%	3.831%			70%	8.939%		
Passenger Food	1.30	80	1040			20	.260		
Other Passenger Service	8.30	82	6.806			18	1.494		
	22.37		11.677				10.693		
Aircraft & Traffic Service									
Landing Fees	6.85					100	6.850		
Aircraft Terminal Opns.	23.62	42	9.920	30	7.086	28	6.614		
	30.47		9.920		7.086		13.464		
Reservations & Ticket Sales									
Passenger Commissions	6.08	100	6.080						
Reservation & Ticket Offices	9.76	42	4.099					58	5.661
	15.84		10.179						5.661
Sales & Advertising	8.26	40	3.304					60	4.956
General & Administrative	19.30							100	19.30
Depreciation Ground Property	3.76					49	1.842	51	1.918
Total Percent	100.0%		35.080%		7.086%		25.999%		31.835%
Percent Per Departure		.405121		7.086%		.1801495%		.968416%	
IOC Cost Formula	$306.3723	$1.241178 (No. Pass.)		$21.7095(No. Departs.)		$.551928(Aircraft Size)		.00296696 (ASN)	
Annual Operating Statistics		5,162,278		80,379		144,319		1,585,392,000	

Table A-12. Revised Indirect Operating Cost Analysis Per Departure IOC Derivation

ITEM	PSA %	IOC SEGMENT DISTRIBUTION				
		CONSTANT	NO. PAX	CAPACITY	AVSM	RPMI
PASSENGER SERVICE						
STEWARDESS EXPENSE	12.77				(80) 10.2160	(20) 2.554
PASSENGER FOOD	0.48				(80) 0.3840	(20) 0.0960
PASSENGER LIABILITY INS.	5.32					(100) 5.3200
OTHER PAX SERVICE	3.80		(47) 1.7860		(30) 1.1400	(23) 0.8740
AIRCRAFT & TRAFFIC SERVICE						
LANDING FEES	6.85			(100) 6.8500		
AIRPORT TERMINAL OPS	23.62	(30) 7.0860	(42) 9.9204	(28) 6.6136		
RESERVATIONS & TICKET SALES						
PASSENGER COMMISSIONS	6.08					(100) 6.0800
RESERVATIONS & TICKET OFF	9.76		(42) 4.0992		(58) 5.6608	
ADVERTISING & PUBLICITY	8.26		(40) 3.3040		(60) 4.9560	
GENERAL & ADMINISTRATIVE	19.30				(100) 19.3000	
DEPRECIATION (GROUND PROP)	3.76			(49) 1.8424	(51) 1.9176	
TOTAL	100.00	7.0860	19.1096	15.3060	43.5744	14.9240

FROM PSA DATA: AVERAGE CAP = 144.319, NON-STOP STAGE LENGTH = 227.7819MI, AVSM = 32873.256
DEP/YR = 80379, ANNUAL IOC = $24,625,900, IOC/DEP = 306.27

ASSUME: AVERAGE LOAD FACTOR = 0.60, THEN: AVE. NO. PAX = 86.5914, RPMI = 19723.9536

$$\text{THEN IOC/DEP} = \frac{306.37}{100}\left[7.086 + \frac{19.1096}{86.5914}(\text{No PAX}) + \frac{15.3060}{144.319}(\text{CAP}) + \frac{43.5744}{32873.256}(\text{AVSM}) + \frac{14.9240}{19723.9536}(\text{RPMI})\right]$$

$$= 21.7094 + 0.676119\,(\text{No PAX}) + 0.324926\,(\text{CAP}) + 0.00406102\,(\text{AVSM}) + 0.00231813\,(\text{RPMI})$$

Table A-13. Trunk System Load Factors

AIR CARRIER	Actual Load Factors, % 1965	1966	1967	1968	1969	Adjusted Load Factor, %
AMERICAN	58.8	63.2	59.9	55.7	52.7	57.3
BRANIFF	54.7	58.3	51.2	53.5	48.5	51.5
CONTINENTAL	48.3	55.3	48.0	47.7	50.0	55.8
DELTA	58.6	66.0	61.7	58.8	52.6	56.3
EASTERN	56.2	58.8	58.7	55.0	50.6	53.1
NATIONAL	52.5	52.5	53.1	46.6	43.1	49.2
NORTHEAST	54.3	58.2	52.9	46.3	43.1	46.9
NORTHWEST	53.4	55.1	55.3	51.8	46.6	55.1
TWA	53.7	53.5	54.8	49.5	48.4	55.5
UNITED	53.8	56.7	58.4	53.5	51.3	55.9
WESTERN	56.0	61.1	56.9	54.3	48.1	55.7
	55.2	58.5	57.2	53.0	50.0	55.0

Table A-14. Populations (000)

SMSA	1970	1980	1990
ALBANY	721.0	784.5	840.2
ATLANTA	1390.0	1604.9	1820.2
AUSTIN	296.0	344.7	397.2
BALTIMORE	2071.0	2234.4	2377.7
BOSTON	2754.0	2898.7	3012.2
BUFFALO	1349.0	1415.2	1460.5
CHICAGO	6979.0	7503.2	7989.4
CINCINNATI	1373.0	1426.4	1542.6
CLEVELAND	2064.0	2204.6	2316.1
COLUMBUS	916.0	1002.6	1079.8
DALLAS/FT. W	2318.0	2699.9	3115.9
DENVER	1228.0	1405.6	1577.2
DES MOINES	286.0	301.6	315.6
DETROIT	4434.0	4705.5	4927.3
FRESNO	413.0	462.6	486.0
GREENSBORO	604.0	662.2	719.5
HARTFORD	1220.0	1351.7	1474.5
HOUSTON	1958.5	2246.0	2535.0
INDIANAPOLIS	1110.0	1215.1	1311.5
JACKSONVILLE	529.0	600.0	670.3
KANSAS CITY	1254.0	1371.7	1486.4
LOS ANGELES	9596.0	10497.5	11200.2
LAS VEGAS	273.0	320.3	364.3
LOUISVILLE	819.0	886.1	945.6
MEMPHIS	770.0	848.3	921.7
MIAMI	1268.0	1464.1	1661.7
MILWAUKEE	1404.0	1513.9	1611.8
MINNEAPOLIS	1814.0	1990.3	2195.8
NEW ORLEANS	1046.0	1182.9	1320.0
NORFOLK	681.0	730.2	767.5

SMSA	1970	1980	1990
N.Y./N.J.	14166.0	15138.1	15951.3
OKLAHOMA CITY	641.0	717.5	756.7
OMAHA	540.0	587.8	635.5
PHILADELPHIA	4818.0	5187.5	5482.8
PHOENIX	968.0	1128.0	1301.3
PITTSBURG	2401.0	2450.5	2485.9
PORTLAND	1009.0	1122.5	1233.9
PROVIDENCE	900.0	1403.5	1465.4
RALEIGH	419.0	474.4	541.5
RENO	121.0	145.8	171.2
RICHMOND	516.0	563.7	611.7
ROCHESTER	883.0	971.8	1057.7
SACRAMENTO	801.0	930.0	1037.7
SALINAS	250.0	284.4	327.4
SALT LAKE	558.0	623.8	689.3
SAN ANTONIO	864.0	958.6	1054.3
SAN DIEGO	1358.0	1503.1	1661.7
SEATTLE	1422.0	1596.2	1763.9
S.F./OAKLAND	4174.0	4515.3	4827.3
SPOKANE	287.0	304.1	318.3
ST. LOUIS	2363.0	2565.6	2766.2
SYRACUSE	636.0	694.3	750.3
TAMPA	1106.0	1234.6	1115.6
TUCSON	352.0	396.4	439.6
WASHINGTON D C	2836.0	3186.9	3529.7
DAYTON	10070.0	1087.0	1119.0
HONOLULU	629.0	757.0	885.0
LIHUE, KAUAI	30.0	31.3	32.3
HILO, HAWAII	26.0	26.7	27.1
KAHULI	46.0	48.0	49.3
KAILUE	34	35.5	36.5

Table A-15. Predicted Travel Demand

CITY-PAIR	Car Dist.	Air Dist.	Annual Person Trips (000) All-Modes 1970	1980	1990	Annual Person Trips by Air (000) Competition Market (55% LF) Min 80	Max 80	Min 90	Max 90	Non-Competition Market (65% LF) Min 80	Max 80	Min 90	Max 90
LOS ANGELES-SAN FRANCISCO	417	354	11969.3	14544.8	16079.0	6174.7	6937.9	6826.0	7669.7	7288.0	8188.7	8056.7	9052.5
BOSTON-NEW YORK	219	190	6502.9	7678.0	9209.8	2908.0	3947.4	3488.2	4734.9	3464.4	4025.2	4155.6	4828.3
NEW YORK-WASHINGTON	230	216	7800.0	10015.5	12203.3	2726.4	4136.2	3322.0	5039.7	3457.9	4276.6	4213.3	5210.8
LOS ANGELES-SAN DIEGO	120	102	24763.2	29729.7	32928.4	1164.2	1308.1	1289.5	1448.8	1878.6	2110.8	2080.7	2337.9
LOS ANGELES-LAS VEGAS	280	226	5176.5	7480.3	8411.6	1715.2	2901.9	1928.7	3263.2	2261.8	3161.3	2543.4	3554.9
NEW YORK-DETROIT	665	489	1650.0	1415.7	1858.2	868.2	1037.6	1139.6	1362.0	1010.3	1183.7	1326.1	1553.7
SAN DIEGO-SAN FRANCISCO	537	465	1568.1	2393.7	3273.0	1235.6	1388.3	1689.5	1898.4	1299.5	1460.2	1776.9	1996.5
NEW YORK-PITTSBURG	378	330	2055.4	2456.2	3023.9	1028.5	1441.2	1266.2	1774.3	1190.8	1619.3	1466.0	1993.6
LOS ANGELES-SACRAMENTO	381	380	1984.8	3153.6	3857.9	1037.5	1094.3	1269.2	1338.7	1237.8	1390.7	1514.2	1701.3
NEW YORK-CLEVELAND	507	410	1413.0	1909.2	2506.6	1112.5	1396.5	1460.6	1833.4	1228.7	1506.6	1613.2	1978.0
CHICAGO-DETROIT	296	238	2502.2	3240.4	4159.5	952.7	1545.7	1222.9	1984.1	1187.3	1814.6	1524.0	2329.3
CHICAGO-MINNEAPOLIS	419	345	2158.5	3098.5	4299.1	1149.8	1659.7	1595.3	2302.8	1344.4	1905.7	1865.3	2644.2
BOSTON-WASHINGTON	449	406	1034.3	1590.1	2185.2	1015.3	1270.0	1395.3	1745.3	1112.5	1394.8	1528.8	1916.8
NEW YORK-BUFFALO	397	289	1609.1	2058.8	2719.5	884.7	1228.2	1168.6	1622.3	1017.4	1386.1	1343.9	1831.0
CHICAGO-ST. LOUIS	293	256	2055.8	2863.4	3935.8	798.7	1261.7	1097.9	1734.2	1006.4	1377.4	1383.3	1893.2
LOS ANGELES-PHOENIX	399	358	964.5	1797.0	2541.7	940.4	1239.9	1330.1	1753.8	1056.0	1378.4	1493.6	1949.6
NEW YORK-ROCHESTER	327	252	1372.4	2013.4	2525.0	737.3	1073.1	924.6	1345.8	878.9	1183.8	1102.2	1484.5
BOSTON-PHILADELPHIA	309	274	1369.0	1820.9	2453.7	655.0	954.7	882.6	1286.4	785.4	1041.0	1058.3	1402.7
CHICAGO-CLEVELAND	345	311	1128.7	1592.7	2150.7	664.2	911.0	896.8	1230.2	773.2	1030.5	1044.1	1391.5
HONOLULU,LIHUE,KAUAI,HAWAII	0	101	361.0	565.3	779.8	565.3	565.3	779.8	779.8	565.3	565.3	779.8	779.8
DALLAS/FT. WORTH-HOUSTON	243	223	1908.1	3520.9	5260.2	815.0	1330.6	1217.6	1987.8	1073.6	1397.5	1603.9	2087.8
NEW YORK-SYRACUSE	260	197	1319.2	1908.9	2767.3	596.1	887.6	864.1	1286.8	736.4	937.3	1067.6	1358.7
HONOLULU-HILO,HAWAII	0	216	341.0	520.4	709.2	520.4	520.4	709.2	709.2	520.4	520.4	709.2	709.2
PHILADELPHIA-PITTSBURG	306	274	1980.6	2400.6	2992.5	536.8	930.8	669.2	1160.3	709.2	1041.4	884.1	1298.2
HONOLULU,KAHULUI,MAUI,HAWAII	0	100	294.0	473.0	663.9	473.0	473.0	663.9	663.9	473.0	473.0	663.9	663.9
CHICAGO-KANSAS CITY	504	407	632.3	1037.0	1583.0	609.1	764.1	929.9	1166.4	672.2	825.7	1026.1	1260.5
CHICAGO-PITTSBURG	475	403	1178.7	1490.4	1925.6	527.0	758.6	680.9	980.1	617.0	866.8	797.2	1119.9
BALTIMORE-NEW YORK	188	180	1246.5	1754.6	2352.4	429.5	634.9	575.9	851.2	551.4	637.3	739.3	854.4
NEW YORK-COLUMBUS	563	472	568.7	916.1	1278.6	492.7	617.7	687.7	862.2	553.8	624.1	773.0	871.1
DETROIT-WASHINGTON	534	391	568.3	975.5	1413.6	520.9	660.2	754.8	956.7	582.2	696.7	843.6	1009.7
MIAMI-TAMPA	251	199	1571.4	2870.2	4392.6	543.0	972.2	831.0	1487.9	754.0	1036.0	1153.9	1585.6
DETROIT-PHILADELPHIA	601	452	573.7	855.2	1248.4	424.9	535.1	620.2	781.1	489.3	493.5	714.2	720.4
SAN FRANCISCO-LAS VEGAS	582	419	682.5	1329.0	1805.5	578.8	754.9	786.3	1025.6	672.4	730.3	913.5	992.2
SAN FRANCISCO-RENO	232	187	4755.6	7218.5	10038.6	634.2	1656.9	882.0	2304.3	1162.1	1763.5	1616.1	2452.5
CHICAGO-INDIANAPOLIS	193	168	3854.5	5102.6	5830.6	439.6	1053.6	502.3	1203.9	797.3	1066.4	911.0	1218.5
SEATTLE-PORTLAND	178	132	1922.3	3078.5	4487.7	400.9	739.9	584.4	1078.5	610.3	737.8	889.6	1075.6
HOUSTON-NEW ORLEANS	368	303	946.3	1860.1	2980.9	549.5	862.7	880.7	1382.4	674.0	992.3	1080.2	1590.2
CHICAGO-CINCINNATI	304	254	612.7	930.3	1240.0	356.2	508.6	474.8	677.9	423.1	550.6	564.0	733.9
NEW YORK-PROVIDENCE	179	149	2474.4	4578.7	7553.0	482.9	990.4	796.6	1633.7	795.0	988.2	1311.5	1630.1
KANSAS CITY-ST. LOUIS	247	230	705.9	1176.4	1814.3	356.2	530.4	549.4	818.0	442.7	554.6	682.7	855.3
SEATTLE-SPOKANE	272	223	1029.4	1605.7	2432.1	363.6	614.9	550.8	931.3	481.3	664.9	729.1	1007.1
DETROIT-CLEVELAND	165	93	1103.2	1172.6	1519.2	238.0	267.4	308.3	346.4	249.1	318.1	322.7	412.1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

CITY-PAIR	Car Dist.	Air Dist.	Annual Person Trips (000) All-Modes 1970	1980	1990	Annual Person Trips by Air (000) Competition Market (55% LF) Min 80	Max 80	Min 90	Max 90	Non-Competition Market (65% LF) Min 80	Max 80	Min 90	Max 90
WASHINGTON-PHILADELPHIA	137	133	2615.4	3756.8	4963.5	314.1	599.4	415.0	791.9	536.6	586.7	709.0	775.1
WASHINGTON-PITTSBURG	239	194	650.0	982.4	1325.8	299.8	442.0	404.6	596.5	371.8	459.1	501.8	619.6
PHILADELPHIA-CLEVELAND	436	366	466.7	725.9	1065.0	341.5	459.3	501.1	673.8	386.3	517.1	566.8	758.6
NEW YORK-ALBANY	156	138	2569.2	3426.1	4652.3	298.7	617.1	405.6	838.0	517.6	605.8	702.9	822.6
WASHINGTON-CLEVELAND	369	298	713.0	1197.6	1675.2	384.1	585.7	537.3	819.3	464.2	669.5	649.3	936.5
CHICAGO-COLUMBUS	294	287	1038.7	1578.1	2116.7	346.1	601.6	464.2	806.9	460.5	666.0	617.6	893.3
NEW YORK-RALEIGH	524	425	360.9	730.6	1288.1	408.2	514.2	719.7	906.5	453.5	547.6	799.5	965.5
DALLAS-SAN ANTONIO	275	254	917.6	1824.4	3018.2	415.1	702.1	686.7	1161.5	548.7	761.3	907.7	1259.5
NEW YORK-PHILADELPHIA	90	84	15600.0	21388.9	25111.1	503.4	1026.4	591.0	1205.0	768.9	1001.9	902.7	1176.3
NEW YORK-HARTFORD	128	106	9437.5	11709.0	14260.1	388.8	1174.8	473.5	1430.8	1051.9	1144.5	1281.0	1393.9
NEW YORK-GREENSBORO	486	456	295.0	552.5	919.4	345.5	430.1	574.9	715.7	378.8	468.0	630.4	778.7
NEW YORK-NORFOLK	420	292	448.5	694.0	995.0	302.8	416.9	434.2	597.8	346.4	472.1	496.6	676.9
ATLANTA-JACKSONVILLE	325	275	841.2	1727.3	3093.8	424.0	711.8	759.4	1274.9	545.8	805.3	977.5	1442.4
LOS ANGELES-TUSCON	522	439	471.2	906.8	1275.6	379.6	511.6	534.0	719.6	435.7	554.5	612.9	780.0
DALLAS-NEW ORLEANS	503	423	445.2	1092.1	2124.1	472.1	635.5	918.3	1236.1	538.5	701.1	1047.3	1363.6
CHICAGO-LOUISVILLE	307	277	805.9	1229.8	1829.4	293.9	495.9	437.2	737.7	382.1	553.1	568.5	822.8
HONOLULU-KAILUA,KONA,HAWAII	0	170	137.0	249.2	376.7	249.2	249.2	376.7	376.7	249.2	249.2	376.7	376.7
BOSTON-PITTSBURG	597	496	259.6	343.5	477.1	219.1	263.6	304.3	366.1	244.5	249.2	339.6	346.1
BALTIMORE-BOSTON	410	370	311.6	497.5	730.5	265.4	347.8	389.8	510.7	297.0	386.9	436.1	568.2
CHICAGO-DAYTON	297	231	517.6	752.4	992.9	241.1	363.3	318.1	479.4	295.5	395.0	389.9	521.3
LOS ANGELES-SALINAS	322	273	1040.0	1850.4	2722.4	368.9	676.7	542.8	995.5	499.8	774.5	735.4	1139.5
ATLANTA-TAMPA	462	244	406.3	991.6	1766.5	427.6	584.2	761.8	1040.7	487.7	659.7	868.9	1175.3
DETROIT-MILWAUKEE	382	409	498.0	766.8	1094.0	268.4	397.1	382.9	566.6	318.8	453.5	454.8	647.0
DENVER-SALT LAKE CITY	507	382	793.5	1556.6	2400.7	432.2	663.8	666.6	1023.7	527.0	753.6	812.8	1162.2
DETROIT-ST. LOUIS	521	451	464.2	745.3	1140.4	289.6	398.2	443.2	609.3	335.6	434.1	513.6	664.2
CHICAGO-OMAHA	482	423	341.7	611.8	1009.0	293.5	387.7	484.0	639.4	330.4	430.6	544.9	710.2
CHICAGO-MEMPHIS	518	485	447.3	787.2	1254.4	313.7	428.9	499.8	683.4	362.1	468.5	577.0	746.5
WASHINGTON-HARTFORD	346	319	345.7	746.6	1216.1	323.2	448.7	526.4	730.9	374.6	495.2	610.2	806.7
CHICAGO-DES MOINES	343	306	502.1	759.6	1140.1	240.7	368.3	361.2	552.7	293.2	414.8	440.0	622.5
DALLAS-OKLAHOMA CITY	216	185	828.6	1612.1	2533.6	286.7	502.4	450.5	789.5	403.2	517.1	633.6	812.7
WASHINGTON-NORFOLK	190	149	1487.2	2262.5	2952.6	245.1	512.9	319.9	669.4	402.9	517.0	525.7	674.7
NEW YORK-RICHMOND	338	278	351.5	616.1	959.5	252.7	356.0	393.5	554.4	295.5	392.5	460.2	611.3
MILWAUKEE-MINNEAPOLIS	347	298	504.3	889.6	1391.7	278.7	428.2	435.9	669.9	339.8	484.0	531.6	757.2
DETROIT-PITTSBURG	295	197	1352.9	1630.4	1996.0	244.0	508.3	298.7	622.3	362.1	575.6	443.3	704.7
JACKSONVILLE-MIAMI	355	330	497.8	1151.5	2241.6	358.1	552.0	697.2	1074.6	436.5	627.4	849.8	1221.4
SACRAMENTO-SAN FRANCISCO	93	74	16000.0	20281.5	23678.1	870.0	977.6	1015.7	1141.3	1010.8	1135.8	1180.1	1326.0
LOS ANGELES-FRESNO	215	213	1019.0	1588.0	2061.1	226.3	438.0	293.8	568.4	341.0	451.9	442.6	586.6
CHICAGO-BUFFALO	564	467	254.8	407.9	657.4	221.4	277.0	356.8	446.4	248.7	279.3	400.8	450.1
SAN FRANCISCO-FRESNO	195	164	2971.4	4051.7	5285.2	270.2	763.0	352.5	995.2	555.2	775.1	724.2	1011.1
BOSTON-BUFFALO	459	396	174.8	266.8	424.3	189.6	231.9	301.5	368.7	205.8	252.4	327.3	401.3
DETROIT-INDIANAPOLIS	278	241	403.9	672.6	814.7	210.9	317.3	255.5	384.3	260.1	340.0	315.1	411.8
PHILADELPHIA-BUFFALO	398	282	309.1	476.3	750.8	204.8	284.2	322.9	448.1	235.5	320.9	371.2	505.8
DALLAS-KANSAS CITY	519	488	367.3	858.9	1567.4	342.3	467.8	624.6	853.7	395.2	510.4	721.1	931.4
ATLANTA-MEMPHIS	384	332	448.9	976.4	1703.5	313.1	476.9	546.2	832.0	377.1	549.1	657.9	958.1
DALLAS/FT. WORTH-AUSTIN	196	187	1111.1	2375.5	4097.9	289.8	580.1	499.8	1000.8	457.1	587.9	788.5	1014.1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

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A-5 Air Carrier Traffic Statistics, Civil Aeronautics Board, December 1970, Volume XVI-12.

A-6 Braniff Airways, Incorporated Annual Report, 1970.

A-7 Continental Airlines 1970 Annual Report.

A-8 Allegheny Airlines, Inc. 1970 Annual Report.

APPENDIX B

AVAILABLE AIRCRAFT TECHNOLOGY

CONTENTS

FIGURES

FIGURES (Contined)

TABLES

APPENDIX B

AVAILABLE AIRCRAFT TECHNOLOGY

Any study of the economic viability of short haul air transportation and its environmental impact requires the definition of aircraft compatible with the projected time of introduction of the service and the transportation objectives. The pertinent considerations for this study were: a 1980 initial operating capability (IOC) and an advanced system for 1990, the use of existing airfields where possible, and the minimization of noise impact. These considerations have a significant effect upon the requirements for aircraft technology. There are a number of potential options in aircraft design to be considered. These include the powered lift STOL systems such as the externally blown flap or the augmentor wing concepts, and the VTOL systems such as the lift fan concepts. In addition to the aircraft design concept, there are the type and degree of sound suppression, the engine technology and the structures technology.

Since the first opportunity to phase in a STOL system would be as a replacement for and supplement to present CTOL aircraft used on the short haul routes, the 1980 time period is of interest, for at this time a part of the CTOL fleet will be approaching the end of normal service life. Therefore, a set of four STOL aircraft of varying passenger capacity was defined for each design type. The aircraft represent a minimum technological advancement for the 1980 IOC having the capability to use shorter runways and reduce noise significantly. The 1990 IOC allows for the consideration of a more advanced STOL technology, and the inclusion of a VTOL capability. Again, a set of four aircraft of varying passenger capacity was defined for each design type. The aerodynamic, structural and propulsion technology was defined for each aircraft and the block performance determined as a function of range to permit an economic evaluation.

The noise impact was evaluated for nominal operational paths and airport categories and capacities. These noise data were generated in the form of NEF contours for relative comparison and determination of the impacted area. The resulting designs provide for a relative assessment of technology for STOL/VTOL service introduction and implementation.

B.1 AIRCRAFT DEFINITION

a. Design Selection

In view of the number of options in aircraft design and operations that are possible for the 1980 and 1990 time periods, it was decided to define a single type of STOL design that would represent a reasonable aircraft to be anticipated for 1980, and to define a more advanced STOL and a VTOL for 1990. The most salient characteristics selected were:

1980 STOL

Field Length	3,000 ft.
Powered Lift System	Externally Blown Flap (EBF)
Passenger Size	150-Primary 50, 100, 200 - Secondary
Range	500 smi.
Structures	Aluminum Technology
Noise	Suppression to provide 95 EPNdB @ 500 ft. desired
M_{cr}	0.8 @ 30,000 ft.

1990 STOL

Field Length	2,000 ft.
Powered Lift System	Augmentor Wing (AW)

Passenger Size	150 - Primary 50, 100, 200 - Secondary
Range	500 smi.
Structure	All primary and secondary structures are composite material
Noise	Suppression to provide 85 EPNdB @ 500 ft. desired
M_{cr}	0.9 @ 30,000 ft.

1990 VTOL

Field Length	1,000 ft. (set by terminal, apron, etc. requirements)
Powered Lift System	Lift Fan (LF), (fan-in-wing type)
Passenger Size	150 - Primary 50, 100, 200 - Secondary
Range	500 smi.
Structure	All primary and secondary structures are composite material
Noise	Suppression to provide 90 EPNdB @ 500 ft. desired
M_{cr}	0.9 @ 30,000 ft.

These characteristics were then translated into aircraft designs by the use of standard design procedures for the 1980 aircraft and the use of the V/STOL Aircraft Sizing and Performance Computer Program (VASCOMP II) by ACMD for the 1990 STOL and VTOL designs. The power lift concepts used for the three designs are illustrated in Figure B-1.

b. <u>1980 Externally Blown Flap STOL</u>

The basic aircraft design is illustrated in Figure B-2. The propulsion system used is based on the P & W STF-344 engine design study. This engine is typical of current "paper" engines and could be available for 1980, but additional noise suppression would have to be incorporated into the design to approach the desired noise levels.

Reference to the section on airport requirements and capacities (Appendix D) will indicate that there is no requirement for a field length capability of less than 3000 ft. where available airports, traffic requirements and passenger convenience are considered. This field length tends to reduce the aircraft design problem in terms of weight, wing loading and power requirements. The aircraft geometry and mission characteristics are summarized in Table B-1. The weight and propulsion characteristics are summarized in Table B-2 which also shows a complete weight statement for the 150 passenger basic design airplane. The empty weight, engine weight and thrust of aircraft with other passenger capacities are listed in Figure B-3 and the variations as a function of passenger capacity are also shown.

A comparison of the takeoff gross weight as a function of passenger capacity is shown in Figure B-4 for 1980 EBF-STOL relative to other V/STOL design aircraft and the other aircraft of this study. A simplistic check was made of the impact of range, cruise altitude and fuel reserves by considering the additional fuel in terms of equivalent passengers. A nominal increase in TOGW of approximately 20,000 lb for the 1980 EBF STOL 150-passenger aircraft results from an increase in design range from 500 smi to 500 nmi, an increase in reserves from 100 nmi at 30,000 ft to 200 nmi at 20,000 ft, plus 15 min at 10,000 ft and cruise at 0.76 M at 20,000 ft instead of 0.8 M at 30,000 ft. Considering the differences in aircraft design range, field length requirement, fuel reserves, cruise altitude, and material technology, a reasonable level and variation relative to the other studies are shown for the basic 1980 EBF STOL.

The block performance for the 1980 EBF-STOL is shown in Table B-3 for stage lengths from 50 to 500 statute miles. These data were used in the determination of operating costs.

c. 1990 Augmentor Wing STOL

A conceptual illustration of the basic aircraft design is shown in Figure B-5. The geometry and design mission are summarized in Table B-4. The primary changes from the 1980 EBF-STOL are in the engine configuration and the wing and tail surfaces geometry. The weight and engine characteristics are summarized in Table B-5. The use of composites in the structure and a more advanced engine technology result in a lower weight than for the 1980 EBF-STOL even though a 2000 ft field length capability is specified in place of the 3000 ft for the 1980 case.

The block performance for the 1990 AW-STOL is summarized in Table B-6. The block performance mission flight profiles are shown in Figure B-6. The higher cruise Mach number for the 1990 STOL results in reduced block times, as might be expected. The reduced field length capability will result in a reduced noise impact area, but is not required for the available fields selected for STOL operations. Where a new STOL-port might be considered, the necessary size is reduced.

d. 1990 Lift-Fan VTOL

A conceptual illustration of the basic aircraft design is shown in Figure B-7. The geometry and design mission are summarized in Table B-7. The wing geometry has been altered to accommodate the lift-fan engines, and the cruise engines have been placed in a single nacelle because of the reduced wing span. The weight and engine characteristics are summarized in Table B-8. The use of composites and advanced engine technology results in a lower weight for this aircraft also. This aircraft has a vertical takeoff capability, but a reasonable ground area is required for aircraft parking, taxiing and turning.

The block performance of the 1990 LF-VTOL is summarized in Table B-9. The block performance mission flight profiles are shown in Figure B-8. The block times are further reduced from those for the 1990

AW-STOL. The VTOL capability allows the implementation of a CBD VTOLport with minimum land acquisition requirements.

B.2 AIRCRAFT NOISE DEFINITION

A potential benefit to be derived from the introduction of V/STOL aircraft is the significant reduction in noise impact on the area surrounding the airport. Partial benefits result from the reduced field length requirements with steeper approach and departure flight path angles. The full potential for noise reduction, however, requires the maximum use of noise suppression techniques on the V/STOL aircraft. The combination of V/STOL operations and full realization of noise suppression would permit the use of municipal and general aviation airports where CTOL aircraft are not welcome or are not permitted.

The definition of noise levels and of noise suppression methods is currently receiving considerable attention and study by government agencies and industry. The principal internal and external noise sources for a turbofan engine are illustrated in Figure B-9. A nominal comparison of current aircraft noise levels relative to FAA-FAR 36 is illustrated in Figure B-10. In general, most of the current aircraft are above the FAR 36 level, and are far above the desired noise level of 95 EPNdB for the 150-passenger 1980 V/STOL aircraft, 85 EPNdB for the 1990 STOL and 90 EPNdB for the 1990 VTOL. While these were the designated desired noise levels for this study and provided the basis for the NEF impact, a buildup of predicted noise level was constructed for each of the aircraft designs to provide an assessment of the R&D technology requirements.

a. 1980 EBF-STOL

The externally blown flap concept was selected for the 1980 STOL design, as indicated in the aircraft section. The noise sources for this concept are illustrated in Figure B-11. In addition, current EBF programs are indicated, the requirements to reach the desired noise level are summarized, and some new research areas to improve noise alleviation are noted. A noise buildup was made for the current study using available engine data and NASA noise test results. The noise estimate assumptions for this case were:

- Engine exhaust velocity characteristics of the P&W STF-344 design used for the aircraft.
- Flap interaction noise based on NASA research results.
- Attenuation with distance based on spherical radiation.
- Atmospheric absorption of 1 dB per 100 ft.
- No tone corrections required.
- Duration correction based on scaled CTOL data.

Considering the assumptions above and the available data, there were two possible approaches to the noise derivation:

(1) Use the NASA research data to predict the PNL at 500 ft.

(2) Use the P&W engine noise prediction and scale up for flap effects to predict PNL at 500 ft.

It was decided to derive the noise using both approaches and compare the results. In applying approach (1) a core velocity of 935 fps was used to yield 114 PNdB at 500 ft. for takeoff and a core velocity of 750 fps yielded 114 PNdB at 500 ft for landing. It was decided to use the same curve for takeoff and landing. In approach (2) a P&W estimate of 94 PNdB at 500 ft for a single engine at takeoff thrust and 90 KIAS provided the initial print. A 6 PNdB increment was added for four engines. A 10 PNdB increment was added for flap interaction and reflection effects. The result is a 114 PNdB noise level for approach (1) and a 110 PNdb noise level for approach (2), both for the 150-passenger size aircraft. The noise levels as a function of passenger size for the two approaches are compared in Figure B-12. A NASA EBF noise estimate from Reference B-1 is shown in Figure B-13 for the same class of engine. Since this reference was the basis for approach (1) the results are comparable. However, the results for both approaches are well above the desired goal.

In addition to the EBF-STOL, an evaluation was made of the AW-STOL concept for 1980. The 1980 AW-STOL did not include the sonic inlet noise suppression option as this was considered questionable for the 1980 operational capability. The resulting noise level is compared with the EBF design in Figure B-14. While a reduction in noise level is realized, it is well above the desired level. It was not considered sufficient to alter the basic 1980 aircraft design selection. The evaluation and RDT&E costing of the 1980 EBF-STOL have included factors to account for the necessary technology in the appropriate time period (i. e., 1980 IOC). Current studies indicate that in the 1980 time period the desired noise levels are more likely to be obtained with an AW design than with the EBF. However, it is felt that the choice of propulsive lift concept would not significantly affect the costing and modal split study. The PNdB data developed were converted to EPNdB by application of distance and atmospheric attenuation and duration corrections. These corrections are illustrated in Figure B-15. The resulting predicted takeoff and landing and sideline EPNdB variations with distance and aircraft size are shown in Figures B-16 and B-17 for the 1980 EBF-STOL. This represents a normal development for the EBF, but the noise level is above the NASA quiet STOL desired goal of 95 EPNdB at 500 ft. An EPNdB variation with distance and aircraft size (both takeoff and landing and sideline) that matches the design goal is shown in Figure B-18. Progress toward this goal would require accelerated RDT&E effort. The desired EPNdB noise level was used to determine noise impact, and allowance for RDT&E acceleration was made in the cost study.

The 1980 augmentor wing estimates developed for comparison are shown in Figures B-19 and B-20. These predictions do not include the sonic inlet effect. These data are for information only since the 1980 EBF-STOL was used in the study.

b. 1990 AW-STOL

The augmentor wing concept was selected for the 1990 STOL. An augmentor wing installation is illustrated in Figure B-21. Noise sources are indicated on the illustration. In addition, listed in the figure are areas of research, engine requirements and augmentor requirements for reduced noise levels. On the basis of the data available at the time of the prediction, it was determined that a 95 EPNdB level at 500 ft could be realized. These data are sufficiently promising to indicate that this noise level might be available well before 1990. On this basis, a desired noise level of 85 EPNdB was selected for the 1990 AW-STOL. The EPNdB variation with aircraft size and distance is shown in Figures B-22 and B-23 for the initial prediction of 95 EPNdB at 500 ft for the 150-passenger aircraft. The EPNdB variation for the desired level of 85 EPNdB at 500 ft is shown in Figure B-24. The desired level was used for the noise impact analysis.

c. 1990 Lift-Fan VTOL

The lift-fan VTOL concept utilizes four low BPR turbofan cruise engines and four lift fan-in-wing installations. The sound suppression techniques for the cruise engines will be the same as for CTOL or EBF turbofan engines. The lift-fans will use the standard techniques for the gas generators, but the fans will require special attention. The predicted noise levels are shown as EPNdB as a function of aircraft size and distance in Figure B-25. The desired noise levels for the LF-VTOL are shown in Figure B-26.

As previously indicated, the desired noise levels have been used to determine noise impact relative to current CTOL operations. This provides an index of what might be achieved in terms of relative noise reduction. Achievement of the desired noise levels will require favorable development of the current and future noise suppression studies. There may be changes in engine and aircraft weight and performance characteristics that will result from such things as the reduction of exhaust velocities to the 550 fps level. These changes have not been estimated here, nor has any allowance been made for such effects in the aircraft and engine performance or weights.

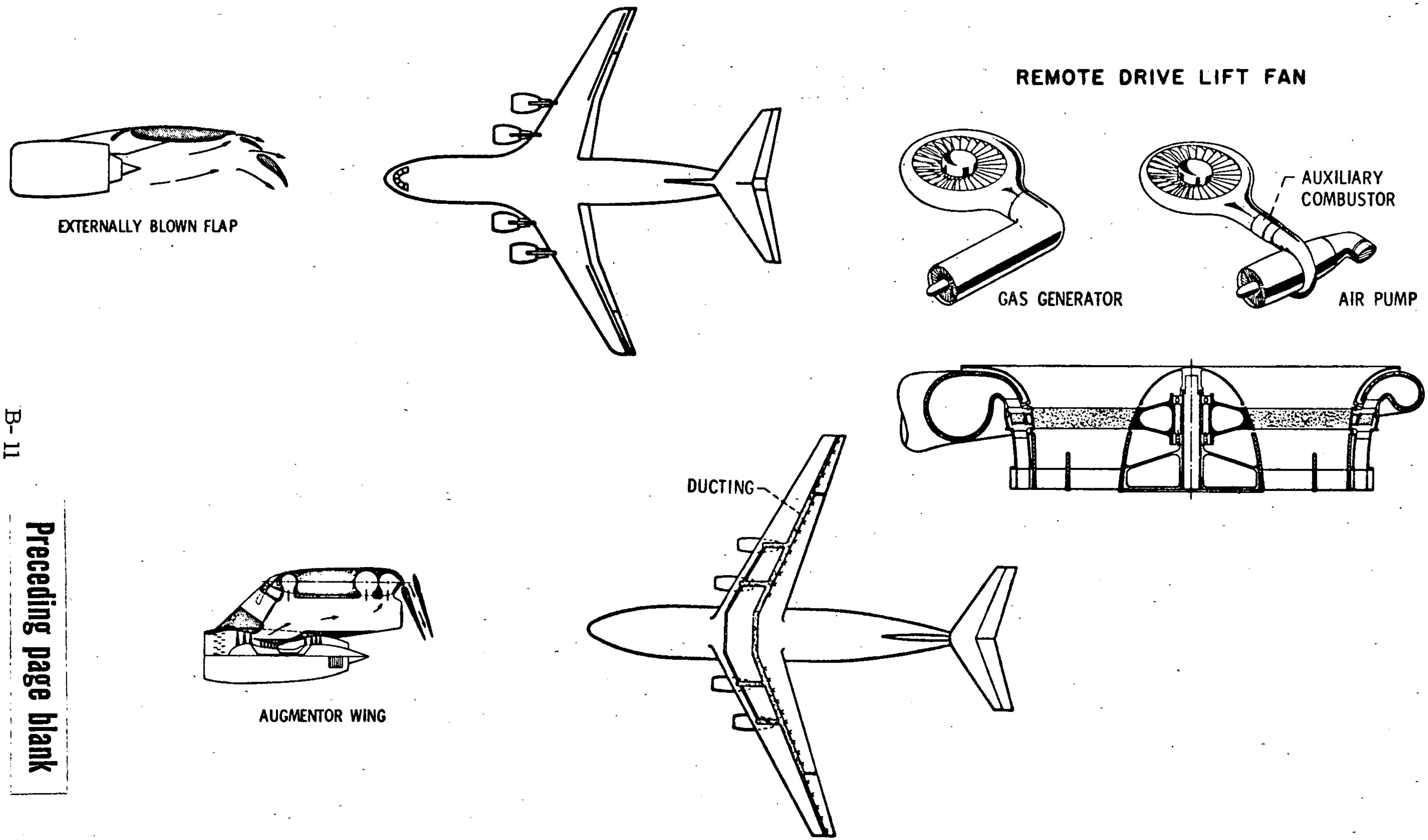


Figure B-1. Propulsive Lift Concepts

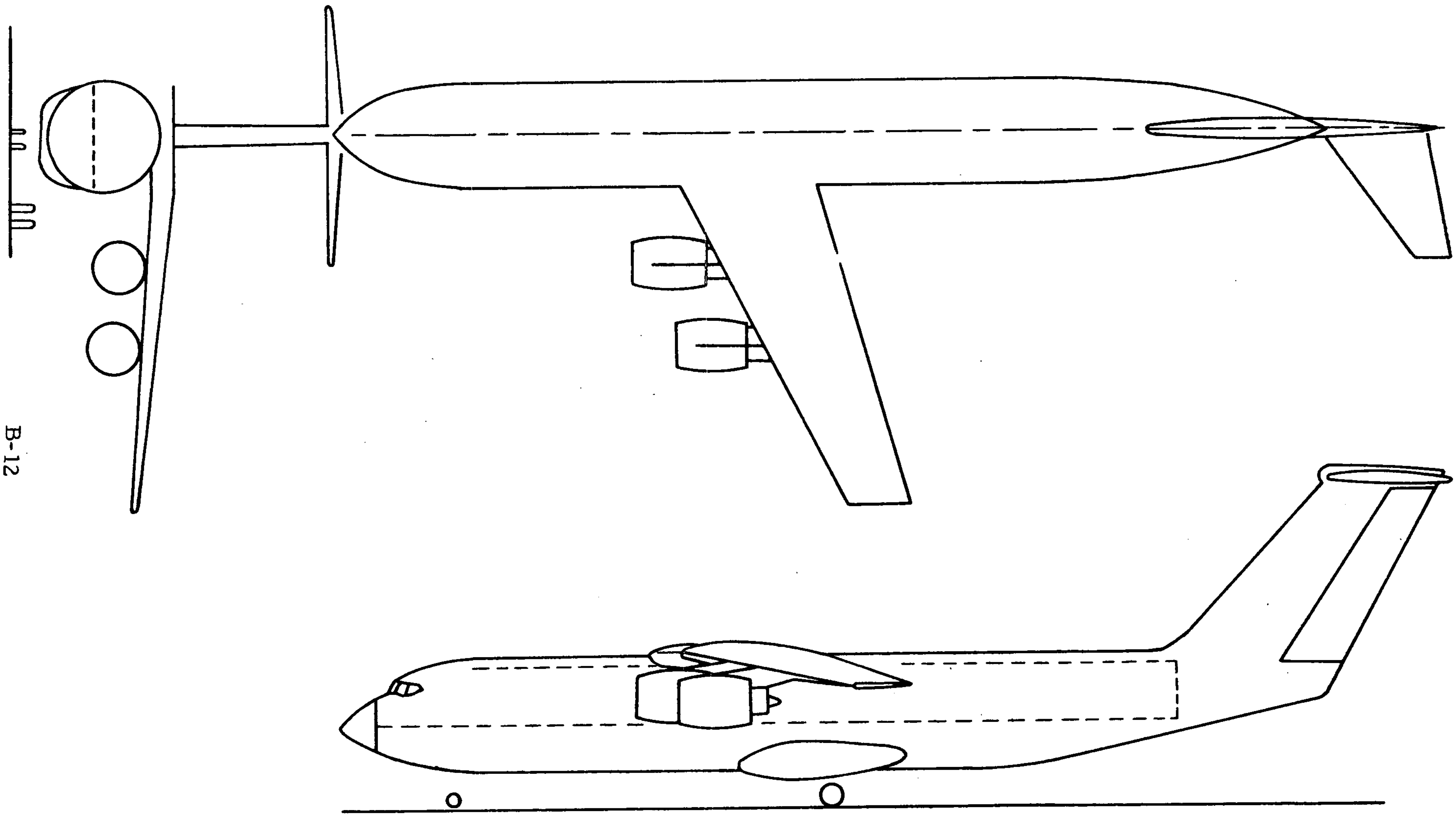


Figure B-2. 1980 Externally Blown Flap STOL

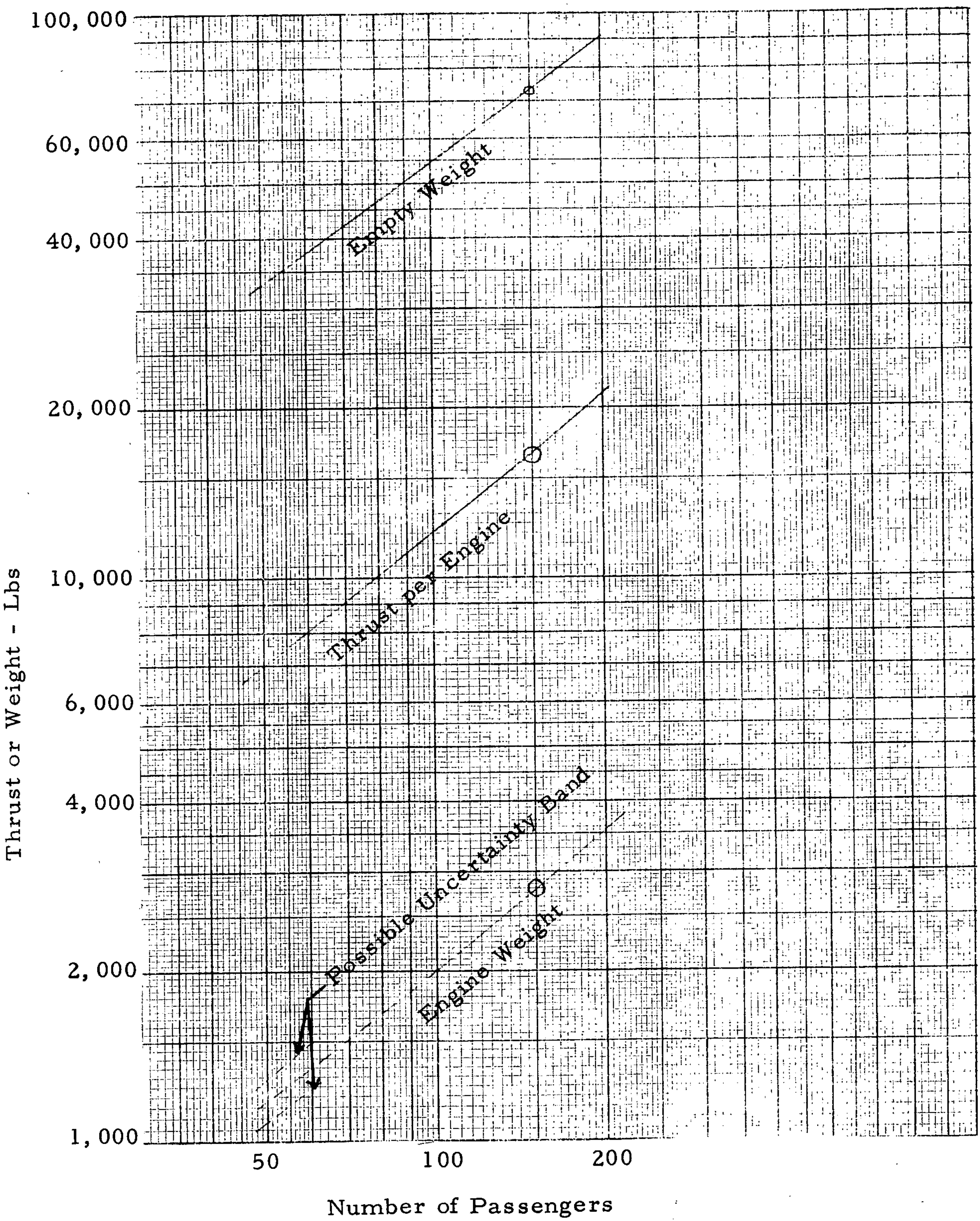


Figure B-3. 1980 STOL Externally Blown Flap Weight and Thrust Versus Passenger Capacity

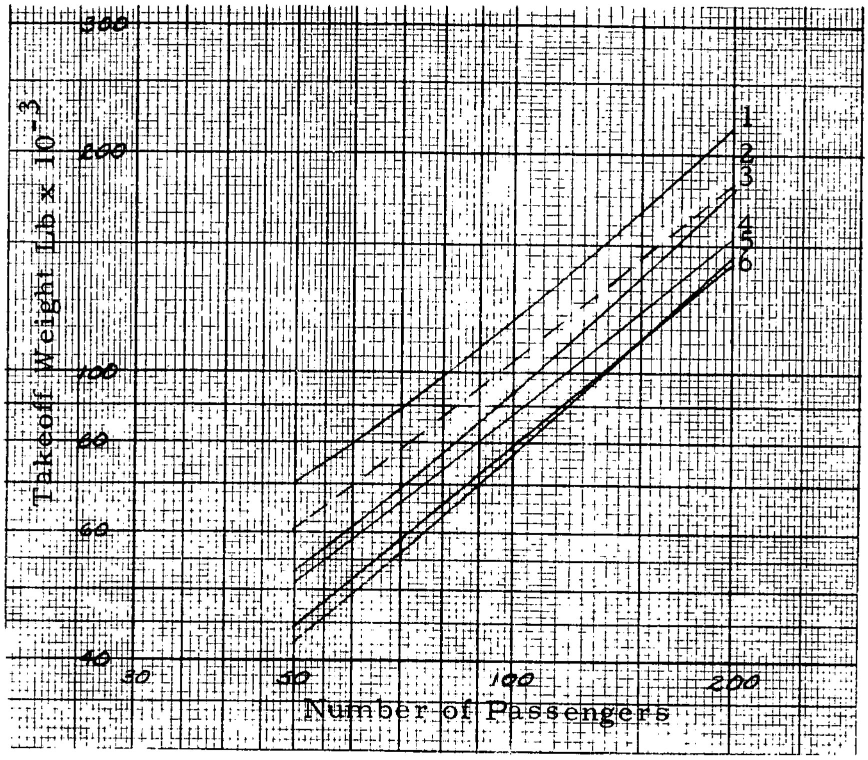


Figure B-4. Takeoff Gross Weight Summary

1. Douglas 1980 EBF Design
   Condition A, M_{cr} = 0.7
2. Aerospace 1980 EBF Design (modified)
   Condition A, M_{cr} = 0.76
3. Lockheed 1980 EBF Design
   Condition A, M_{cr} = 0.8
4. Aerospace 1980 EBF Design
   Condition B, M_{cr} = 0.8
5. ACMD/Aerospace 1990 VTOL Design
   Condition C, M_{cr} = 0.9
6. ACMD/Aerospace 1990 AW Design
   Condition D, M_{cr} = 0.9

Condition A - 500 nmi Range; 200 nmi at h_{cr} + 15 min at 10000 ft Reserves; h_{cr} = 2000 ft.

Condition B - 500 smi Range; 100 nm at h_{cr} Reserves h_{cr} = 30000 ft.

Condition C - 500 smi Range; 0.5 hr at S. L. Reserves h_{cr} = 30000 ft.

Condition D - 500 smi Range; 1.25 hr. at 10000 ft Reserves h_{cr} = 30000 ft.

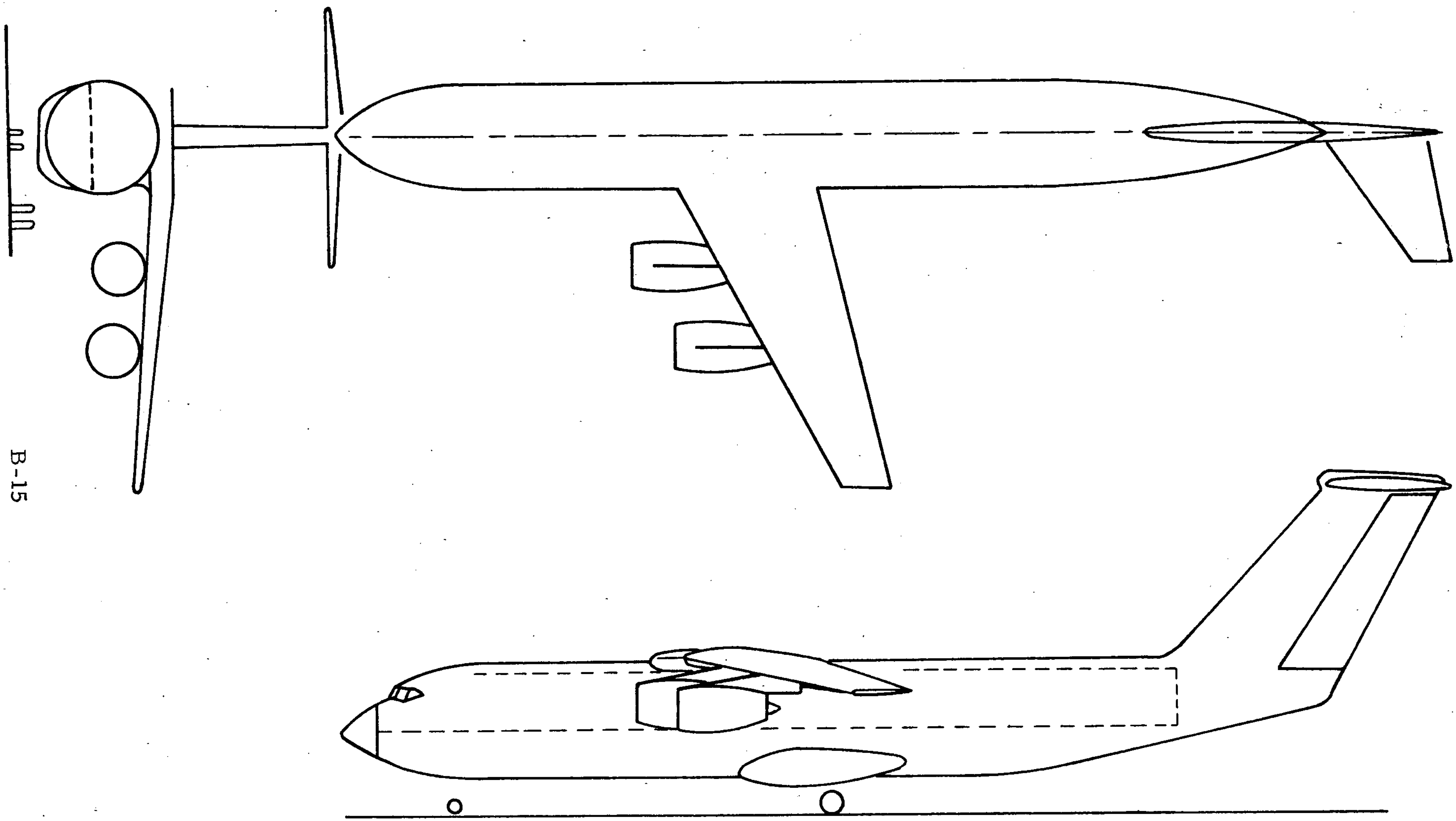


Figure B-5. 1990 Augmentor Wing STOL

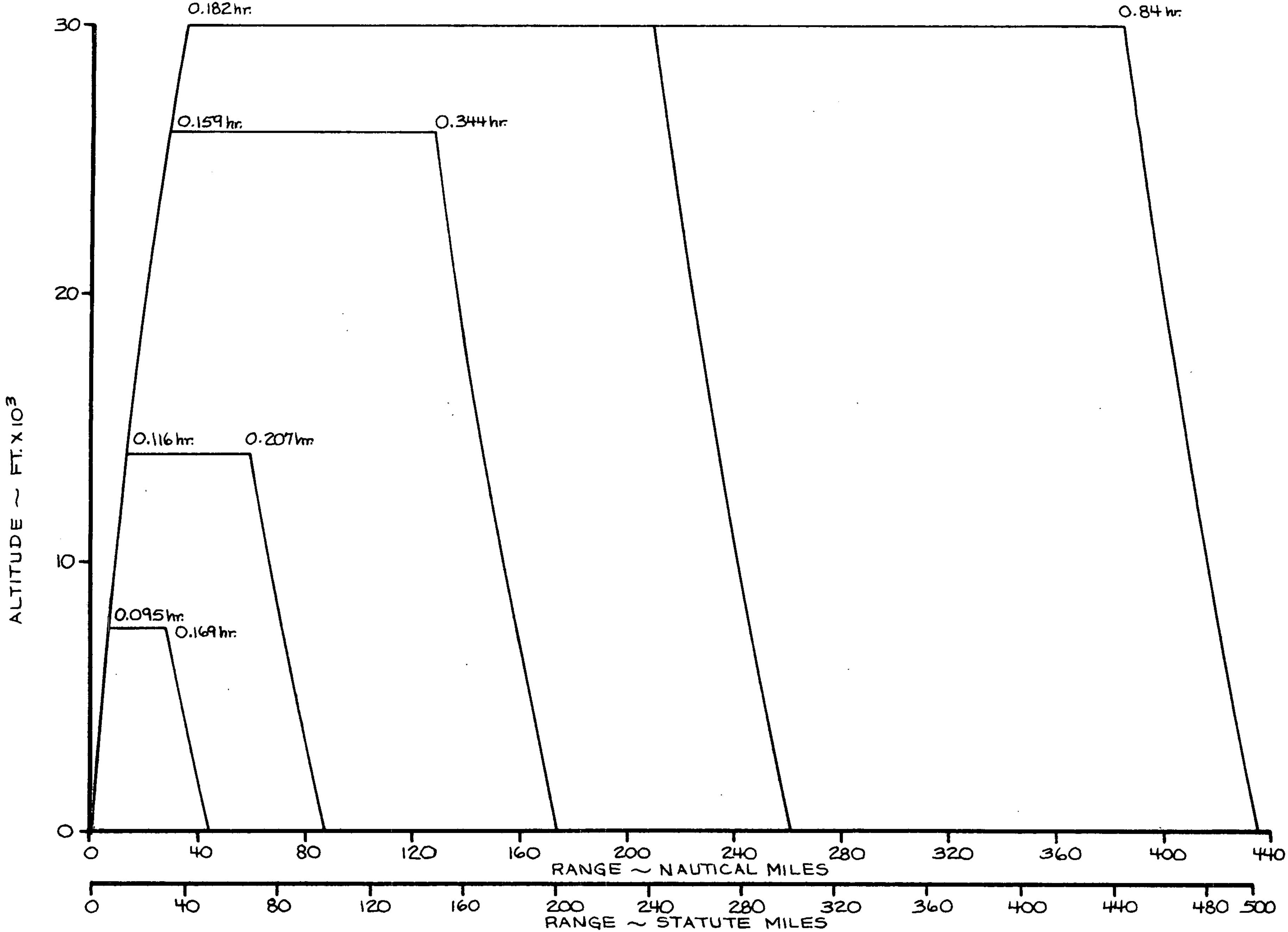


Figure B-6. Mission Performance Profiles - 150-Passenger STOL

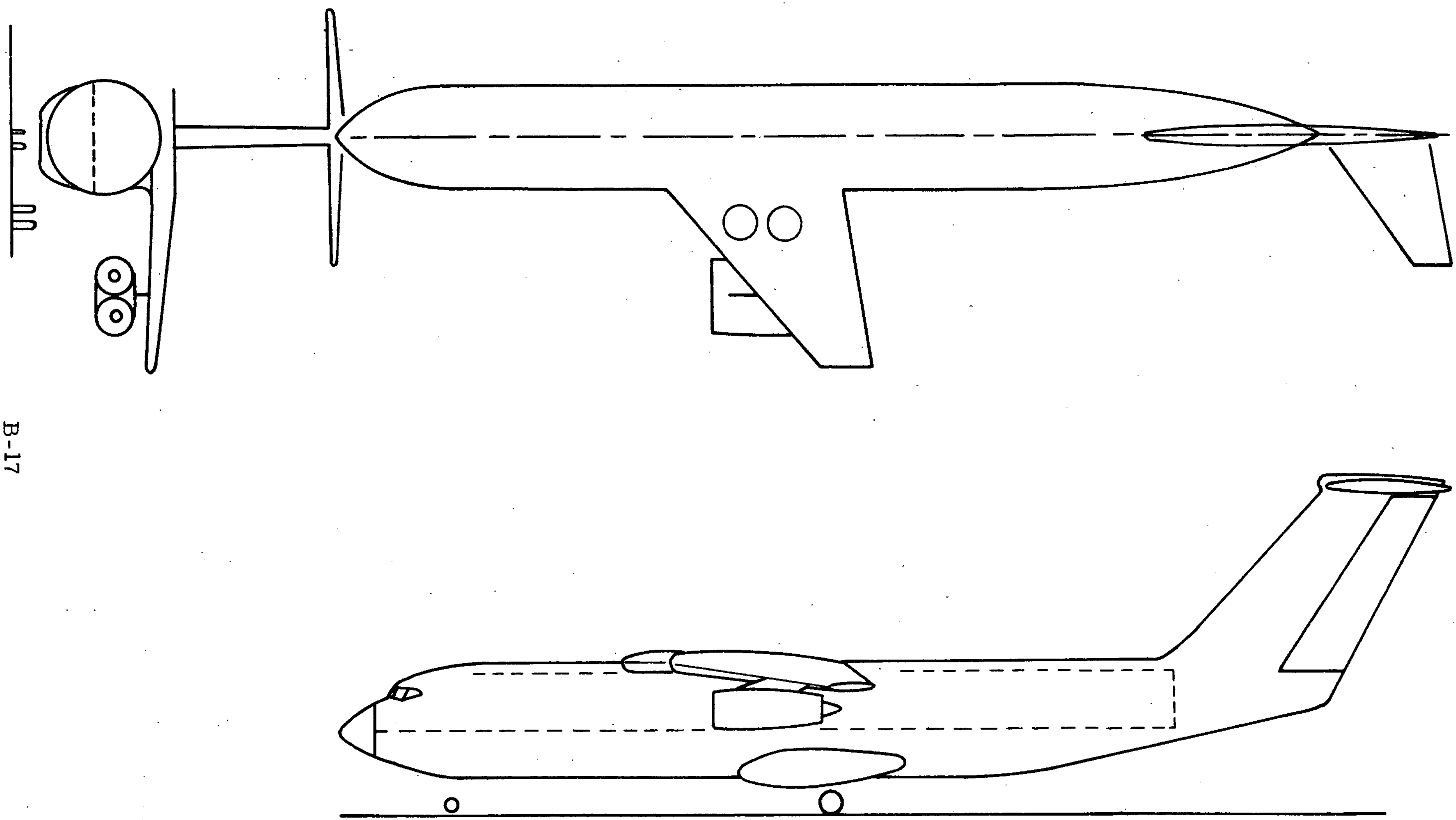


Figure B-7. 1990 Lift-Fan VTOL Aircraft

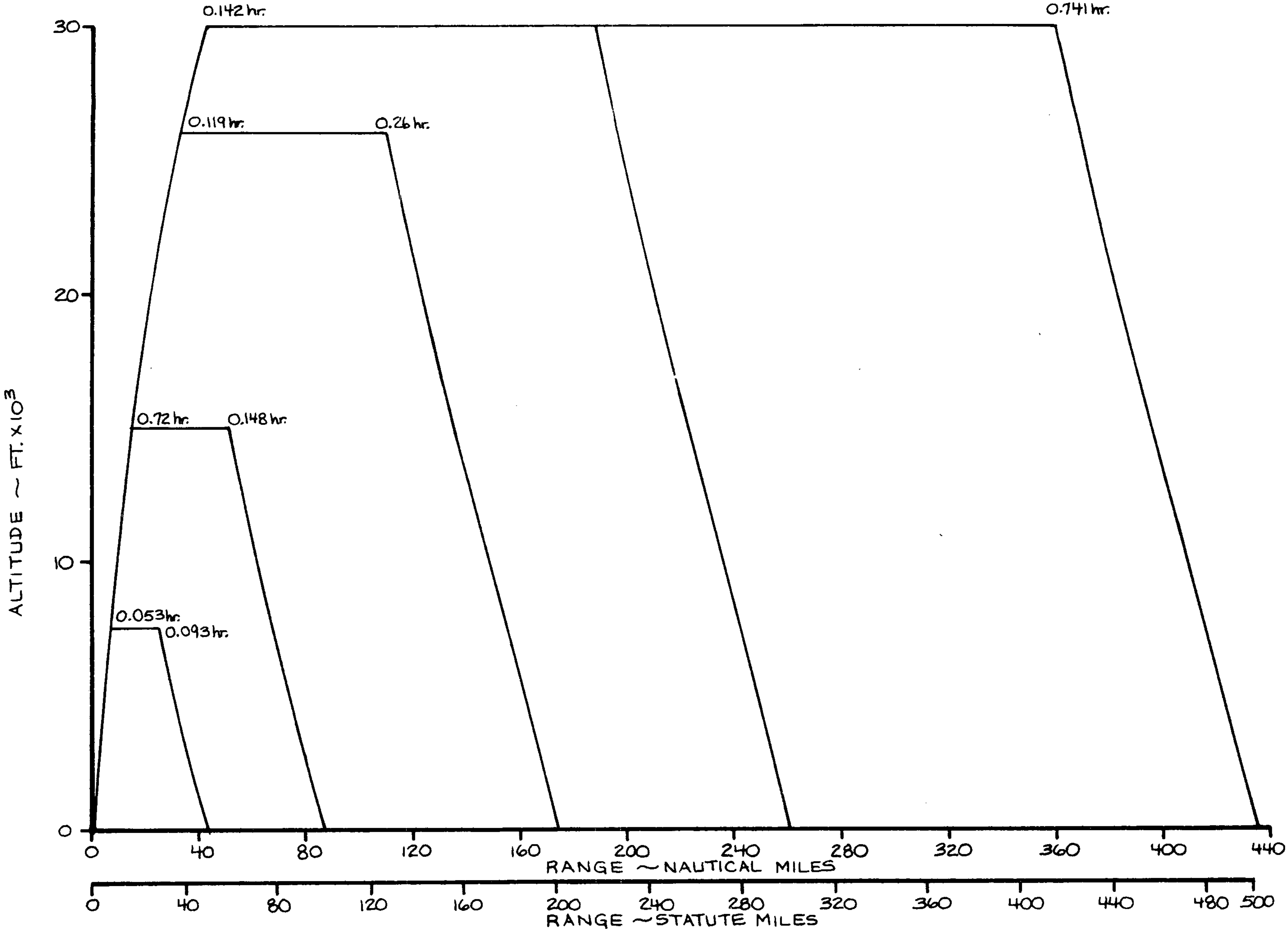


Figure B-8. Mission Performance Profiles - Baseline Lift Fan 150-Passenger

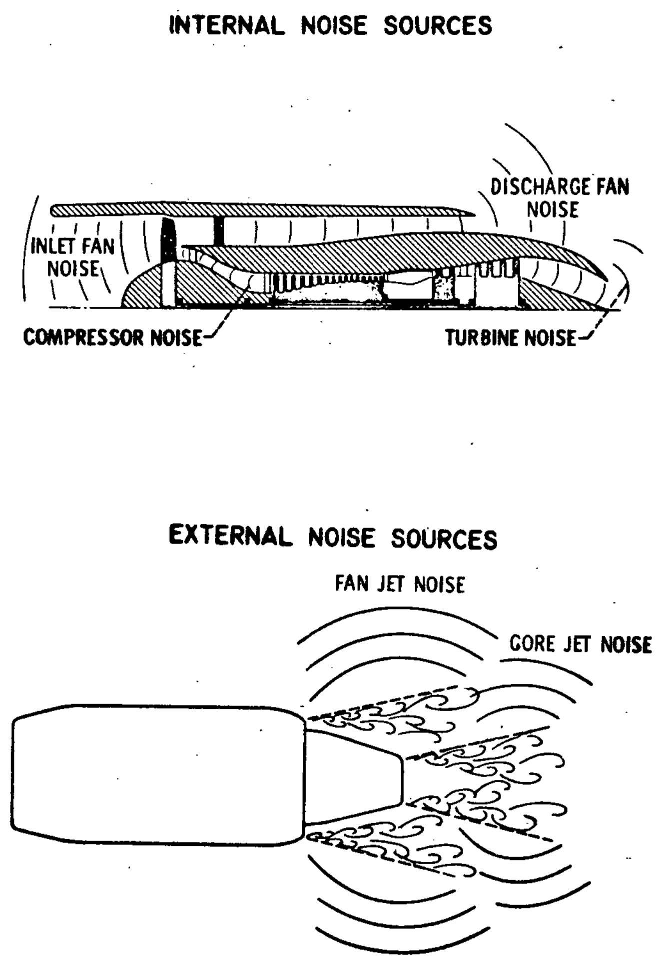
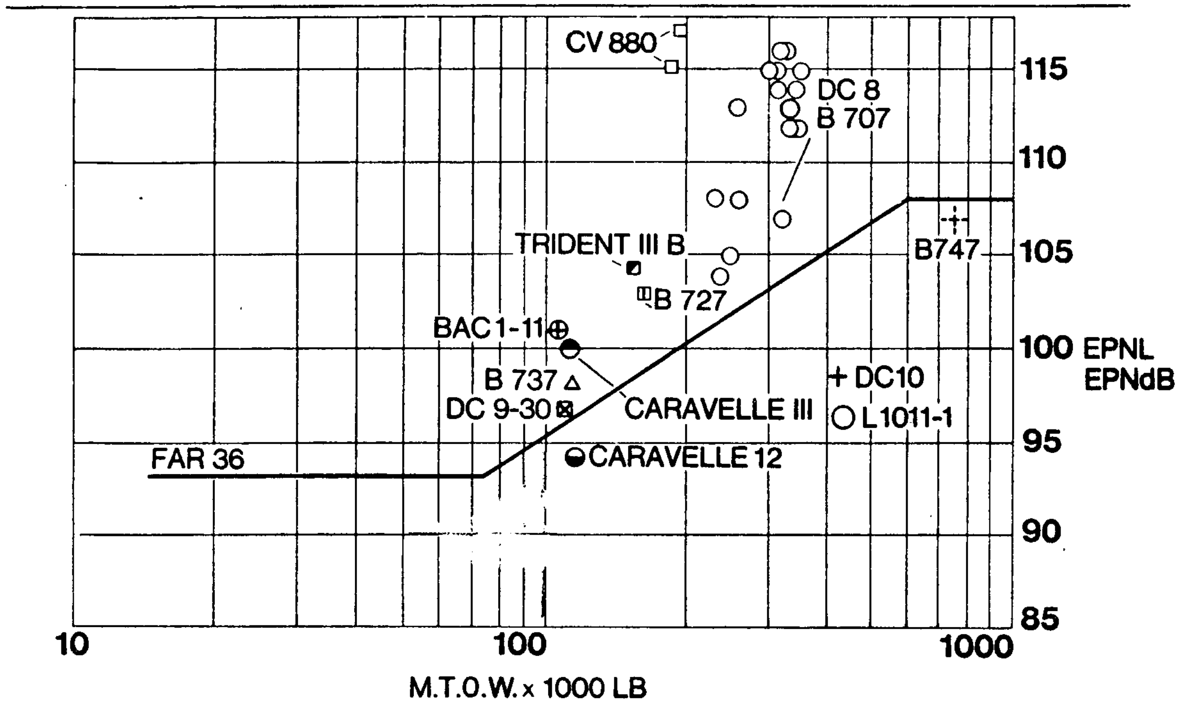


Figure B-9. Principal Internal and External Noise Sources

take-off (fly over) noise



approach noise

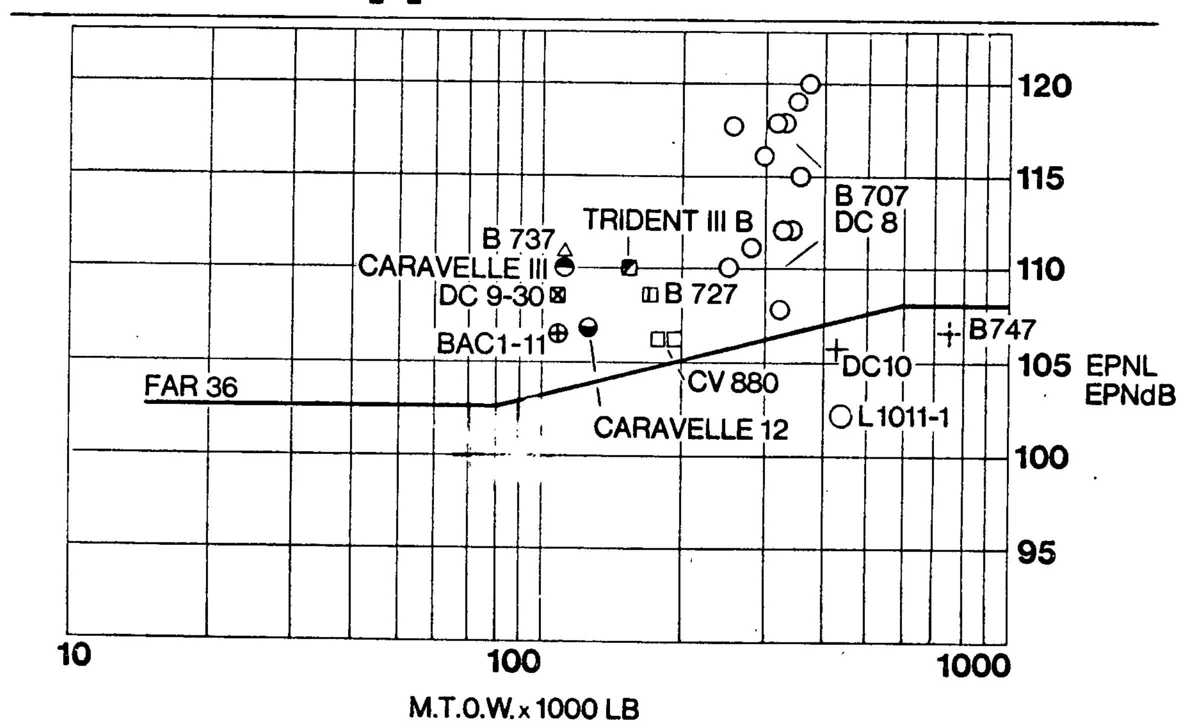
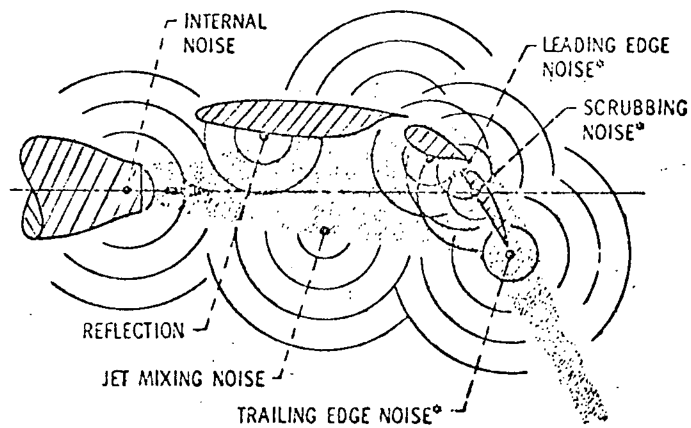


Figure B-10. Comparison of Aircraft Noise Levels Relative to FAA-FAR 36



- CURRENT EXHAUST/FLAP INTERACTION NOISE TESTING PROGRAMS
  - LEWIS COLD FLOW 1/13 AND 1/2 SCALE
  - LANGLEY COLD FLOW PROP FAN
  - EDWARDS FULL SCALE HOT EXHAUST
- ENGINE REQUIREMENTS FOR 95 PNdB AT 500 FT
  - 1.2 FAN PRESSURE RATIO
  - 12.0 BYPASS RATIO
  - 550 FPS EXHAUST VELOCITY
- NEW RESEARCH AREAS
  - MIXER NOZZLES
  - OVER-THE-WING ENGINE INSTALLATION

Figure B-11. Externally Blown Flap Noise

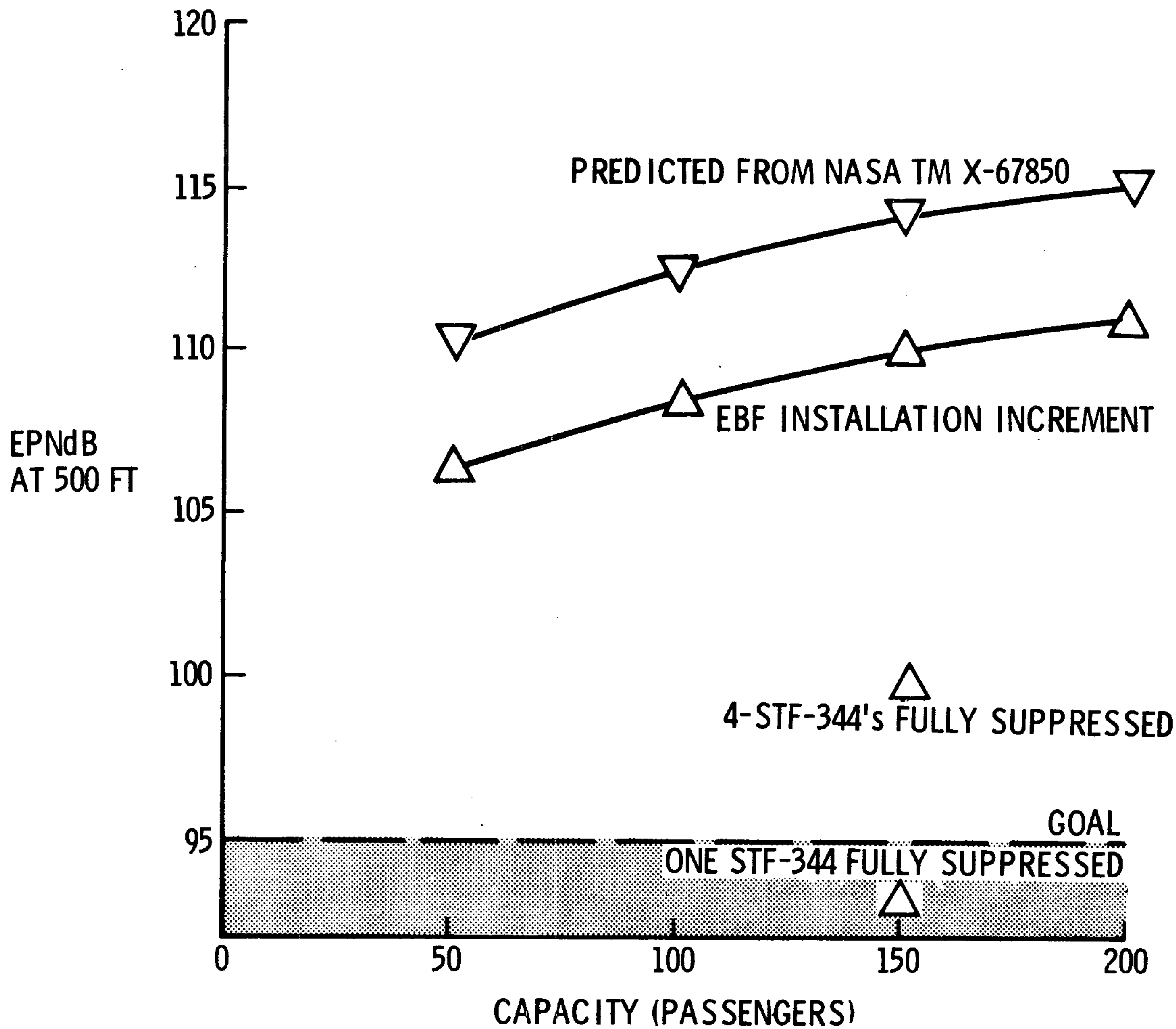


Figure B-12. Estimated 1980 EBF Takeoff and Landing Noise

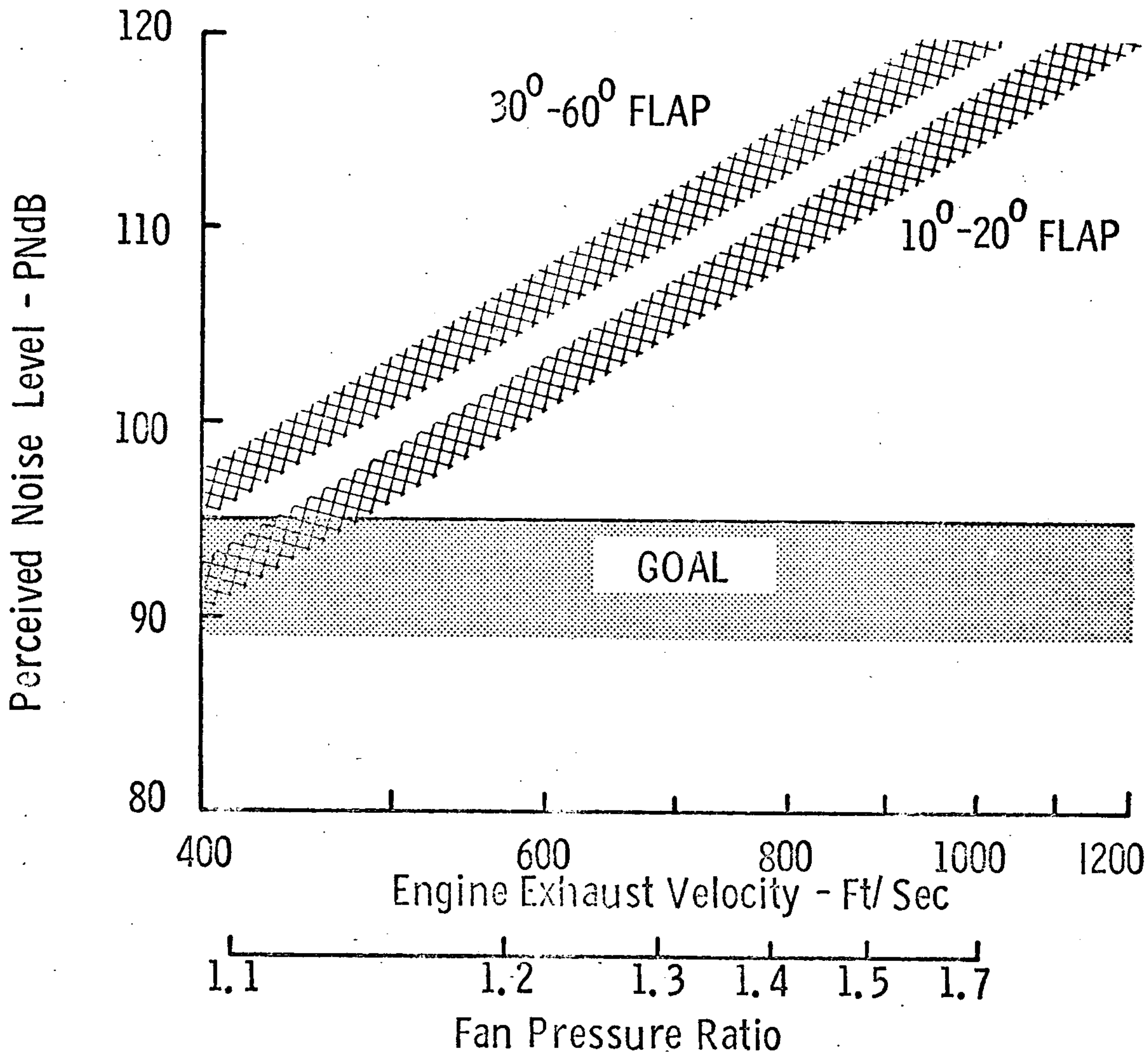


Figure B-13. NASA EBF Noise Estimates

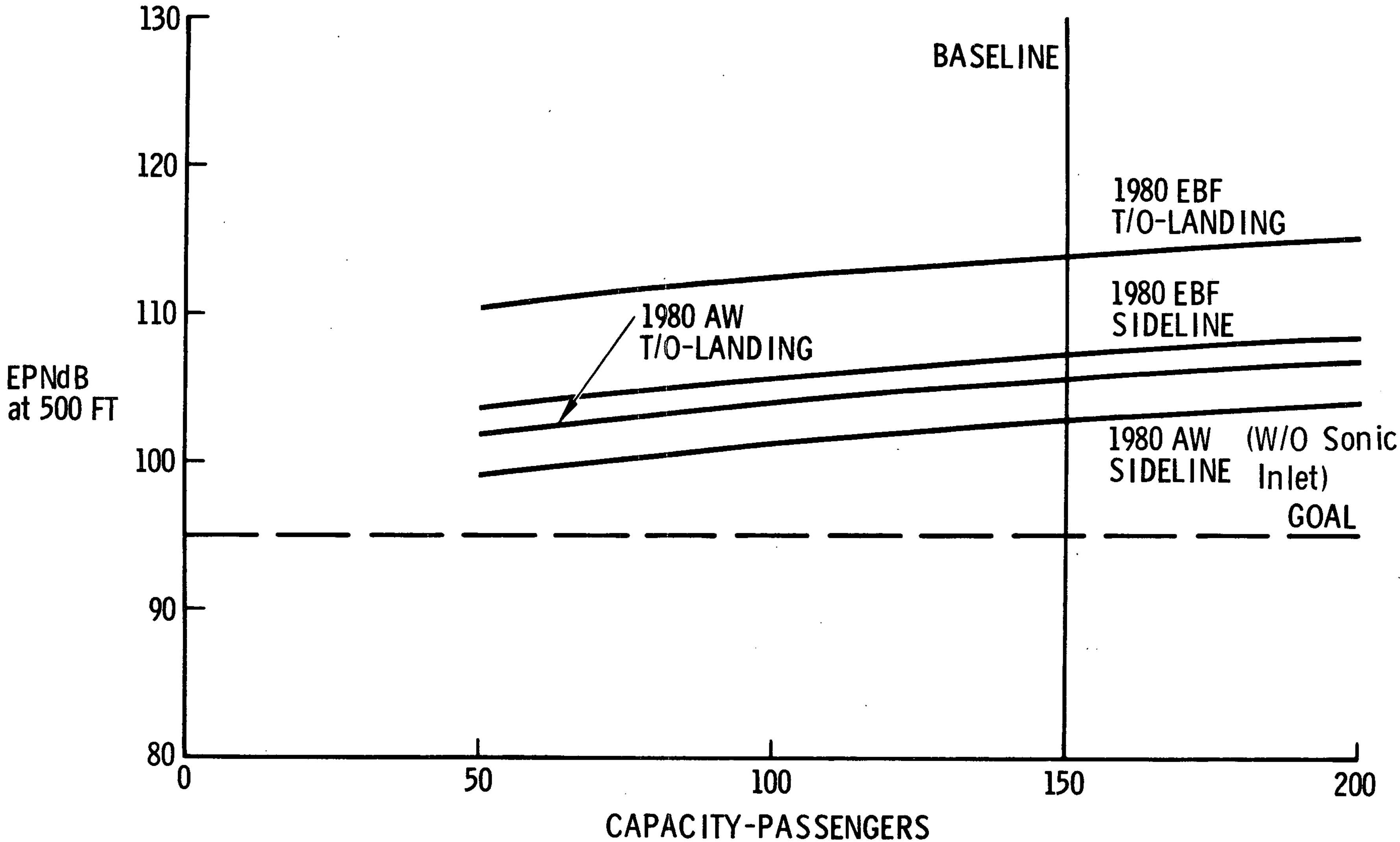


Figure B-14. Estimated 1980 STOL Noise

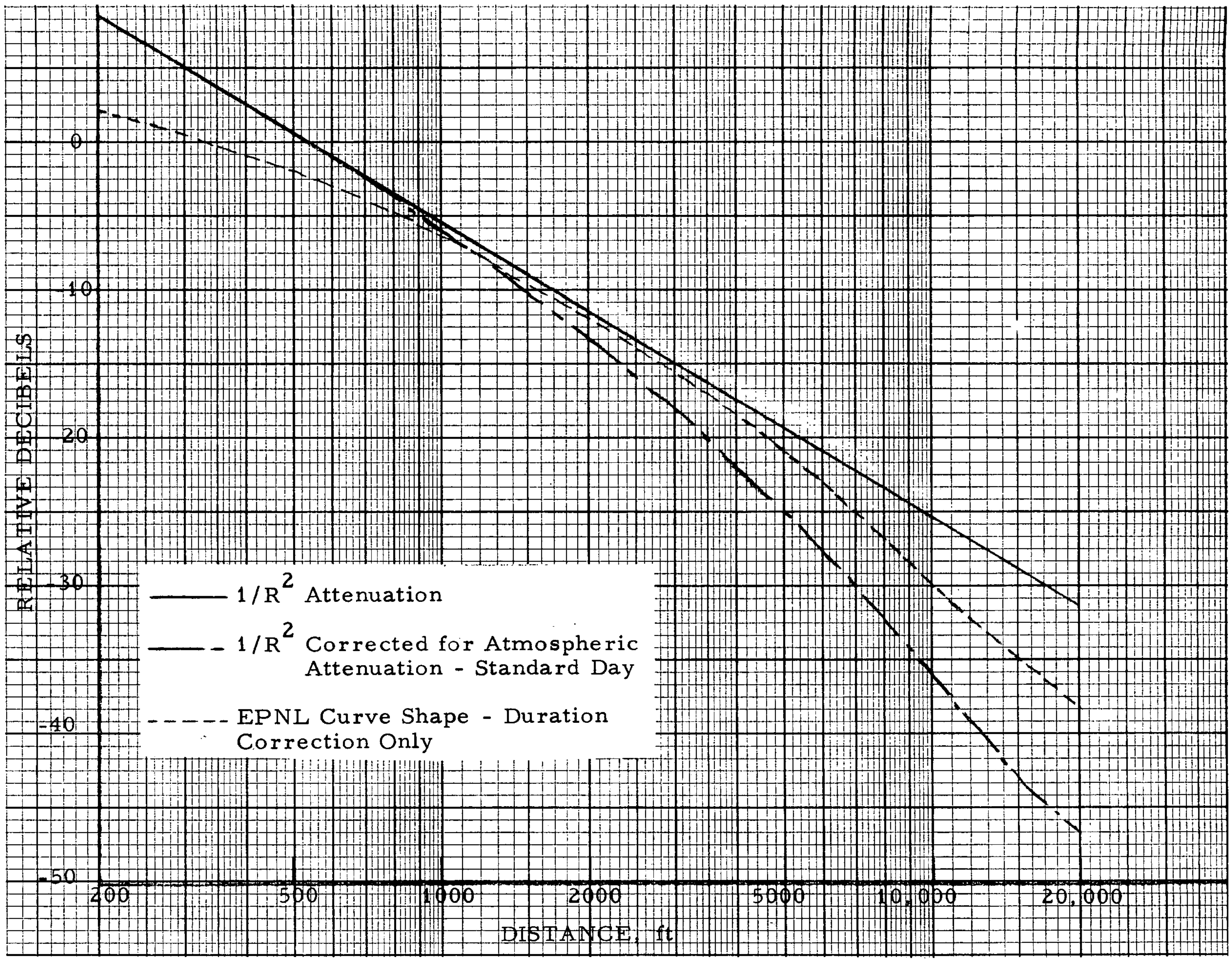


Figure B-15. Conversion of PNL at 500' to EPNL vs Distance

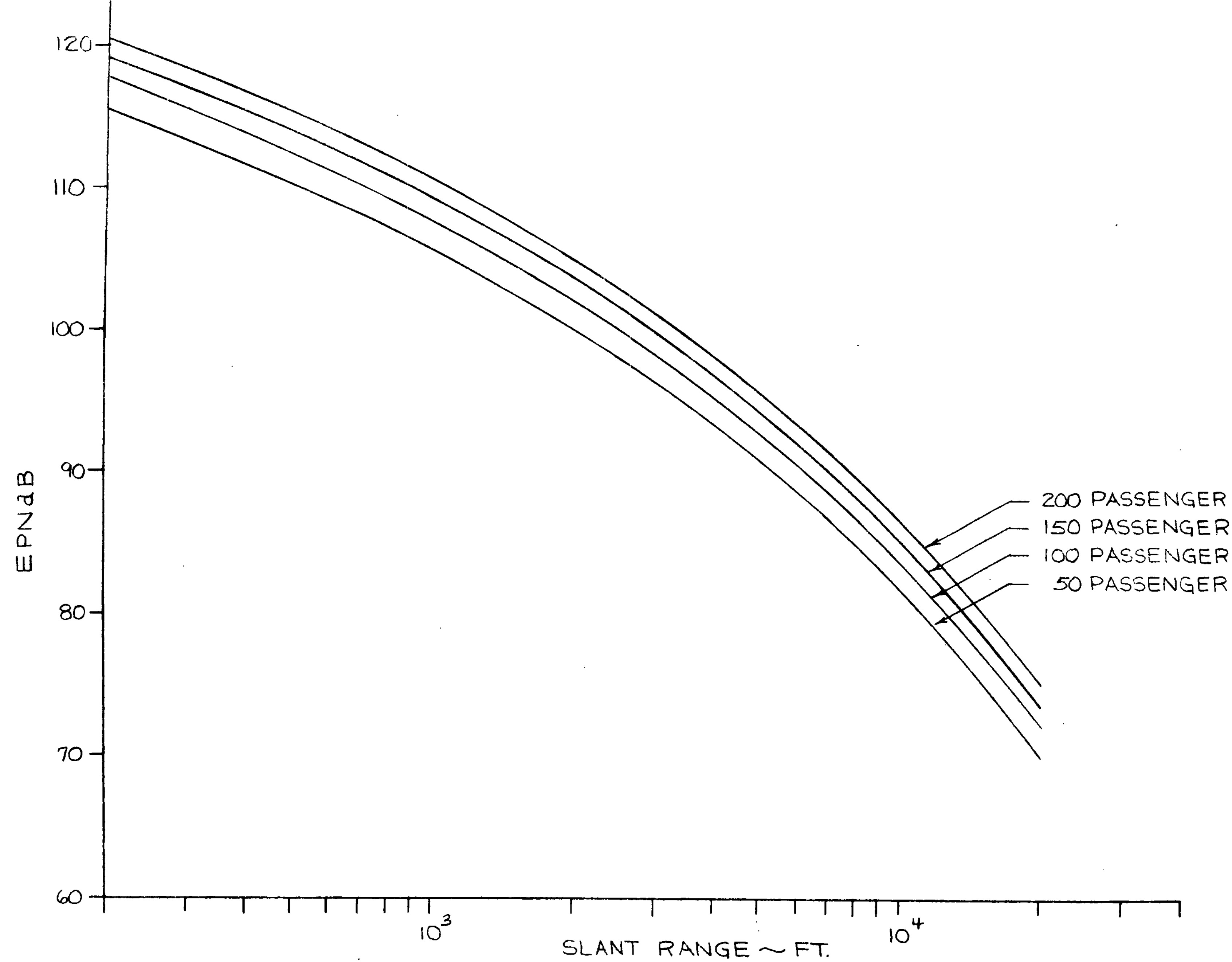


Figure B-16. 1980 EBF Takeoff and Landing Noise Levels

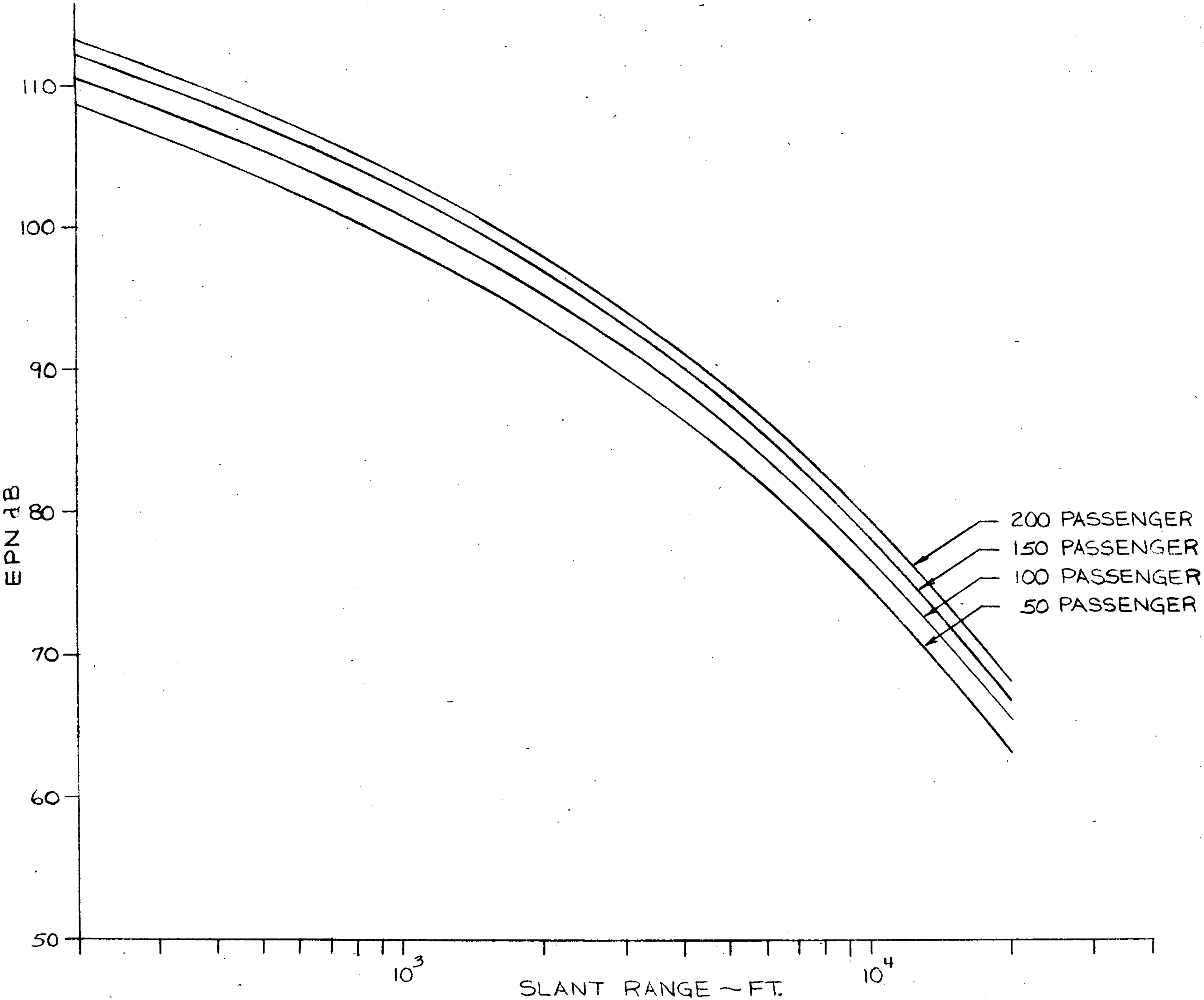


Figure B-17. 1980 EBF Sideline Noise Levels

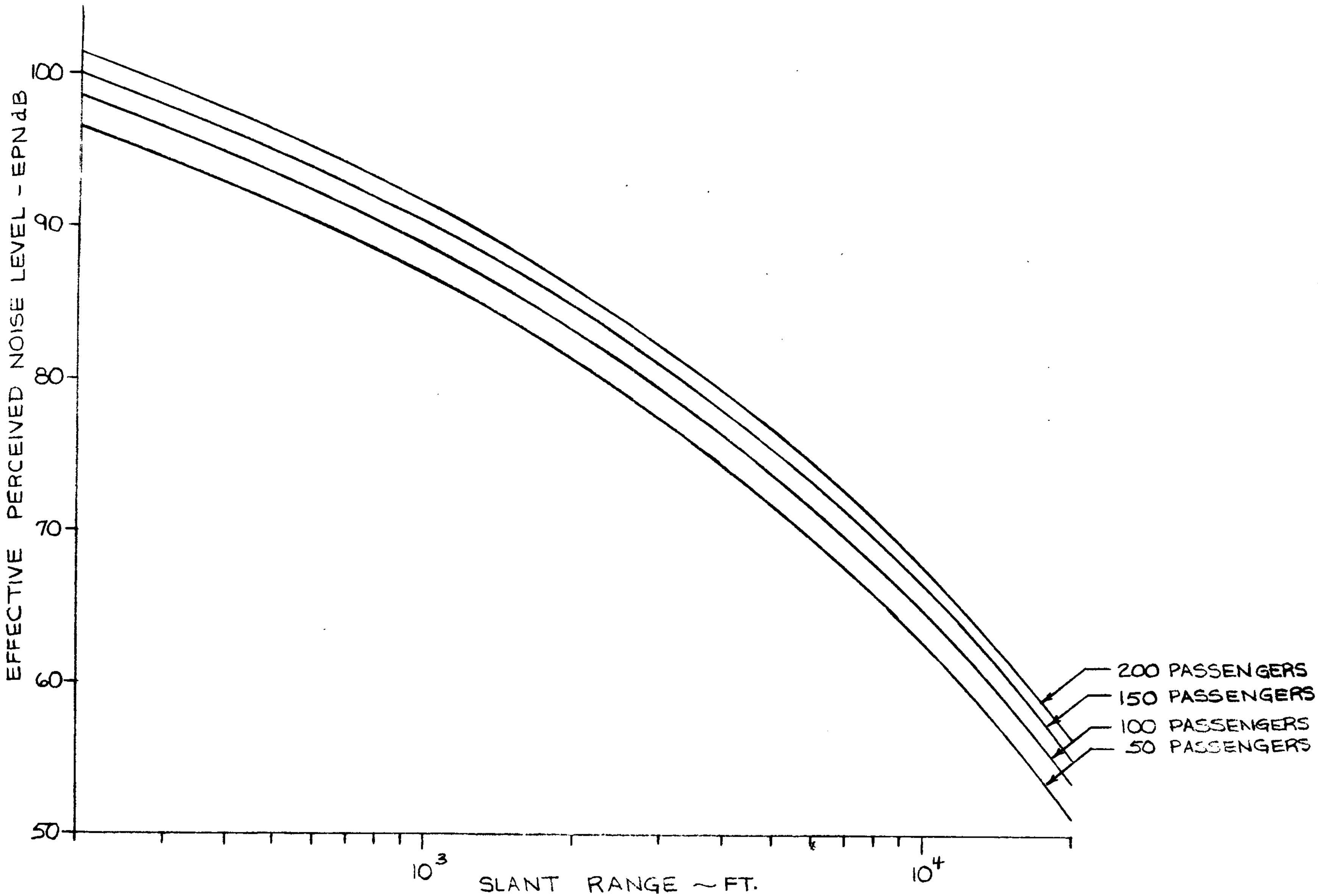


Figure B-18. 1980 STOL EBF Desired Noise Levels

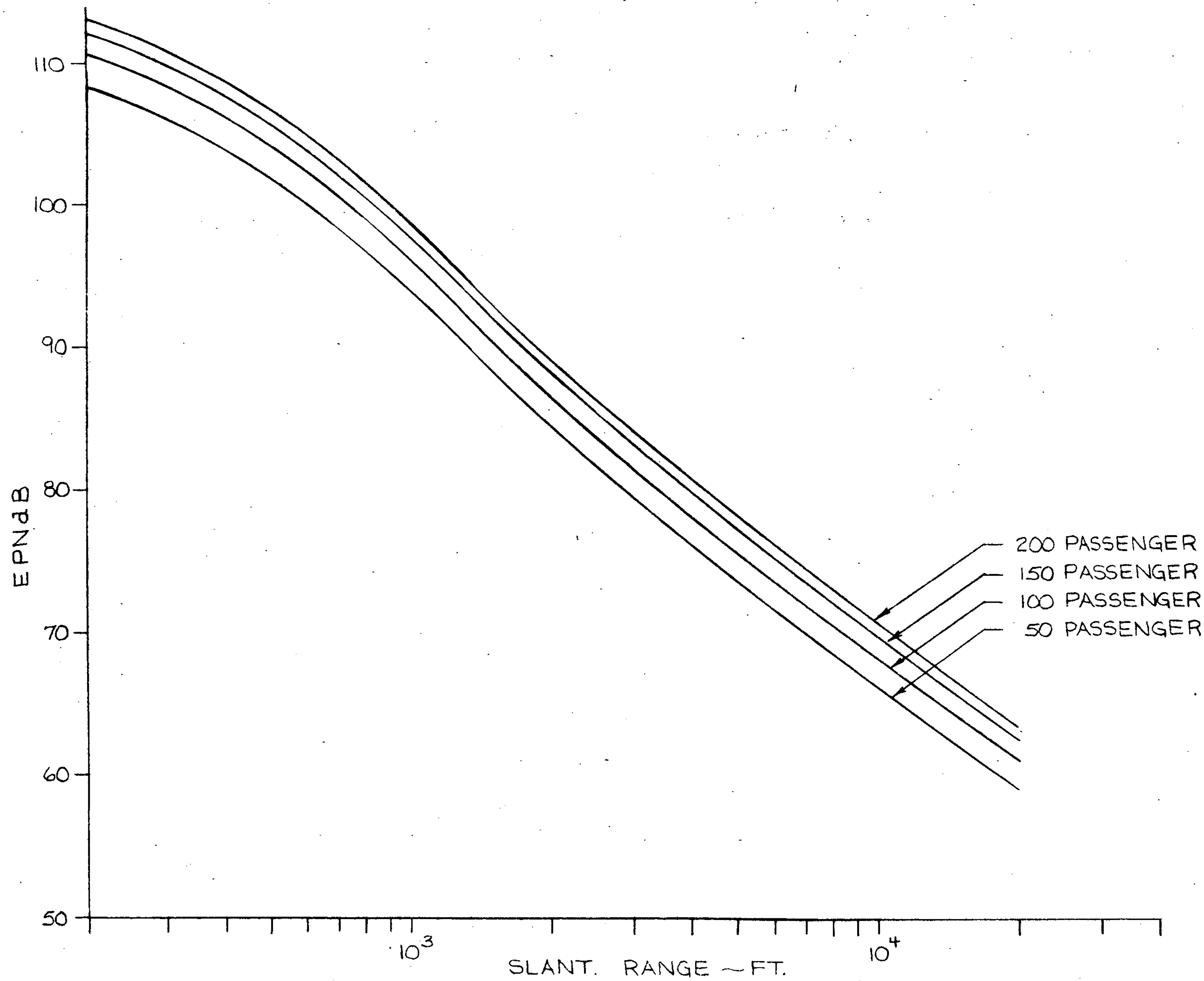


Figure B-19. 1980 Augmentor Wing Takeoff and Landing Noise Levels

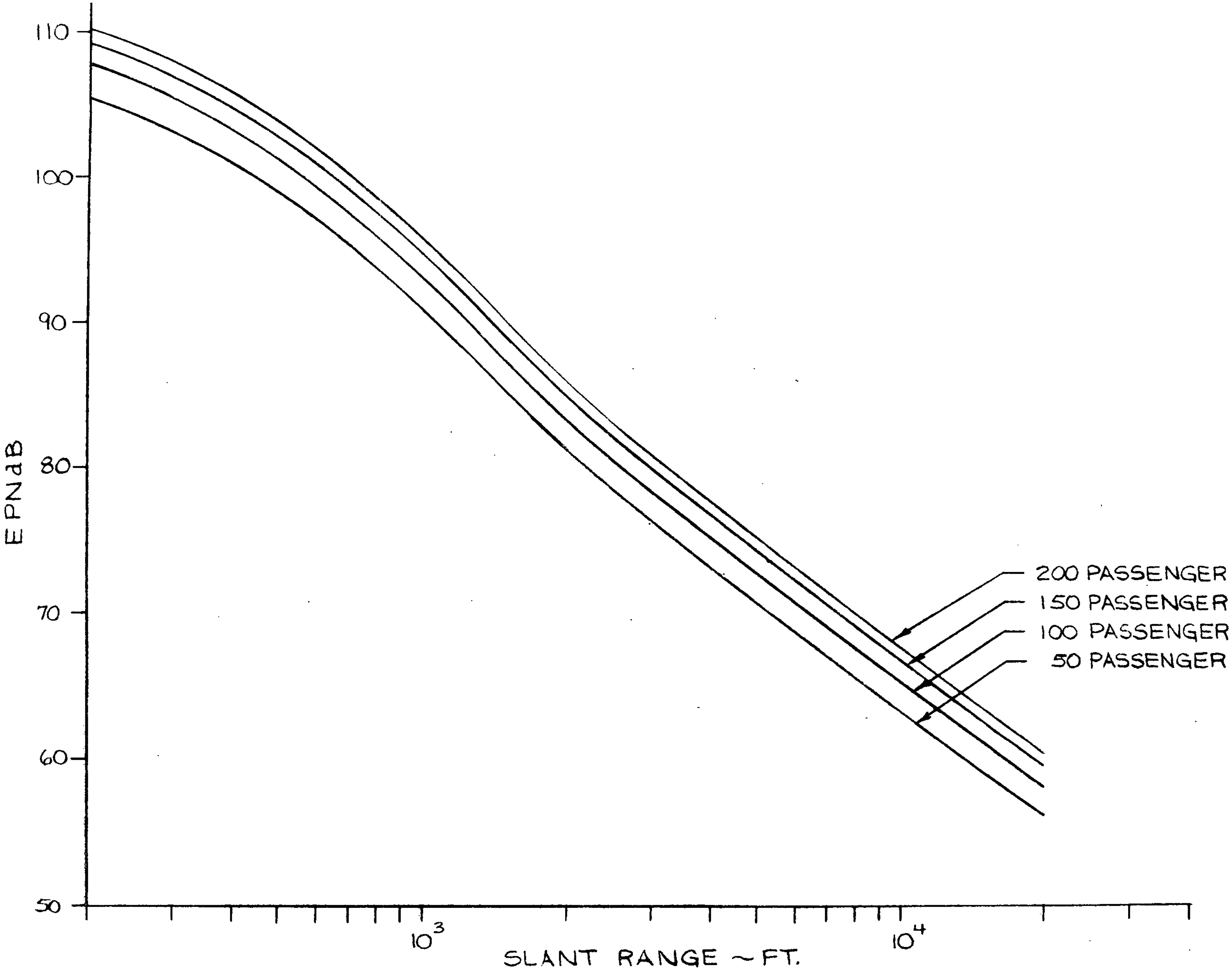
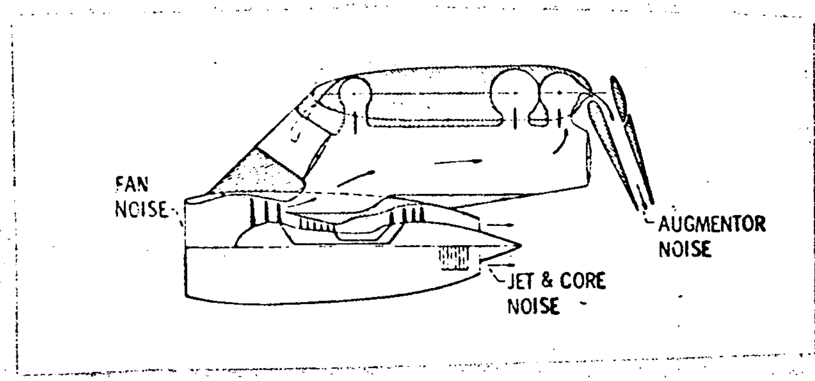


Figure B-20. 1980 Augmentor Wing Sideline Noise Levels



- AUGMENTOR RESEARCH
  - MULTIPLE NOZZLES
  - SCREECH SHIELDS
  - LINED FLAPS
- ENGINE REQUIREMENTS FOR 95 PNdB AT 500 FT
  - 800 PFS CORE VELOCITY
  - SONIC INLET
  - 3.0 FAN PRESSURE RATIO
  - 2.8 BYPASS RATIO
- AUGMENTOR REQUIREMENTS FOR 95 PNdB AT 500 FT
  - 2.6 NOZZLE PRESSURE RATIO
  - 1.4 THRUST AUGMENTATION
  - ALL POSSIBLE SUPPRESSION TECHNIQUES

Figure B-21. Augmentor Wing Noise

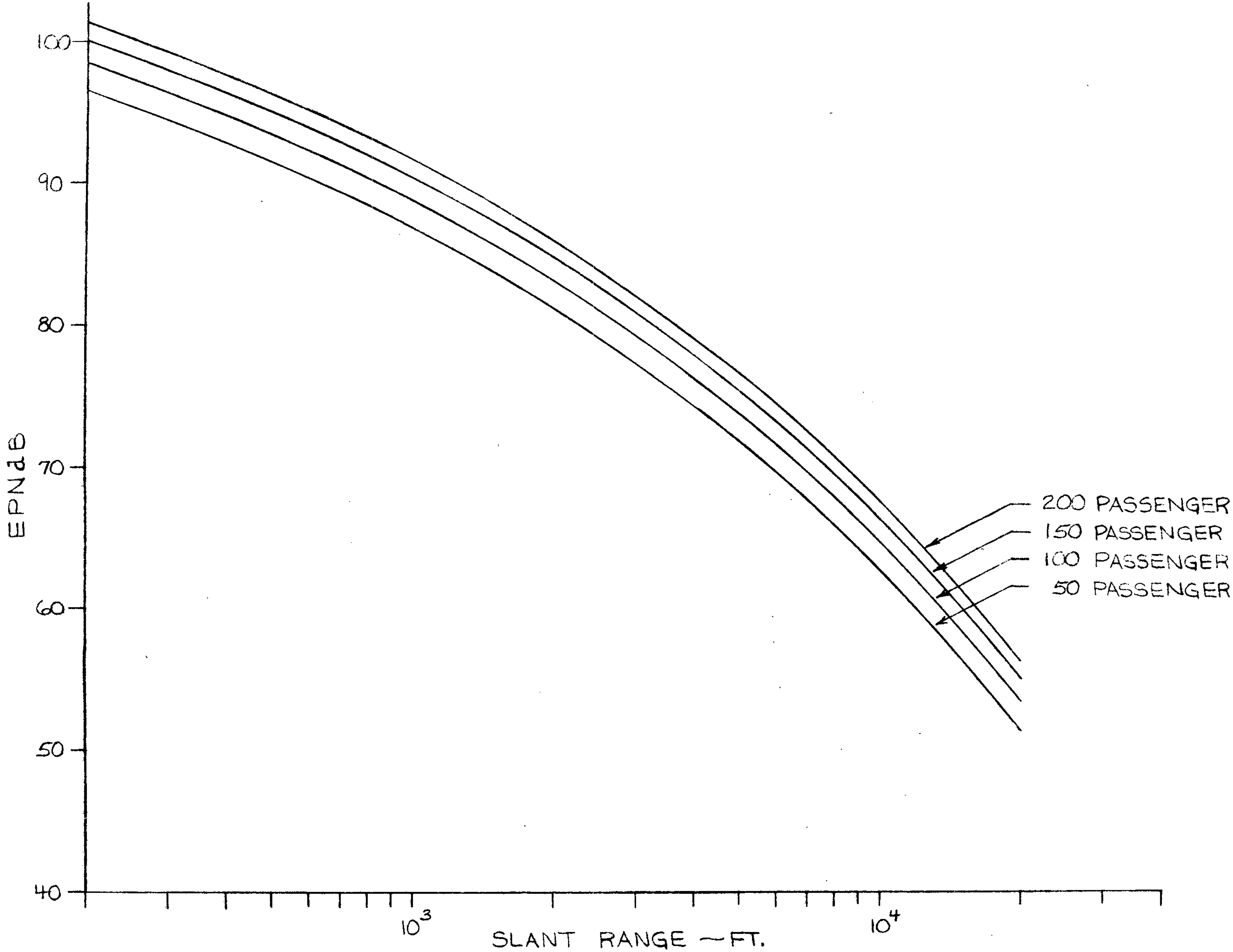


Figure B-22. 1990 STOL AW Takeoff and Landing Noise Levels

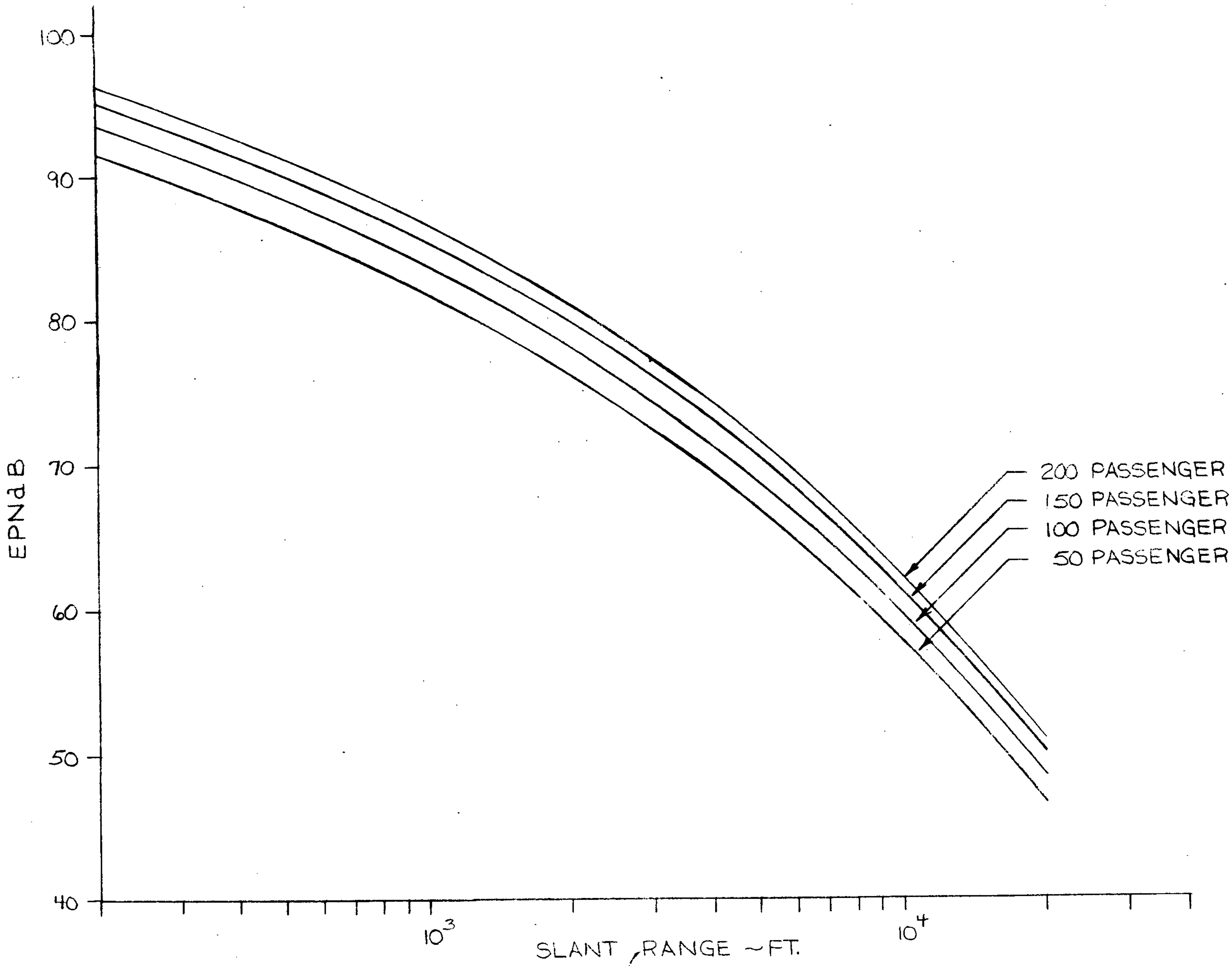


Figure B-23. 1990 STOL AW Sideline Noise Levels

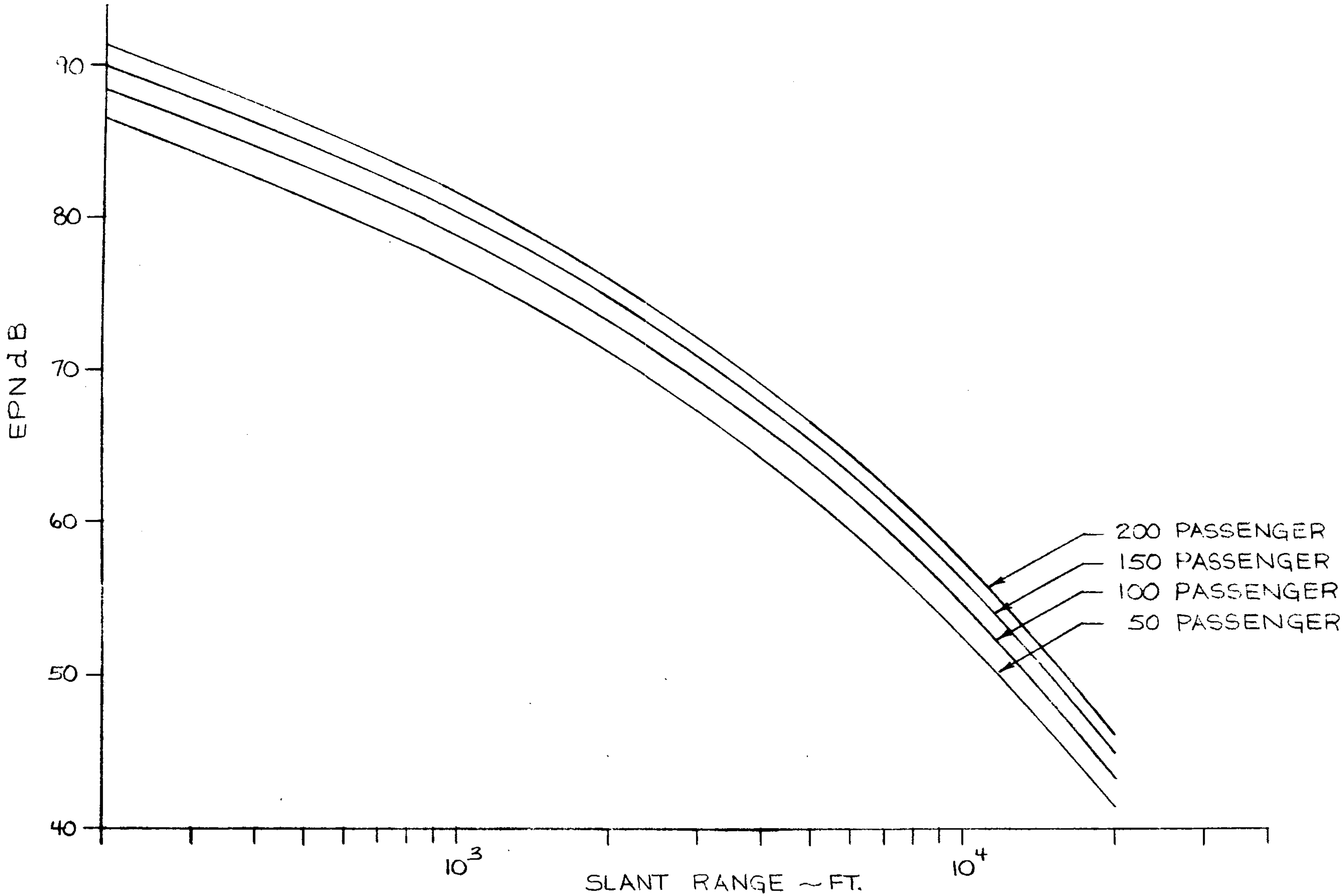


Figure B-24. 1990 STOL-AW - Desired Noise Levels

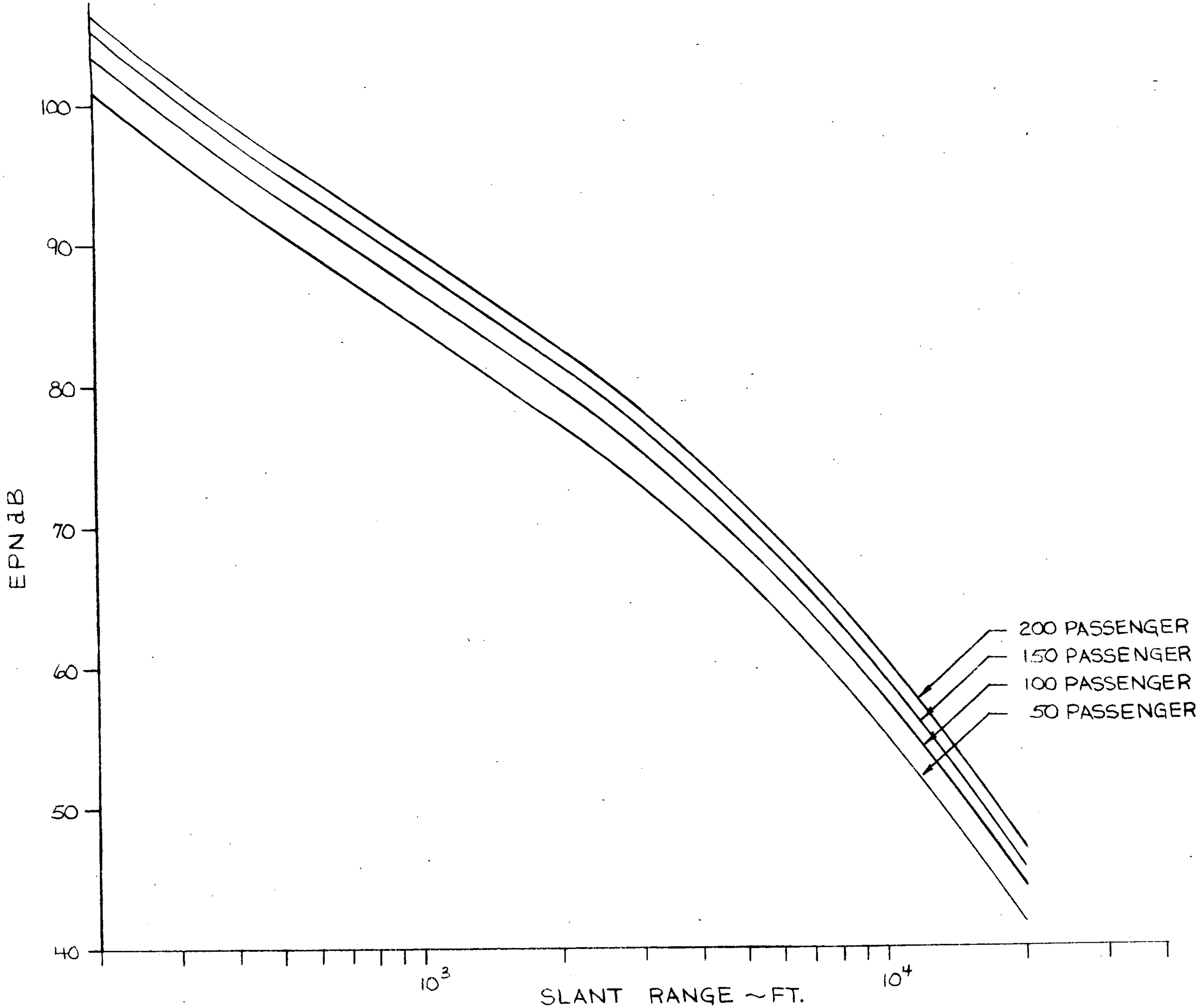


Figure B-25. 1990 VTOL - Approach, Takeoff and Sideline Noise Levels

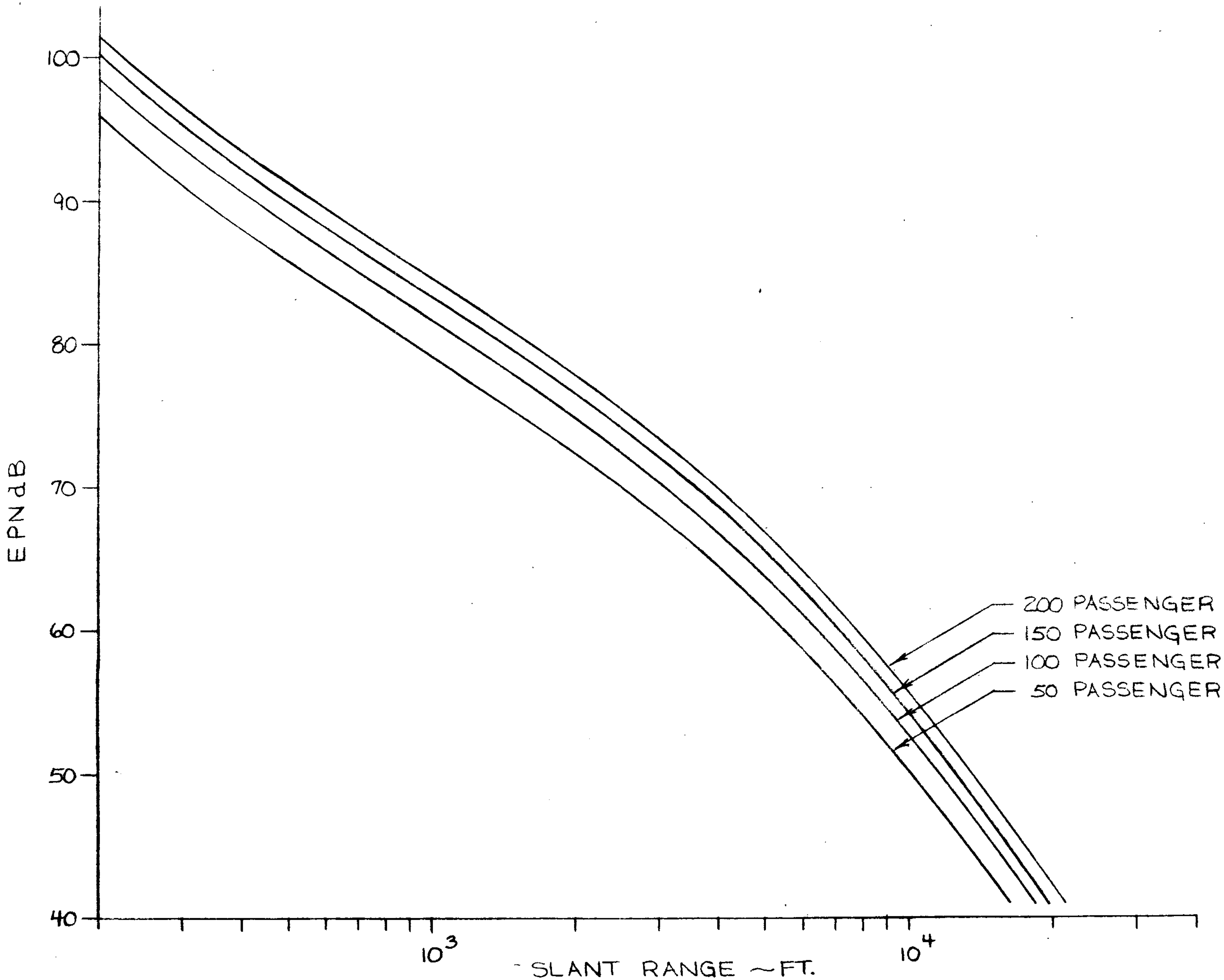


Figure B-26. 1990 Lift Fan VTOL - Desired Noise Levels

Table B-1. EBF STOL Aircraft Geometry

PASSENGER SIZE	50	100	150	200
FUSELAGE LENGTH	--	--	129	--
FUSELAGE WIDTH	--	--	13.34	--
WING LOADING	90	90	90	90
WING AREA	569	975	1,358	1,715
THRUST/WEIGHT	0.544	0.544	0.544	0.544
FIELD LENGTH	3,000	3,000	3,000	3,000
NUMBER OF ENGINES	4	4	4	4
THRUST/ENGINE (LB)	6,960	11,850	16,600	21,000

DESIGN MISSION

Taxi Out	3
Taxi In	3
Takeoff	1
App. & Land.	4
	11 Min.

Climb	250 KEAS to 10,000 ft., Max R/C above
Cruise	.8 @ 30,000 ft.
Descent	$\theta_f \leq -6^\circ$ @ Flight Idle
Reserve	115 sm @ 30,000 ft.
Range	500 sm

Table B-2. 1980 STOL Aircraft Characteristics Summary

TOFL: 3,000', M_{cr} = 0.8 @ 30K'

Passenger Size	50	100	150	200
Weight Statement				
Structure				
Composites				
Aluminum			40,890	
Total			40,890	
Flight Controls			1,355	
Fixed Equipment			15,075	
Engines (Bare)	4,720	7,960	11,200	14,160
Engine Equipment			4,608	
Weight Empty	33,000	54,000	73,123	91,000
Useful Load				
OWE				
Payload	11,000	22,000	33,000	44,000
Fuel	6,070	9,946	13,207	15,930
TOGW	51,205	87,711	122,000	154,320
Engine Specifications				
Cycle: EBF				
BPR: 12				
PR: 20	Nominal Differential Pressure: 13043			
SLST:	6,960	11,850	16,600	21,000
No: 4				
T_{TI}: 2860°R				
SLSFC: .303				

OWE, Operating Weight Empty; TOGW, Take-Off Gross Weight; BPR, By-Pass Ratio; PR, Pressure Ratio; SLST, Sea Level Strategic Thrust; T_{TI}, Turbine Inlet Temp; SLSFC, Sea Level Specific Fuel Consumption.

Table B-3. 1980 EBF-STOL Block Performance

Stage Length (s.m.)	50 Pass.		100 Pass.		150 Pass.		200 Pass.	
	Time	Fuel	Time	Fuel	Time	Fuel	Time	Fuel
50	.317	1382	.317	2166	.317	2850	.317	3449
100	.428	1712	.428	3040	.428	4000	.428	4840
200	.672	2556	.672	4241	.672	5580	.672	6752
300	.895	3927	.895	6516	.895	7280	.895	8809
400	1.11	4159	1.11	6901	1.11	9080	1.11	10987
500	1.32	4969	1.32	8246	1.32	10850	1.32	13129

Table B-4. 1990 Augmentor Wing STOL Aircraft Geometry

PASSENGER SIZE	50	100	150	200
FUSELAGE LENGTH (FT)	70	105	132	159
FUSELAGE WIDTH (FT)	12. 4	14. 1	14. 1	14. 1
WING LOADING (psf)	90	90	90	90
WING AREA (FT^2)	494	882	1, 239	1, 595
THRUST/WEIGHT	0. 45	0. 45	0. 45	0. 45
FIELD LENGTH (FT)	2, 000	2, 000	2, 000	2, 000
NUMBER OF ENGINES	4	4	4	4
THRUST/ENGINE (LBS)	6, 431	10, 824	14, 363	17, 807

DESIGN MISSION

TAXI OUT	3 Min
TAXI IN	3 Min
TAKEOFF	1 Min
APP. & LAND.	4 Min
	11 Min

CLIMB -	250 KEAS to 10, 000 ft., Max R/C Above
CRUISE -	. 90M @ 30, 000 ft.
DESCENT -	$\theta_f \leq -6°$ @ Flight Idle
RESERVE -	1. 25 hr @ 10, 000 ft.
RANGE -	500 s m

ENGINE:

BPR = 2. 8, OVERALL PR = 20, TIT = 2860° K, FPR = 3. 0, V_j = 700 fps

Table B-5. 1990 STOL Aircraft Characteristics Summary

TOFL: 2000', M_{cr} = 0.9 @ 30K'

Passenger Size	50	100	150	200
Weight Statement				
Structure				
Composites	7,135	14,629	21,648	28,888
Aluminum	1,840	3,211	4,124	5,098
Total	8,975	17,840	25,772	33,986
Flight Controls	1,068	1,728	2,326	2,921
Fixed Equipment	7,700	11,200	14,700	18,100
Engines (Bare)	3,515	6,044	8,157	10,261
Engine Equipment	1,968	2,962	3,630	4,269
Weight Empty	23,226	39,774	54,585	69,537
Useful Load	1,100	1,800	2,500	3,200
OWE	24,326	41,574	57,085	72,737
Payload	11,000	22,000	33,000	44,000
Fuel	9,101	15,843	21,393	26,833
TOGW	44,427	79,417	111,478	143,570

Engine Specifications

Cycle: AW

BPR: 2.8

PR: 20 Nominal Differential Pressure: 16508

	50	100	150	200
SLST:	6,431	10,824	14,363	17,807

No: 4

T_{TI}: 2860°R

SLSFC: 0.452 Est., Based on Fuel for T.O. and SLST

Lift Engine Ops.

T.O. .021 hr

Lndg. .080 hr

OWE, Operating Weight Empty; TOGW, Take-Off Gross Weight; BPR, By-Pass Ratio; PR, Pressure Ratio; SLST, Sea Level Strategic Thrust; T_{TI}, Turbine Intlet Temp; SLSFC, Sea Level Specific Fuel Consumption.

Table B-6. 1990 Augmentor Wing STOL Block Performance

STAGE LENGTH (S. M.)	50 PASS		100 PASS		150 PASS		200 PASS	
	BLOCK TIME (HRS)	BLOCK FUEL (LBS)	BLOCK TIME	BLOCK FUEL	BLOCK TIME	BLOCK FUEL	BLOCK TIME	BLOCK FUEL
50	. 326	1, 532	. 324	2, 650	. 322	3, 614	. 321	4, 570
100	. 385	2, 324	. 386	3, 947	. 386	5. 283	. 387	6, 590
200	. 556	3, 397	. 558	5, 791	. 559	7, 777	. 560	9, 720
300	. 730	4, 288	. 731	7, 304	. 734	9, 804	. 735	12, 254
500	1. 058	6, 524	1. 060	11, 096	1. 062	14, 866	1. 063	18, 541

Table B-7. 1990 Lift-Fan VTOL Aircraft Geometry

PASSENGER SIZE	50	100	150	200
FUSELAGE LENGTH (FT)	76.5	105.4	132.5	159.8
FUSELAGE WIDTH (FT)	14.1	14.1	14.1	14.1
WING AREA (FT)	425	765	1112	1458
WING LOADING (psf)	100	100	100	100
LIFT/CRUISE THRUST	23,804	40,680	57,612	74,470
LIFT THRUST	32,619	60,901	90,050	119,118

DESIGN MISSION

TAXI OUT	1 Min	CLIMB -	@ Max. R/C
TAXI IN	1 Min	CRUISE -	M = .9 @ 30,000 ft.
TAKEOFF	1 Min	DESCENT -	$\theta_f \geq -6°$
APP. & LAND.	4 Min	RESERVE -	.5 hrs @ 10,000 ft.
	7 Min	STAGE LENGTH -	500 s.m.

Table B-8. 1990 VTOL Aircraft Characteristics Summary

TOFL: 0, $M_{cr} = 0.9$ @ 30K'

Passenger Size	50	100	150	200
Weight Statement				
Structure				
Composites	6,796	12,117	18,005	24,024
Aluminum	1,752	2,660	3,430	4,239
Total	8,548	14,777	21,435	28,263
Flight Controls	1,340	1,829	2,320	2,806
Fixed Equipment	7,700	11,200	14,700	18,100
Engines (Bare)				
Lift/Cruise	2,639	4,270	5,905	7,534
Lift	1,458	5,253	9,165	13,066
Engine Equipment	1,889	3,822	5,787	7,743
Weight Empty	23,574	41,151	59,313	77,512
Useful Load	1,200	1,900	2,700	3,400
OWE	24,774	43,051	62,013	80,912
Payload	11,000	22,000	33,000	44,000
Fuel	6,699	11,444	16,201	20,906
TOGW	42,474	76,495	111,214	145,817

Engine Specifications

Cycle: TF; GGLF

BPR: 2; 11

PR: 20; 13 Nominal Differential Pressure: 16508

SLST: 14404; 22512

	50	100	150	200
Lift/Cruise	5,951	10,170	14,403	18,618
Lift	8,155	15,225	22,513	29,780

No: 4 L/C; 4L

T_{TI}: 2900; 2900

SLSFC: .33; .55

OWE, Operating Weight Empty; TOGW, Take-Off Gross Weight; BPR, By-Pass Ratio; PR, Pressure Ratio; SLST, Sea Level Strategic Thrust; T_{TI}, Turbine Inlet Temp; SLSFC, Sea Level Specific Fuel Consumption.

Table B-9. 1990 Lift-Fan VTOL Aircraft Block Performance

STAGE LENGTH (S. M.)	50 PASS		100 PASS		150 PASS		200 PASS	
	BLOCK TIME (HRS)	BLOCK FUEL (LBS)	BLOCK TIME	BLOCK FUEL	BLOCK TIME	BLOCK FUEL	BLOCK TIME	BLOCK FUEL
50	.224	1684	.223	2894	.221	4106	.221	5309
100	.317	2140	.314	3623	.312	5107	.311	6566
200	.491	2973	.485	5059	.482	7137	.480	9199
300	.663	3735	.657	6382	.653	9024	.650	11643
500	.994	5360	.987	9153	.983	12965	.980	16747

REFERENCES

B. 1 Robert G. Dorsch, Eugene A. Krejsa and William A. Olsen, Blown Flap Noise Research, AIAA-SAE Paper 71-745, NASA Lewis Research Center, 7th Propulsion Joint Special Conference, Salt Lake City, Utah.

APPENDIX C

AIRCRAFT PRODUCTION REQUIREMENTS

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APPENDIX C

POTENTIAL AIRCRAFT PRODUCTION REQUIREMENTS

The potential STOL and V/STOL production for the 1980 and 1990 time periods is presented in Volume I, Section V as a summary of replacement potential, demand sensitivity and costs, high density short haul fleet requirements and possible international demand. The high density short haul market demand and load factor determination are discussed in Appendix A.2. The determination of indirect and direct operating costs is discussed in Appendix F. This appendix provides additional background and supporting data on the replacement potential, sensitivity and potential international demand in combination with the results from Appendixes A.2 and F to define potential aircraft production requirements.

C.1 V/STOL REPLACEMENT POTENTIAL

The profiles of the number of aircraft in service, by type, as a function of time shown in Figure C-1 indicate a replacement market develops from 1978 onwards for short to medium haul aircraft. These profiles are based upon the number of and service life history of U.S. carrier aircraft since 1946. The service introduction dates for different aircraft are shown in Table C-1. In the different categories, the introduction of replacement types varies from 6 to 11 years. The number of 2 and 3 engine jets in carrier service is shown in Table C-2. A leveling off in the total number is indicated for the 1969 through 1971 time period. It is not clear from these data whether this is due to market saturation or a recession. However, it may be conservatively assumed that the air modal split for this market will not drastically change without significant service changes that are not presently obvious. Assuming a 15-year service life as a reasonable maximum, the entire fleet for the short and medium haul market will have to be replaced by 1983. This replacement schedule could be accelerated by environmental noise requirements that may make engine retrofit uneconomical. For example, quiet STOL is a replacement candidate for the high density short haul portion of this market. A suggested schedule for this replacement is shown in Table C-3.

The data shown in Figure C-1 also include four engine jets and wide-body jets. The number and type of aircraft operated by U.S. carriers in 1971 are shown in Table C-4. Air carriers often sell an aircraft before it has been fully depreciated to replace it with a newer, larger aircraft. For example, while sales of 727s have continued, the fleet size for 2 and 3 engine jets has remained almost constant (see Table C-3) due to the replacement of smaller aircraft with the 727s. These data tend to confirm the estimate of a nearly constant level of 2 and 3 engine jets in the U.S. carrier fleet from 1972 through 1980.

C.2 DEMAND SENSITIVITY AND OPERATING COSTS

While all of the 2 and 3 engine jet fleet will be replaced, only the use of a quiet STOL in the short haul high density market has been examined. The details of the definition of the demand for this market and probable load factors are given in Appendix A.2. There, both maximum and minimum growth markets and competitive and noncompetitive load factors are defined. The DOC and IOC developments for the STOL and V/STOL aircraft are detailed in Appendix F. The cost data, market data and aircraft utilization were then studied in combination to determine sensitivities and fleet sizes.

Examples of DOC and IOC variation with stage lengths, and the variation of fare and air modal split, also as functions of stage length, are included in Volume I, Section V. These data are a summary of what is considered to be the most significant case of those examined. The complete matrix included fare levels varying from the California intrastate case to the CAB fare level, as indicated in Figure 15, Volume I; the competitive 55 percent load factor and the non-competitive 65 percent load factor; the maximum and minimum growth markets; and aircraft annual utilization levels of 2500, 3000, and 3500 hours. The resulting short haul high density market fleet sizes are shown in Tables C-5, C-6, and C-7. The data are for the 1980 STOL, 1990 STOL and 1990 V/STOL, respectively. These data represent the domestic fleet sizes as a function of utilization and aircraft size for the market growth and load factor conditions indicated. The data were derived by determining the number of aircraft flights required to serve each city pair route as a function of the parameters just indicated.

The methodology utilized for estimating the STOL fleet size is illustrated in Figure C-2. As the figure shows, the number of annual flights necessary to provide service to satisfy a city pair demand is determined as a function of aircraft size and load factor. A minimum service level of 4 flights per day is provided for any city pair route, even where demand does not require 4 flights. The aircraft annual utilization and the city pair route block time provide the number of annual flights given aircraft can make on a city pair route. The flights required and the flights available per aircraft give the required number of aircraft for that city pair route. Since most of the traffic is to and from hub cities, fractional aircraft can be obtained by scheduling adjustments between different routes at that hub. Fleet spares requirements are added to the total obtained for the routes.

Different regions of the country have market elasticities that are dependent on the local economics, competitive transportation modes, short haul service characteristics and fares. Thus, the fare reduction which is made possible by increasing the passenger load factor from 55% to 65% produces an increase in total air demand which varies differently under different market elasticities. The minimum growth market, characterized by the California Corridor, has an elasticity which requires an increased number of aircraft to satisfy the short haul air demand created by the air fare reduction associated with the load factor increase. The maximum growth market, characterized by the Midwest Corridor, has a different elasticity. Here, the increased number of air passengers is less than the additional aircraft seats made available in going from 55% to 65% passenger load factor, and, hence, a fewer number of aircraft are required. Each region will have a slightly different market elasticity characterized by local conditions. The results here are approximations of the total U.S. short haul fleet requirements and do not necessarily predict the exact requirements for any route or region, although the extreme values should be indicative of the potential fleet requirements.

As indicated in Volume I, the 150-passenger aircraft with 2500 hours per year of utilization at a 55 percent load factor in the maximum growth market was selected for primary emphasis. The 150-passenger size was selected as this size of aircraft is currently successfully used in this market and similar studies have indicated this is a satisfactory to near optimum size for this application. The 2500 hour annual utilization represents current good service practice. The load factor, as discussed in Appendix A.2, represents the average load factor obtained when two or more airlines operate in competition on a given route, while the maximum market is representative of the potential in most of the U.S. The 100-passenger VTOL was selected since even with new construction for 1990 there will be relatively fewer CBD VTOLports than STOLports. Therefore, better service can be offered with the smaller aircraft.

A sensitivity check was made for the 1980 STOL case. These data are summarized in Figure 16 of Volume I and are discussed there.

C.3 INTERNATIONAL DEMAND FOR STOL

The international market for U.S. built commercial aircraft has often been a significant portion of the production of a given type. While this cannot be guaranteed for STOL or VTOL because of the high interest in STOL development in European countries, it may still be the case since past history indicates a tendency to buy U.S. aircraft even where a given type was first produced elsewhere. An indication of the international market is given by Table C-8 where the world fleet of turbine powered aircraft is listed. Table 7 of Volume I indicates the percent of foreign sales for several major U.S. jet aircraft. An average foreign sales potential of 40 percent of total sales was indicated by this survey. The potential foreign market was not used for basic costing, but a potential reduction in domestic fare (3 to 5 percent) was determined if the full domestic plus foreign production was realized.

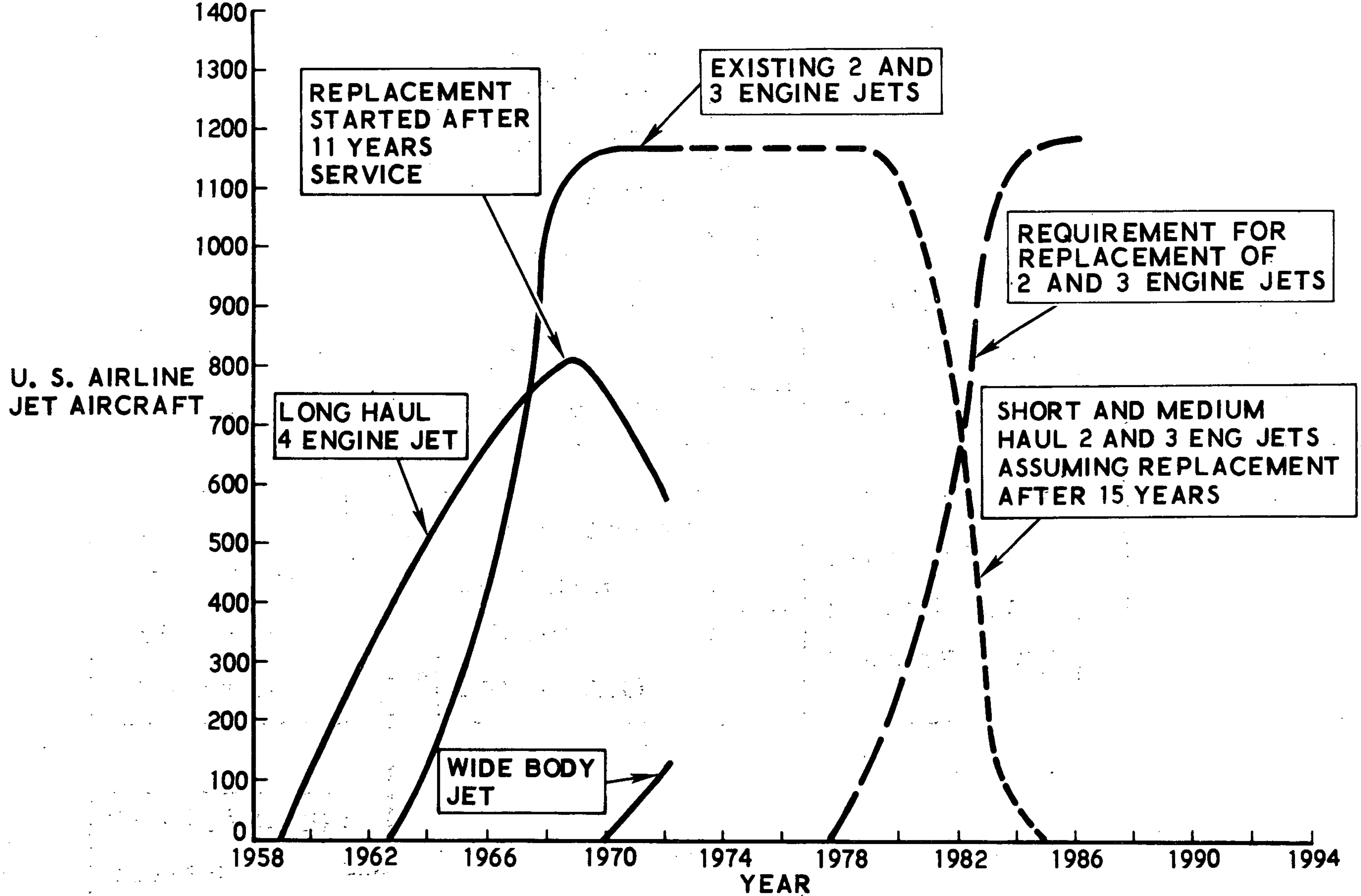


Figure C-1. U.S. Airline Jet Aircraft

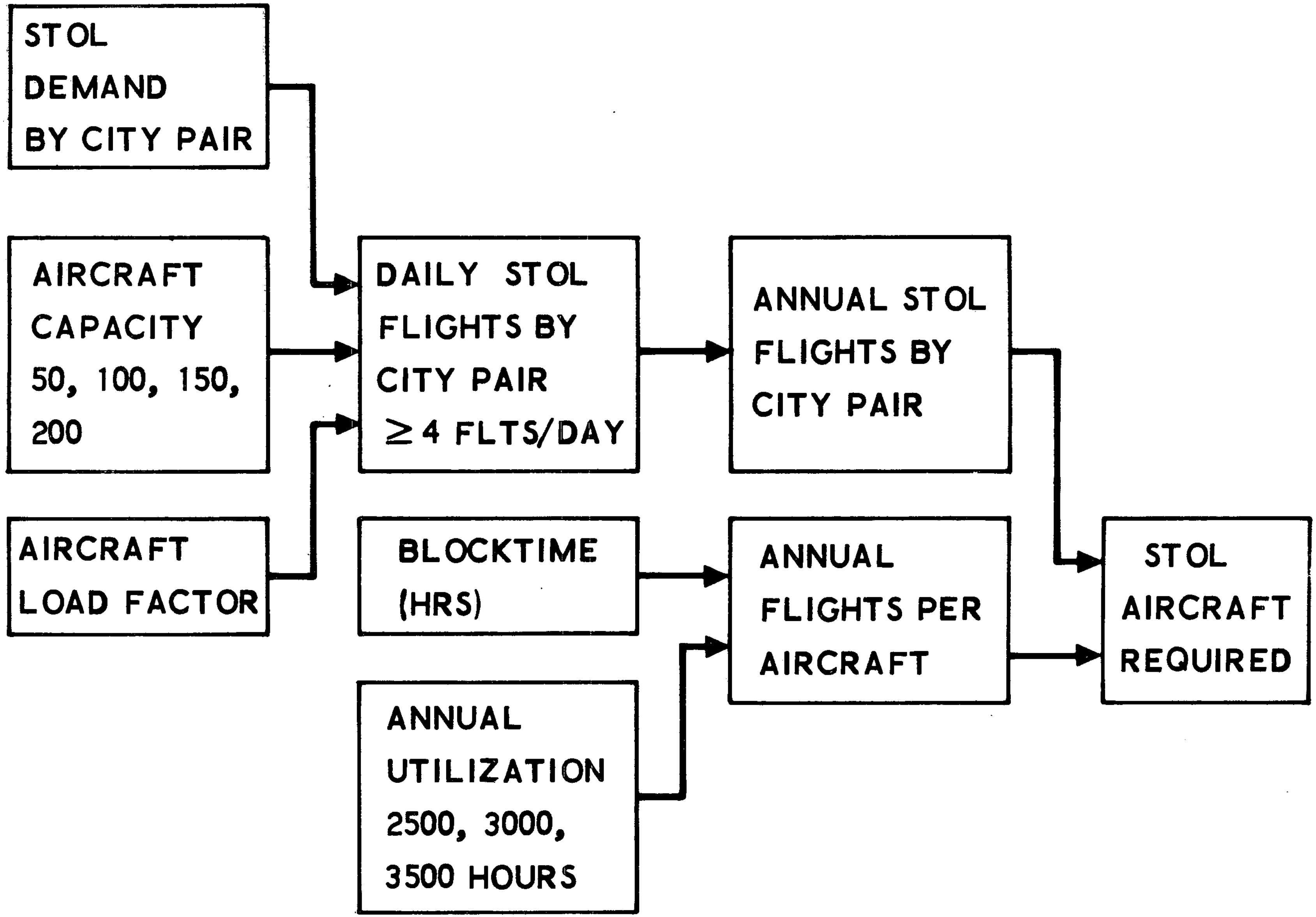


Figure C-2. Methodology for Estimating System Fleet Requirements

Table C-1. Introduction of Aircraft - U. S. Carrier Fleet Pressurized Aircraft

Year	Piston		Turboprop		Turbine		
	2 Eng	4 Eng	2 Eng	4 Eng	2 Eng	3 Eng	4 Eng
1946		L-649*					
1947		DC-6*					
1948	C-240*						
1949		B-377*					
1950							
1951	M-404	L-1049*					
1952							
1953		DC-7*					
1954							
1955				V-745*			
1956		DC-7C*					
1957		L-1649A*					
1958			F-27	V-800*			B-707
1959				L-188	SE-210		DC-8
1960							
1961							
1962							
1963							
1964						727	
1965					DC-9 BAC-111		
1966			YS-11				
1967					737		
1968							
1969							
1970							B-747
1971						DC-10	
1972						L-1011	

* No Longer in Passenger Service

Table C-2. U.S. Air Carrier Fleet - Available for Service 1964-1971
CAB Certificated, Supplemental & California Intrastate Air Carriers
Two and Three Engine Turbine Aircraft

	YEAR ENDING							
	1964	1965	1966	1967	1968	1969	1970	1971
Three Engine								
727 (94-189)	88	169	287	395	540	643	657	672
Two Engine								
DC-9 (80-125)		5	54	143	266	328	334	441
737 (80-113)					70	149	148	148
BAC-111 (65-109)		20	54	57	61	60	67	63
Caravelle (64-104)	20	20	20	20	20	20	15	10
Total Two Engine	20	45	128	220	417	557	564	662
Total Two and Three Engine	108	214	415	615	957	1,200	1,221	1,334

Initial Service

727	Feb 1, 1961
DC-9	Nov 29, 1965
737	Dec 29, 1967
BAC-111	Apr 25, 1965
Caravelle	Jul 14, 1961

Source:

Aviation Data Services 1970 - 1971, Reference C-1.
PSA Annual Report, 1970, Reference C-2.
Air California Financial Statements, 1971, Reference C-:

Table C-3. Forecast Replacement Schedule
CAB Certificated, Supplemental and California Intrastate Air Carriers
Two and Three Engine Turbine Aircraft

	YEAR ENDING							
	1979	1980	1981	1982	1983	1984	1985	1986
Three Engine								
727 (94-189)	88	81	118	108	145	103	14	15
Two Engine								
DC-9 (80-123)		5	49	89	123	62	6	107
737 (80-113)					70	78		
BAC-111		20	34	3	4	2		
Total Two Engine		27	83	92	197	142	6	107
Total Two & Three Engine	88	108	201	200	342	245	20	122

Table C-4. Domestic Jet Aircraft Ownership by Air Carrier (1971)
(Reference C-4)

Airline	Jet 2,3 Engine	No. In Fleet	Jet 4 Engine	No. In Fleet	Jet Wide Body	No. In Fleet	Other	No. In Fleet
Aloha	737	5						
Allegheny	BAC	28					CV580	40
	DC9	30					F27	2
American	727	100	707	97	747	16		
	BAC	24	720	9	DC10	14		
Braniff	727	44	707	7	747	1		
	BAC	5	720	6				
			DC8	7				
Continental	727	23	707	9	747	4	DC6	1
	DC9	16	720	8	DC10	5		
Delta	DC9	76	880	16	747	5	L382	3
			DC8	41				
Eastern	727	101	DC8	26	L1011	3	AC500B	1
	DC9	80					L188	17
							L1329	1
Frontier	737	12					B99	2
							CV580	32
							DHC6	2
Hawaiian	DC9	8					CV640	4
TWA	727	72	707	103	747	19		
	DC9	19	880	25	L1011	1		
United	727	150	720	28	747	14		
	737	71	DC8	112	DC10	14		
Western	727	9	707	5				
	737	30	720	28				
Hughes	DC9	19					F27	24
National	727	38	DC8	15	747	2		
					DC10	5		
North Central	DC9	15					CV580	34
Northeast	727	21					FH227	2
	DC9	14						
Northwest	727	56	707	32	747	15		
			720	7				
Ozark	DC9	17					DHC6	3
							FH227	21
Piedmont	737	13					FH227	9
							YS	21
Southern	DC9	16					M404	17
Texas Int'l.	DC9	15					B99	3
							CV600	25
Air Calif.	737	7					L188	1
PSA	727	18						
	737	9						
		1161		581		118		265

Table C-5. 1980 STOL Fleet Requirements (87 City-Pairs)

ANNUAL UTILIZATION (HRS)	AIRCRAFT CAPACITY (SEATS)	COMPETITIVE MARKET 55% LOAD FACTOR		NON-COMPETITIVE MARKET 65% LOAD FACTOR	
		MINIMUM GROWTH	MAXIMUM GROWTH	MINIMUM GROWTH	MAXIMUM GROWTH
2500	50	700	980	720	910
	100	350	490	360	455
	150	230	325	240	300
	200	175	245	180	225
3000	50	580	815	600	760
	100	290	410	300	380
	150	195	300	220	260
	200	145	205	150	190
3500	50	500	700	515	650
	100	250	350	260	325
	150	165	235	170	215
	200	125	175	130	160

Table C-6. 1990 STOL Fleet Requirements, No VTOL (87 City-Pairs)

ANNUAL UTILIZATION (HRS)	AIRCRAFT CAPACITY (SEATS)	COMPETITIVE MARKET 55% LOAD FACTOR		NON-COMPETITIVE MARKET 65% LOAD FACTOR	
		MINIMUM GROWTH	MAXIMUM GROWTH	MINIMUM GROWTH	MAXIMUM GROWTH
2500	50	830	1170	860	1090
	100	415	585	430	545
	150	280	390	285	365
	200	210	295	215	270
3000	50	690	980	715	905
	100	345	490	360	455
	150	230	325	240	300
	200	175	245	180	225
3500	50	590	840	610	775
	100	295	420	305	390
	150	200	280	205	260
	200	150	210	150	195

Table C-7. 1990 VTOL Fleet Requirements, No STOL (87 City-Pair)

ANNUAL UTILIZATION (HRS)	AIRCRAFT CAPACITY (SEATS)	COMPETITIVE MARKET 55% LOAD FACTOR		NON-COMPETITIVE MARKET 65% LOAD FACTOR	
		MINIMUM GROWTH	MAXIMUM GROWTH	MINIMUM GROWTH	MAXIMUM GROWTH
2500	50	740	1035	760	960
	100	370	520	380	480
	150	245	345	250	320
	200	185	260	190	240
3000	50	615	865	630	800
	100	310	430	315	400
	150	205	290	210	270
	200	155	215	160	200
3500	50	525	740	540	685
	100	265	370	270	345
	150	175	245	180	230
	200	130	185	135	170

Table C-8. World Fleet - Turbine Powered Aircraft

This summary shows, by types, the turbine-powered airlines in service with, and on order, by the world's airlines (excluding Aeroflot, the USSR operator) on May 15, 1972. (Reference C-5)

TURBOJET-POWERED AIRCRAFT	IN SERVICE	ON ORDER	TOTAL BY TYPES
Aerospatiale Caravelle	245	5	250
Airbus Industries A.300B	—	13	13
BAC 1-11	159	—	159
BAC VC10	36	—	36
Boeing 707	659	17	676
Boeing 720	107	—	107
Boeing 727	868	81	949
Boeing 737	292	16	308
Boeing 747	185	27	212
Convair CV880	49	—	49
Convair CV990	24	—	24
Dassault Fan Jet Falcon	8	—	8
Dassault Mercure	—	10	10
Douglas DC-8	534	2	536
Douglas DC-9	628	24	652
Fokker-VFW F28	39	10	49
Gates Learjet	30	1	31
Grumman Gulfstream 2	1	—	1
Hawker Siddeley HS 125	11	1	12
Hawker Siddeley Comet	33	—	33
Hawker Siddeley Trident	73	13	86
HFB 320 Hansa Jet	6	—	6
Ilyushin Il 62	16	1	17
Lockheed L-1011 TriStar	4	121	125
McDonnell Douglas DC-10	31	127	158
N.A.R. Aero Commander	3	—	3
Tupolev Tu-104	4	—	4
Tupolev Tu-124	2	—	2
Tupolev Tu-134	27	—	27
Tupolev Tu-154	—	2	2
VFW-Fokker 614	—	7	7
Yakovlev YAK-40	6	5	11
Totals	4,080	483	4,563

TURBOPROP-POWERED AIRCRAFT	IN SERVICE	ON ORDER	TOTAL BY TYPES
Aerospatiale 262	40	—	40
Antonov An-10	1	—	1
Antonov An-24	49	1	50
Arava STOL	—	2	2
BAC Britannia	18	—	18
BAC Vanguard	37	2	39
BAC Viscount	156	4	160
Beech King Air	5	—	5
Beechcraft 99	127	4	131
Beech Westwind	5	—	5
Canadair CL-44	30	—	30
Convair CV 580	116	—	116
Convair CV 600/640	25	—	25
DHC-2 Turbo Beaver	6	—	6
DHC-6 Twin Otter	232	10	242
Fairchild Hiller F.27/FH.227	114	—	114
Fokker VFW F.27	260	8	268
Grumman Gulfstream I	1	—	1
Grumman Mallard	1	—	1
Hamilton Turboliner	5	2	7
Handley Page Herald	37	—	37
Handley Page Jetstream	4	—	4
Hawker Siddeley Argosy	11	—	11
Hawker Siddeley HS 748	122	11	133
Ilyushin Il-18	78	—	78
J. A. Jetstream	1	—	1
Let L 410	4	—	4
Lockheed L 188 Electra	108	3	111
Lockheed Hercules	31	—	31
Mitsubishi MU-2	5	—	5
NAMC YS-11	129	1	130
N.A.R. Aero Turbo Commander	8	—	8
PAC/Beech Tradewind	1	—	1
Pilatus Turbo Porter	48	2	50
Saunders ST-27 Heron	2	—	2
Short Skyvan	24	—	24
Swearingen Merlin	1	—	1
Volpar Beech	24	6	30
Totals	1,866	56	1,922

TURBINE-POWERED HELICOPTERS	IN SERVICE	ON ORDER	TOTAL BY TYPES
Aerospatiale Alouette	120	—	120
Aerospatiale 315 Lama	6	1	7
Aerospatiale/Westland Gazelle	—	1	1
Aerospatiale/Westland Puma	7	—	7
Agusta Bell	5	—	5
Bell 204	45	—	45
Bell 205	24	1	25
Bell 206 JetRanger	197	—	197
Bell 212	4	—	4
Fairchild Hiller FH.1100	14	—	14
Fuji Bell	6	—	6
Hughes 500	34	5	39
Kawasaki KV-107	3	—	3
MIL Mi-8	—	1	1
Sikorsky S 58T	17	—	17
Sikorsky S 61	43	1	44
Sikorsky S 62	10	—	10
Westland Wessex	16	—	16
Westland WS-55	22	—	22
Totals	573	10	583

REFERENCES

C. 1 Aviation Data Services, private communications, 1970-1971.

C. 2 PSA Annual Report, 1970.

C. 3 Air California Financial Statements, 1971.

C. 4 Air Transport World, World Aviation Publications, Washington, D. C. (November, 1971).

C. 5 ESSO, as reproduced in Aviation Daily (1972).

APPENDIX D

AIRPORT REQUIREMENTS

CONTENTS

FIGURES

FIGURES (Continued)

TABLES

TABLES (Continued)

TABLES (Continued)

APPENDIX D

AIRPORT REQUIREMENTS

The results presented in Volume I have indicated that the successful implementation of STOL short haul operations is dependent upon providing increased passenger convenience at acceptable fare levels, and upon meeting the environmental criteria anticipated for the time period. Major elements in the airport requirements are that the reduction of air and surface congestion at these STOLports should be such as to increase passenger convenience without providing for uneconomical service paths. The STOLports must be configured to reduce passenger access and processing time. The environmental impact of noise due to STOL operations must meet the community acceptance level. While the requirements generated by these criteria were summarized in Volume I, the subsequent sections of this appendix provide additional background and amplification to the summary data.

D.1 STOLPORT REQUIREMENTS FOR PASSENGER CONVENIENCE

The number of STOLports and service paths for passenger convenience in a large metropolitan area is dependent on the area demography and the city pairs being served. For a given city pair, the number of ports and paths may be increased until the gain in air travelers by the addition of another new port-path is not sufficient to justify its addition. This methodology and route analysis is detailed in Reference D-1, and the results obtained were utilized here. Summary results presented in Volume I show that the incremental increase in air modal split decreases at some point as additional port-paths are made available. The number of port-paths where this decrease occurs represents the point where fare economics and convenience are no longer attractive to the air traveler. Some additional results to further illustrate the methodology are presented here.

An aircraft is assigned to fly each given route and/or service path. In Figure D-1 one Augmentor Wing aircraft was assigned to the Los Angeles-San Francisco route which has only one service path between the Chavez Ravine STOLport in Los Angeles to the Crissy Field STOLport in San Francisco. For each given aircraft capacity (40 passenger increasing in increments of 20 seats to 200 passenger) the fares are varied and the STOL air modal split and load factors are determined. This gives a carpet plot of aircraft capacity and load factor as a function of modal split (the percent of the total travel demand between Los Angeles and San Francisco that is captured by this particular STOL service.)

Independent of the above calculations, the economics portion of the program calculates for each given capacity and several load factors the DOC, IOC, ROI and fare required to get a fair return on investment for the aircraft operating on the route and service path. A 10.5 percent ROI was used and the results are shown as broken lines for fares of $16.00 and $21.50. At any point along the line the ROI is 10.5% and the aircraft capacity, load factor, and percent modal split associated with the given fare are available from the plot.

As additional service paths and aircraft are assigned to the route the travelers on the route are served more conveniently and more travelers utilize the STOL service increasing the modal split. This is shown in Figure D-2 for fares of $16.00 and $21.60, still maintaining a ROI of 10.5 percent for all aircraft assigned to the route. The results for the combined service paths are shown by the solid upper line while the results for the weakest service path are shown by the lower broken line. The weakest service path loses travelers to the other service paths as they are added. This is the result when some of the STOL air travelers switch from one STOLport to a new one that has been added, which is more conveniently located. These data are representative of the California, Midwest and Northeast arenas that were considered to obtain the approximation of Volume I.

D. 2 RUNWAY CAPABILITY AND AVAILABILITY

The data presented in Volume I indicate that there were 472 airports available for consideration for the 61 cities of the study. This number was arrived at by examining all of the airports within reasonable proximity to the urban developed area of the subject cities. Examples for several cities are illustrated in Figures D-3 through D-9. As examination of the figures will show, the radius within which airports were considered varies with the size of the urban developed area. These maps were developed for each of the subject cities. The figures selected here illustrate how the availability of airports varies in each of the cities, and examples of typical airport complexes are given in Table D-7.

The list of airports selected for short haul service for the 61 cities is given in Table D-8. The list does not include the major CTOL airports if they are not used for short haul traffic. The tabulation indicates that most of these airports have adequate runways and landing aids for reliever port operation.

D. 3 TYPICAL URBAN AIRPORT COMPLEX

The example of Chicago was shown in Volume I. This is effectively an enlargement of a portion of Figure D-3. The complex for other cities is obtained in a similar manner once the STOL reliever airports have been selected.

D. 4 AIRPORT CATEGORY AND OPERATIONS

The definition of airport category and capacity is very much a function of the individual airport. It was not within the scope or purpose of this study to do a detailed study of each of the candidate airports and STOLports. Rather, it was desired to apply a uniform measure of capacity to the candidates for both operational capability and noise impact. The data and method of Reference D. 2 provide the desired information. The basic operations definition of the reference is shown in Table D-9. These are the same data shown in Table 12 of Volume I, but there an additional descriptive name is given to the airport categories and it is indicated that the STOL operations are substituted for the 2 and 3 engine jet operations. This is illustrated here by Table D-10 where different arbitrary levels of substitution are shown. These levels are applicable primarily to noise impact. Reference D. 2 also gives the practical annual capacity (PANCAP) of operations for different runway configurations. This is illustrated in Figure D-10 and is based on the operations mix of Table D-10. The pertinent assumptions made in the reference are also listed in Figure D-10. The PANCAP data of the reference were matched to the appropriate runway configuration of the candidate airport to define its capacity in terms of the nominal operations mixes of Table D-10. These data provide an assessment of the relative capacity of the airport, and are used to determine its impact as a reliever STOLport.

D. 5 RELIEVER PORT IMPACT

The airport capacity data described in the previous section were matched with the predicted level of operations to determine the potential STOL reliever port impact. The prediction of the 1980 STOL demand is described in Section III of Volume I and Appendix A of Volume II. These data can then be used to determine the 1980 STOL peak hour O&D passengers. These operations and passengers represent a maximum that can be diverted to reliever STOLports. These data are shown in Table D-11 for the major hub cities. The CTOLport PANCAP, determined as described previously, is also listed. In addition, the predicted total 1980 air carrier operations are shown. The total air carrier operations were derived from the FAA data of References D. 3 and D. 4. Reference D. 3 gives the FAA ten year prediction for 1982, and the 1980 level was interpolated from this. This procedure gives a 1971 to 1980 air carrier aircraft operations growth factor of 1. 128. The total growth factor including air carrier and general aviation is 2.07. The air carrier growth factor was applied to the operations data of Reference D.4, the FAA summary for 1971. These data are shown in Figure 23 of Volume I. The distribution of the STOL traffic among the candidate STOL ports in the various cities was somewhat arbitrary, except that all O&D STOL traffic was removed from the major CTOL port where capacity required or it was advantageous to do so. In cases like Boston, where the major CTOL port is also in a CBD port location, some STOL traffic was left at this location. An optimum split could be determined by use of the traveler preference modeling methods, but this was beyond the scope of this study. The economic impact of a CBD port is examined in Appendix F. The nominal distributions of STOL operations to reliever ports are shown in Tables D-12 through D-30 for the major hub cases.

D.6 NOISE IMPACT EFFECTS

The aircraft noise technology background is given in Appendix B. The aircraft noise levels were converted into airport noise impact by the use of the computer program described in Reference D-5. The output from this program is a set of NEF (noise exposure forecast) contours for a given airport operations level, aircraft mix, day/night distribution and flight paths. This program procedure is summarized in Figures D-11 and D-12. It was decided to confine the NEF effects study to single runway airports operating at maximum PANCAP for the appropriate operations mix. This is typical of the nominal "worst" condition to be encountered at most airports where STOL would be operating. Operations at the Category 1 and 2 airports were assumed to be confined only to daytime (0700-2200) while at Categories 3 and 4 they are divided: 90% daytime (0700-2200) and 10% nighttime (2200-0700). These operations are summarized in Table D-31. Nominal typical flight conditions were assigned, as shown in Table D-32. The NEF contours were then generated for these data by using the 1980 and 1990 STOL aircraft desired noise levels for each category of airport. Contours were developed for these cases: all CTOL aircraft, half two or three engine CTOL and half STOL, and all two or three engine CTOL replaced with all STOL. Current aircraft noise level data were used for all CTOL aircraft. The resulting NEF contours are shown in Figures D-13 through D-20. The zero point represents the beginning of the runway in all cases. The resulting contours show the effect of quiet STOL relative to noise levels for current type aircraft operations.

D.7 AIRPORT/STOLPORT ATC REQUIREMENTS

Air traffic control requirements are a continuing concern of the FAA. Studies and prototype installations have been conducted on instrument landing systems and area surveillance systems. It is assumed that these systems will be installed by the FAA at major airports for the 1980 time period. Therefore, expenses for such systems will not be STOL peculiar and are not charged to the system. In addition to the air safety and control aspects, the reduction of the increment between flight block speed and operational block speed (the increment shown in Figure D-21) would be a primary benefit. This would be a realizable objective for STOL and reliever port traffic.

The major elements of the system -- area navigation, terminal guidance and the instrument landing system -- are briefly described in Table D-33. The upgraded third generation system that is of interest to this study is illustrated in Figure D-22. The MLS antenna patterns are illustrated in Figure D-23. The coverage of this system is adequate for both STOL, VTOL and CTOL operations. Actual, planned and assumed levels of ATC deployment are illustrated by Figure D-24. The number of systems available for the 1980 to 1985 time period is more than adequate, since complete STOLport coverage would be achieved by shifting approximately 10 installations.

D. 8 STOLPORT REQUIREMENTS SUMMARY

The STOLport requirements provide for effective STOLport operations through improved passenger convenience, reduced processing time and expedited V/STOL aircraft operations. In all airports where STOL operations were to take place, a special STOL terminal area was provided. This terminal area must have its own gate/apron area, parking area and passenger processing procedure. The terminal/parking requirements were based on Aerospace in-house studies of V/STOL port requirements. The parking area requirement is a function of the number of inbound vehicles (auto) per enplaned passenger, as shown in Table D-35. These vehicle traffic data were based on Reference D-7. The gate/apron requirements were based on the relation:

$$G = \frac{(T + T_c)\,(PHP)}{60\,(P_e + P_d)}$$

where:

G	=	Number of gates required.
PHP	=	Peak hourly passengers (enplaning plus deplaning). (Fig. D-26).
P_e	=	Average number of enplaning passengers per aircraft.
P_d	=	Average number of deplaning passengers.
T	=	Average gate time (minutes) per aircraft. (Fig. D-25)
T_c	=	Time to clear gate and next aircraft to park (minutes).

The terminal area requirements are shown in Figure D-27 and the parking area requirements in Figure D-28.

- STOL CONCEPT - AUGMENTOR WING
- CITY PAIR - LOS ANGELES -- SAN FRANCISCO
- SERVICE PATH - CHAVEZ RAVINE -- CRISSY FIELD

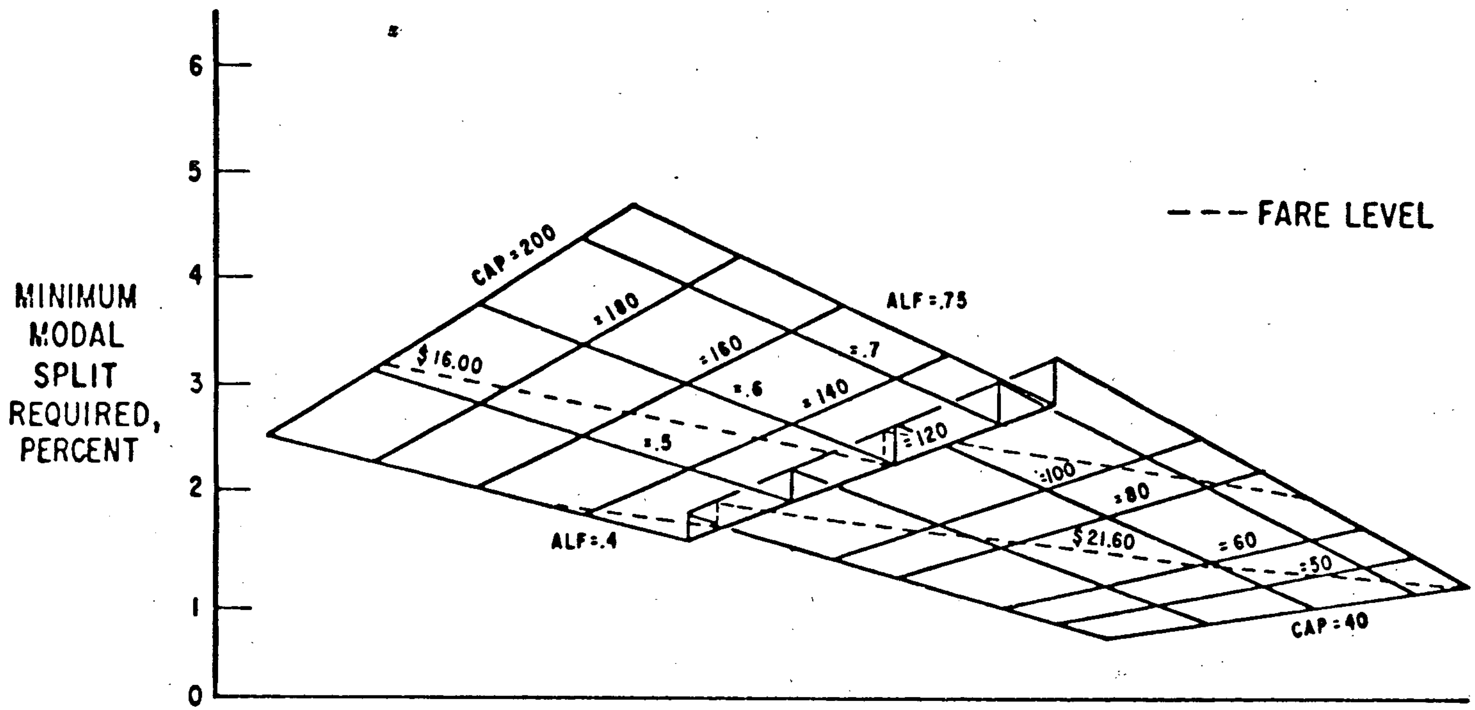


Figure D-1. Percent Modal Split Required for an Economically Viable Service Path

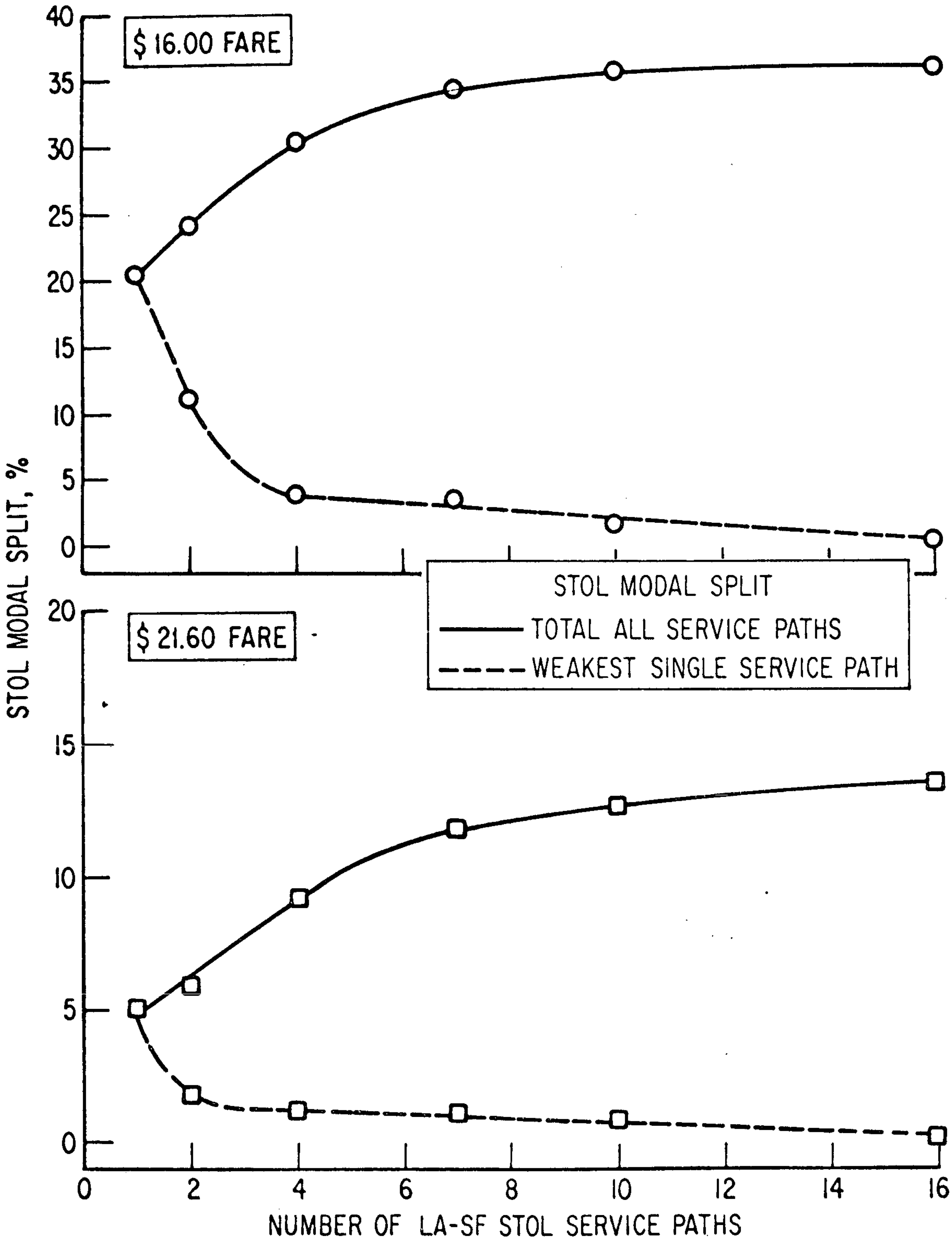
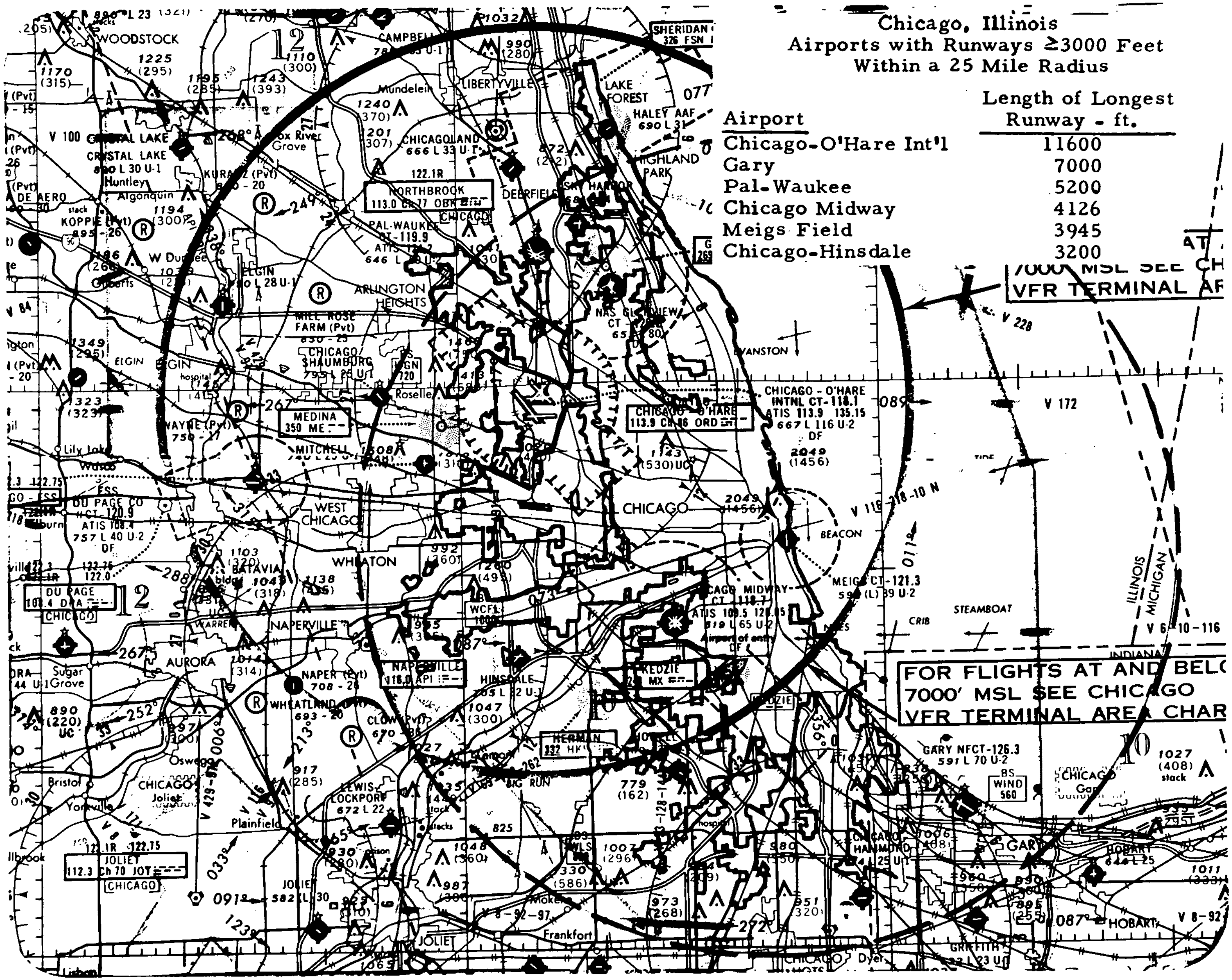
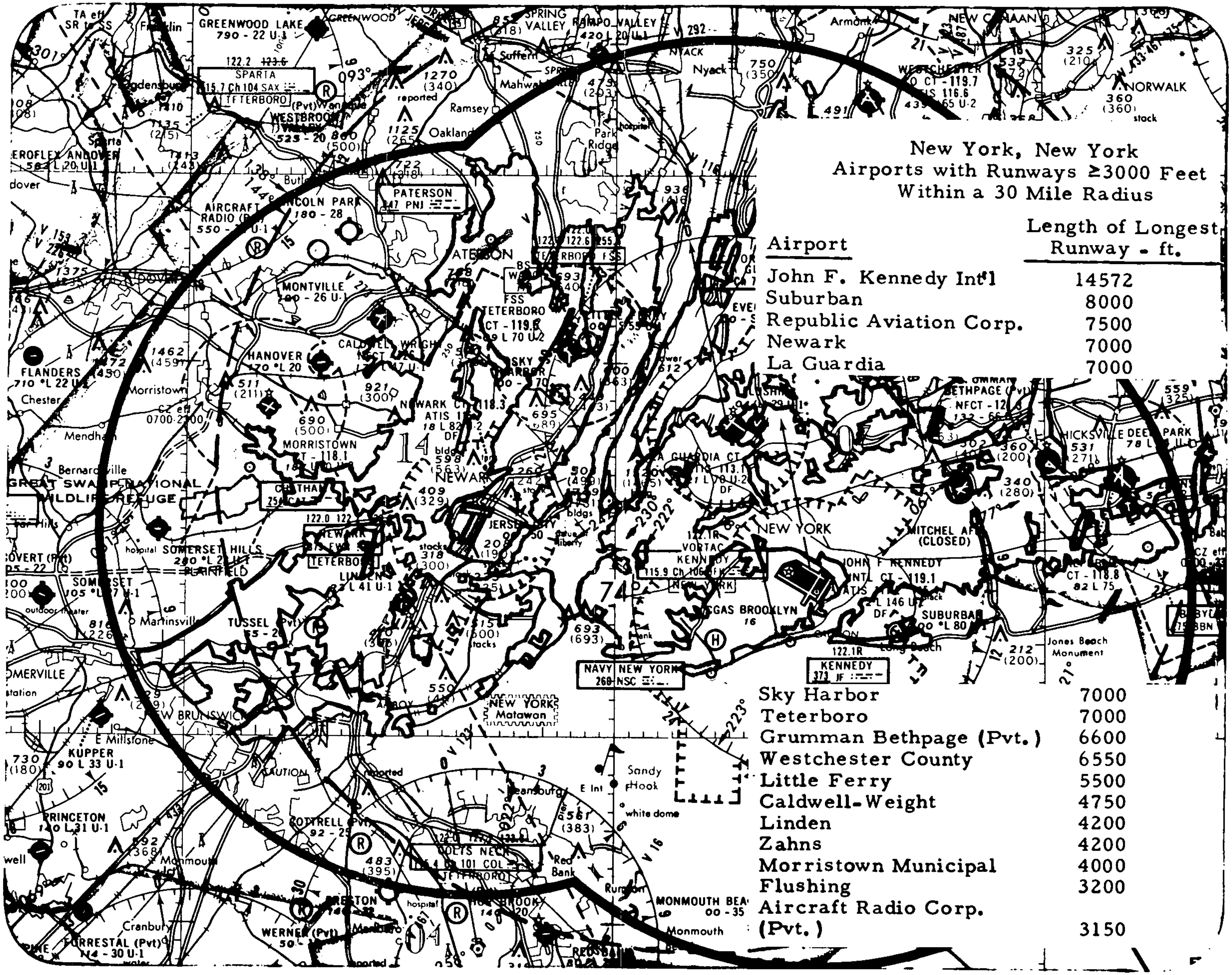


Figure D-2. California Corridor Service Path Evaluation Process



Airport	Length of Longest Runway - ft.
Chicago-O'Hare Int'l	11600
Gary	7000
Pal-Waukee	5200
Chicago Midway	4126
Meigs Field	3945
Chicago-Hinsdale	3200

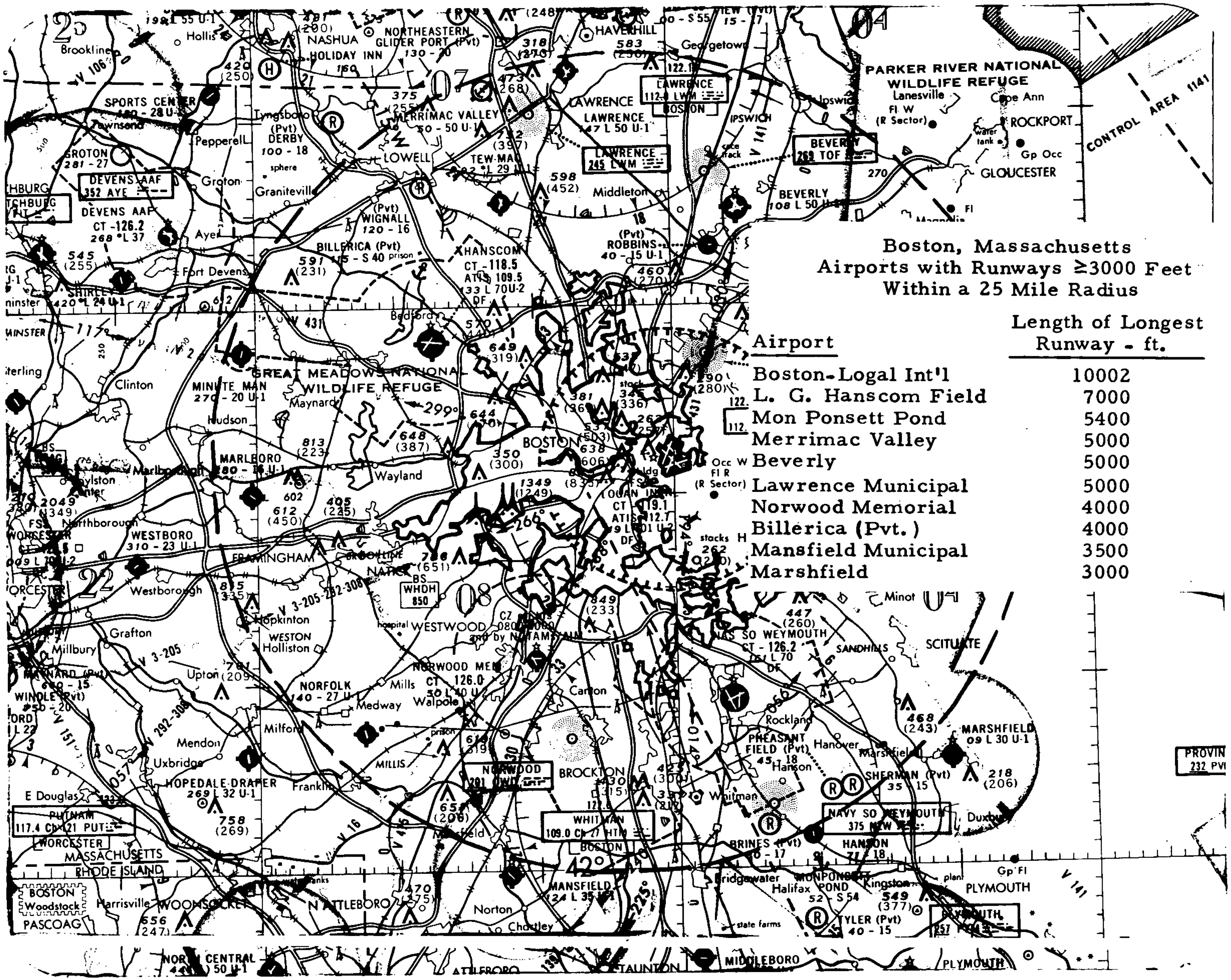
Figure D-3. Airports with Runways ≥ 3000 Feet Within a 25 Mile Radius Chicago, Illinois



New York, New York
Airports with Runways ≥3000 Feet
Within a 30 Mile Radius

Airport	Length of Longest Runway - ft.
John F. Kennedy Int'l	14572
Suburban	8000
Republic Aviation Corp.	7500
Newark	7000
La Guardia	7000
Sky Harbor	7000
Teterboro	7000
Grumman Bethpage (Pvt.)	6600
Westchester County	6550
Little Ferry	5500
Caldwell-Weight	4750
Linden	4200
Zahns	4200
Morristown Municipal	4000
Flushing	3200
Aircraft Radio Corp. (Pvt.)	3150

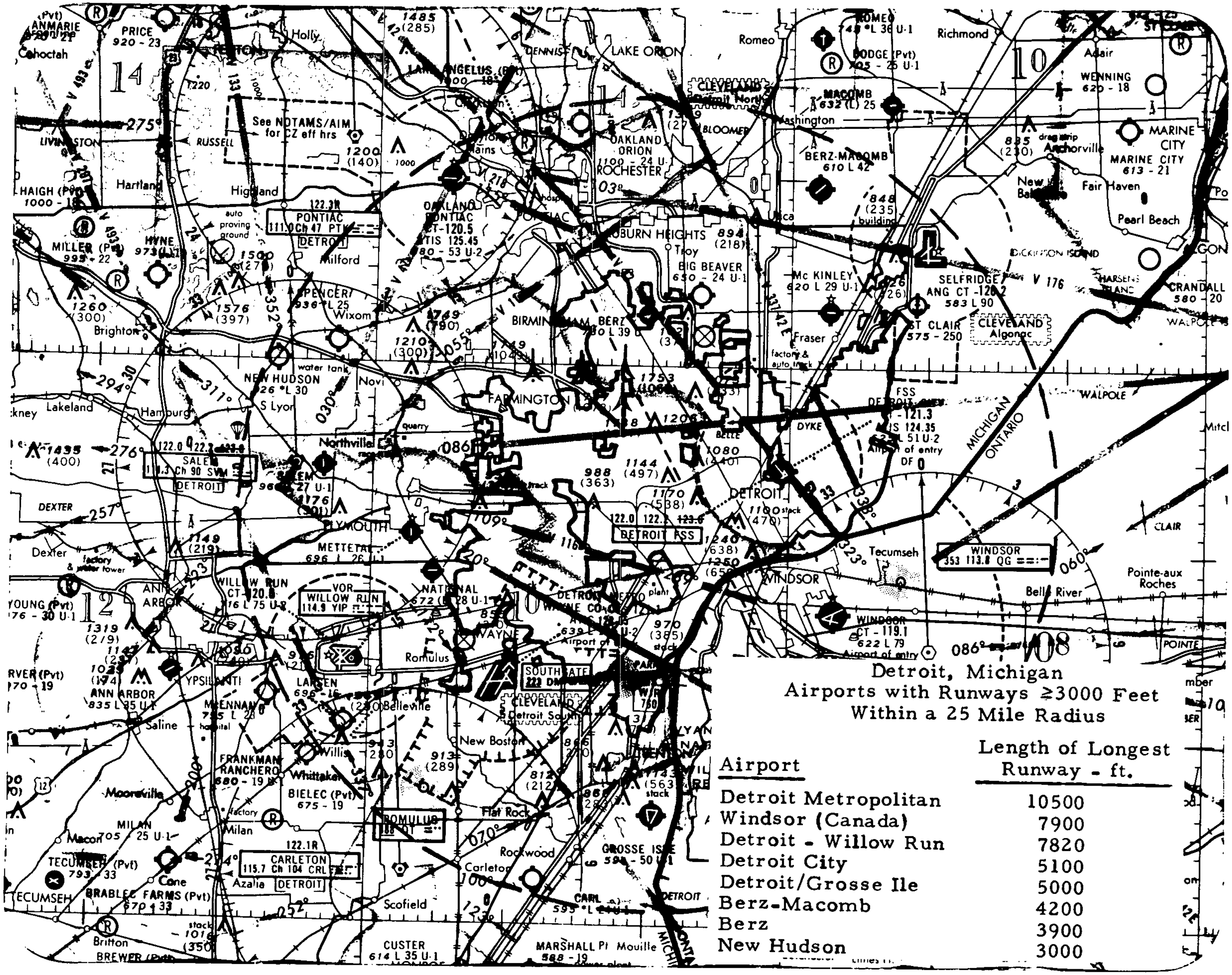
Figure D-4. Airports with Runways ≥ 3000 Feet Within a 30 Mile Radius
New York, New York



Boston, Massachusetts
Airports with Runways ≥3000 Feet
Within a 25 Mile Radius

Airport	Length of Longest Runway - ft.
Boston-Logal Int'l	10002
L. G. Hanscom Field	7000
Mon Ponsett Pond	5400
Merrimac Valley	5000
Beverly	5000
Lawrence Municipal	5000
Norwood Memorial	4000
Billerica (Pvt.)	4000
Mansfield Municipal	3500
Marshfield	3000

Figure D-5. Airports with Runways ≥ 3000 Feet Within a 25 Mile Radius
Boston, Massachusetts



Airport	Length of Longest Runway - ft.
Detroit Metropolitan	10500
Windsor (Canada)	7900
Detroit - Willow Run	7820
Detroit City	5100
Detroit/Grosse Ile	5000
Berz-Macomb	4200
Berz	3900
New Hudson	3000

Figure D-6. Airports with Runways ≥ 3000 Feet Within a 25 Mile Radius Detroit, Michigan

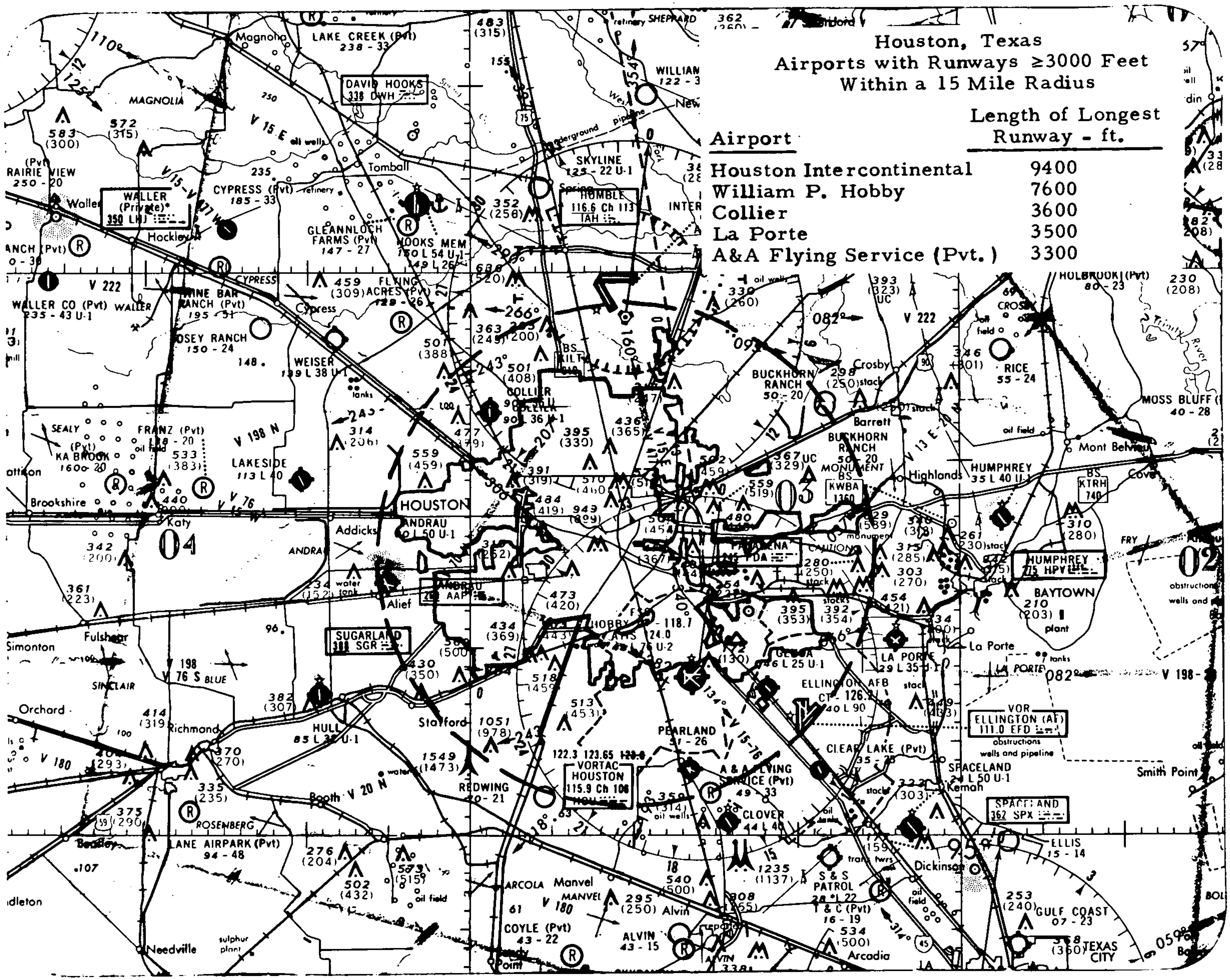
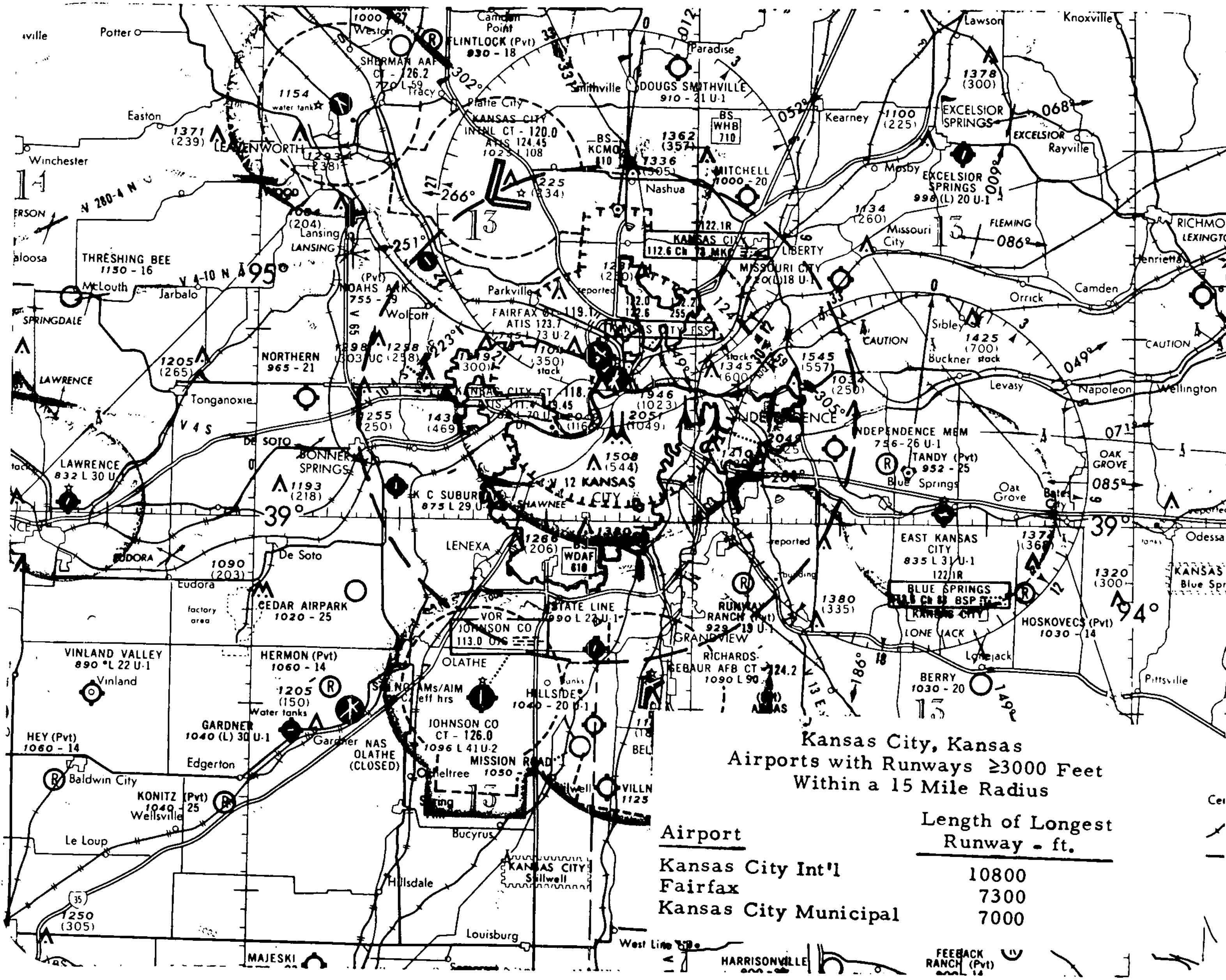
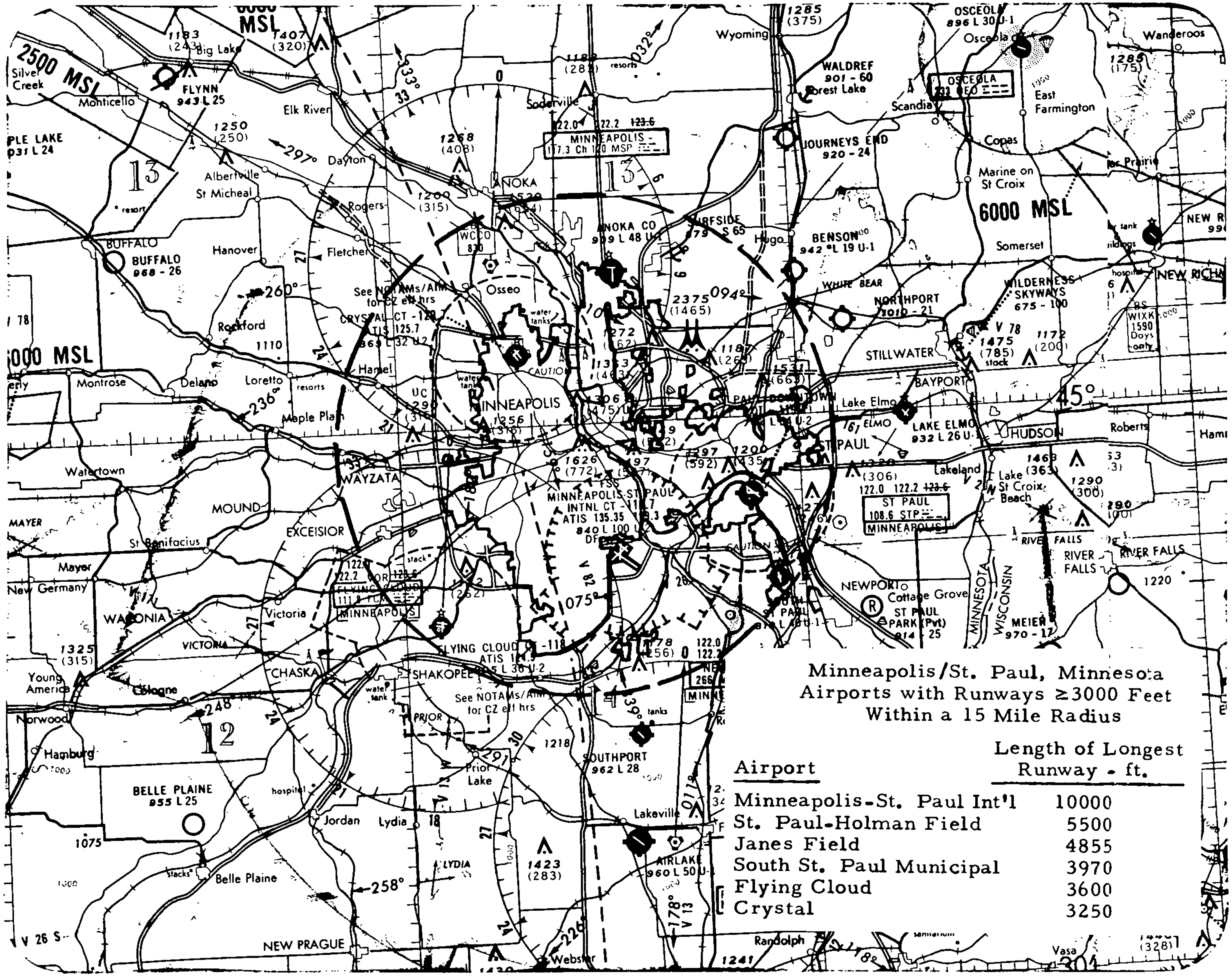


Figure D-7. Airports with Runways ≥ 3000 Feet Within a 15 Mile Radius Houston, Texas



Airport	Length of Longest Runway - ft.
Kansas City Int'l	10800
Fairfax	7300
Kansas City Municipal	7000

Figure D-8. Airports with Runways ≥ 3000 Feet Within a 15 Mile Radius Kansas City, Kansas

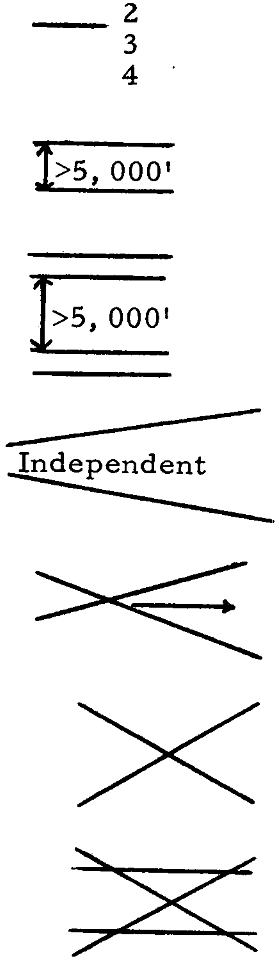


Minneapolis/St. Paul, Minnesota
Airports with Runways ≥3000 Feet
Within a 15 Mile Radius

Airport	Length of Longest Runway - ft.
Minneapolis-St. Paul Int'l	10000
St. Paul-Holman Field	5500
Janes Field	4855
South St. Paul Municipal	3970
Flying Cloud	3600
Crystal	3250

Figure D-9. Airports with Runways ≥ 3000 Feet Within a 15 Mile Radius Minneapolis/St. Paul, Minnesota

(a) Capacity Prediction



Runway Configuration	PANCAP (000)
1	215
2	195
3	180
4	170
	430
	390
	360
	340
	770
	660
	590
	560
	425
	340
	310
	310
	375
	310
	275
	255
	220
	195
	195
	190
	465
	430
	390
	365

(b) Assumptions

Weather: 90% VFR 10% IFR
No Crosswind Reduction

Aircraft Mix: As shown in Table

Peaking Factors and Training:

Mix	1	2	3	4
	15%	12. 5%	9. 5%	8. 0%

Terminal: Central Location for Most Cases

Navigational Equipment:
Full A/C Instr.
Tower, ILS, ALS, Instr. Both Dir.
ASR & CAAS for Mix 3 & 4

Taxiways: Exit Rating of 1 All Runways

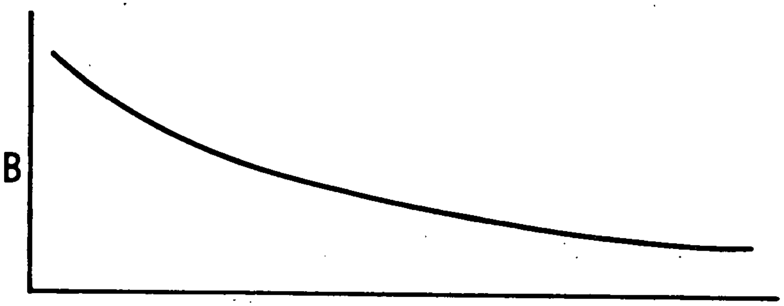
Runways: 50% of all A/C Could use Each Runway

Airspace: Unrestricted

Figure D-10. Typical Airport Capacities - FAA 1980 Prediction
PANCAP Maximum Practical Annual Capacity (000)

- CALCULATE NEF CONTOUR
- ASSUMES
  - STRAIGHT-IN APPROACH TO LANDING
  - STRAIGHT-OUT DEPARTURE FROM TAKEOFF
- INPUT DATA
  - EPNdB PROFILE

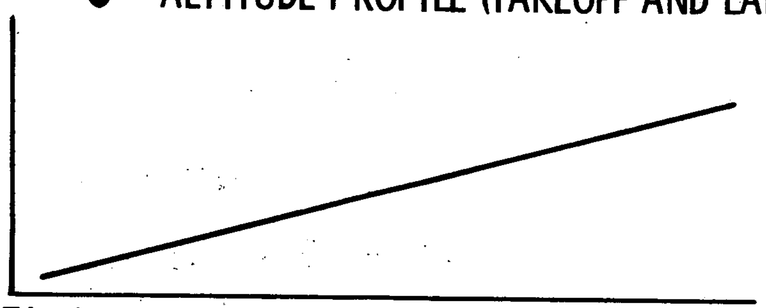
EPNdB



SLANT RANGE, FEET

  - ALTITUDE PROFILE (TAKEOFF AND LANDING)

ALTITUDE



DISTANCE FROM START OF T.O. ROLL OR TOUCHDOWN

Figure D-11. NEF Noise Program

- INPUT DATA (CONTINUED)
  - AIRCRAFT DESCRIPTION
    - SPEED
    - ALTITUDE
    - NOISE CHARACTERISTICS
  - VOLUME OF OPERATIONS ACCORDING TO
    - NUMBER DAYTIME OPERATIONS (0700-2200) PER TYPE AND ALTITUDE PROFILE
    - NUMBER NIGHT OPERATIONS (2200-0700) PER TYPE AND ALTITUDE PROFILE
- OUTPUT DATA - TABULATED COORDINATES FOR EACH NEF CONTOUR

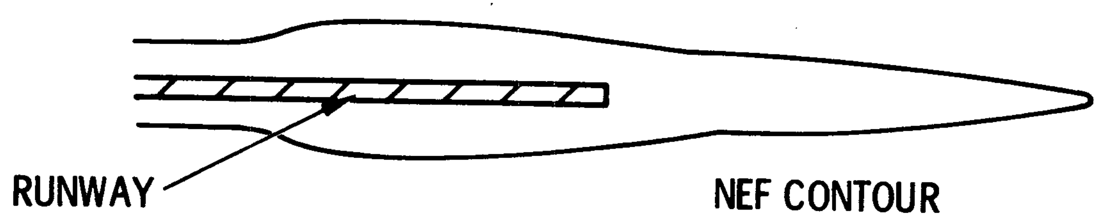


Figure D-12. NEF Noise Program

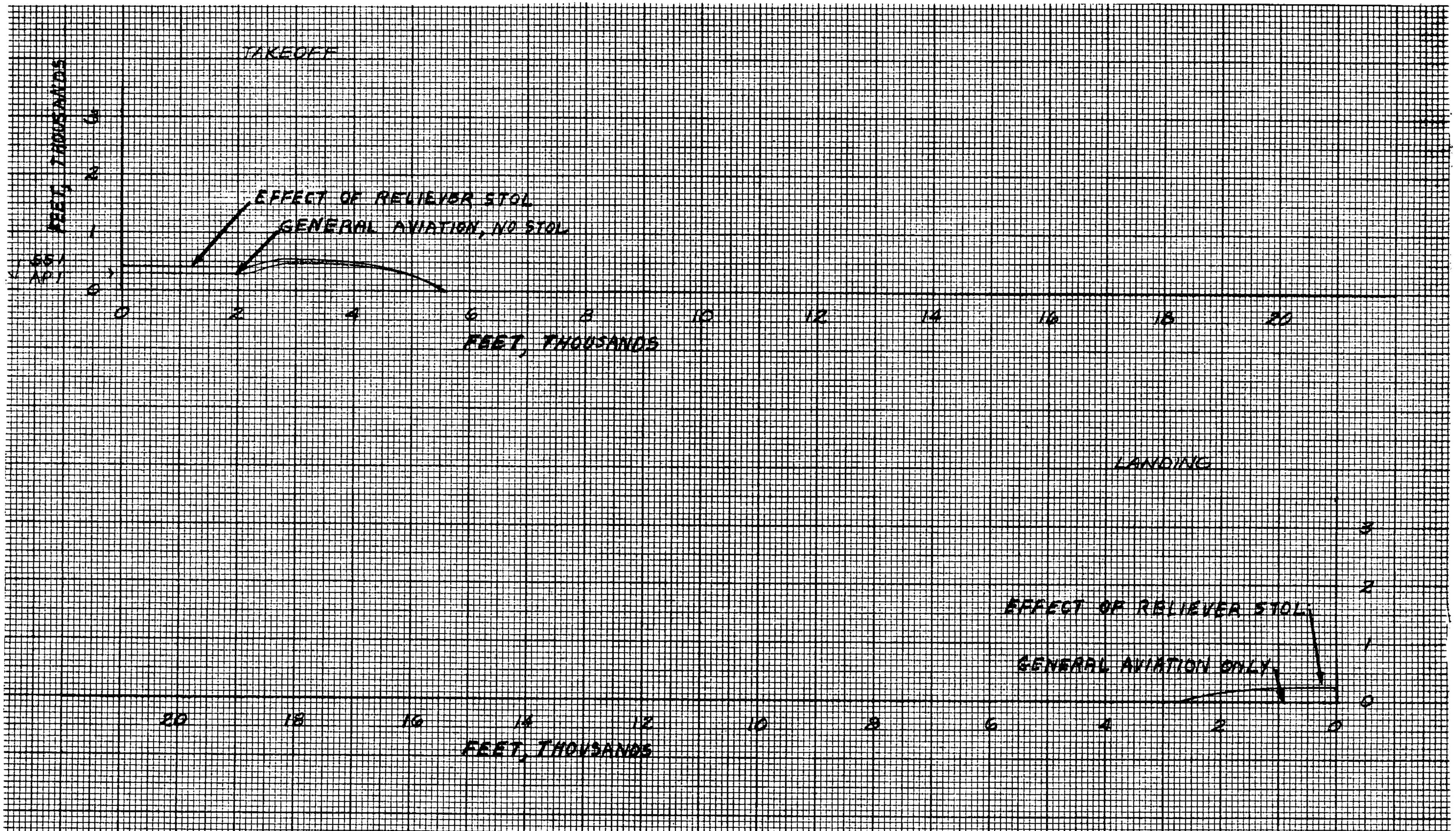


Figure D-13. 1980 General Aviation Airport

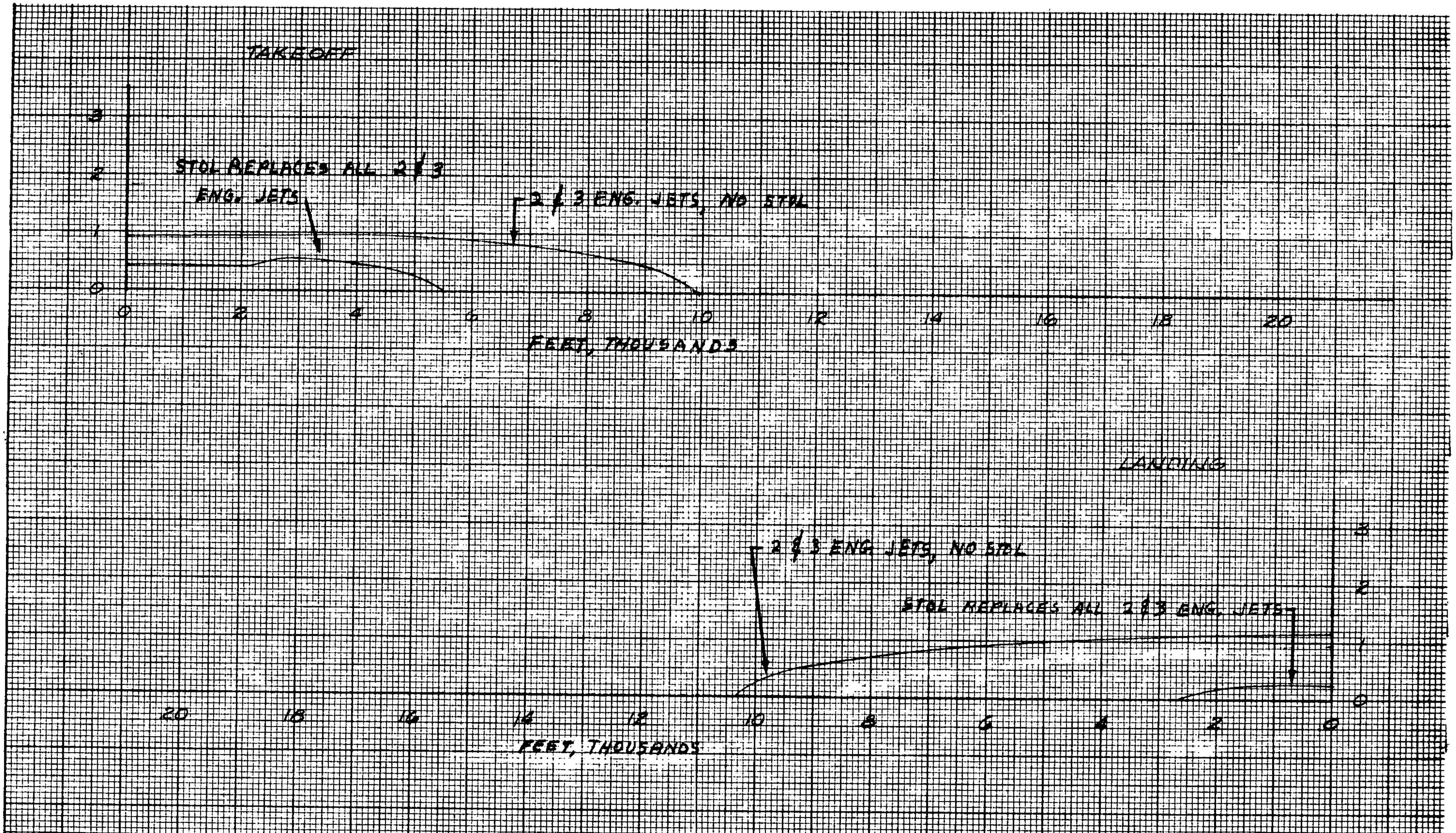


Figure D-14. 1980 Reliever Airport

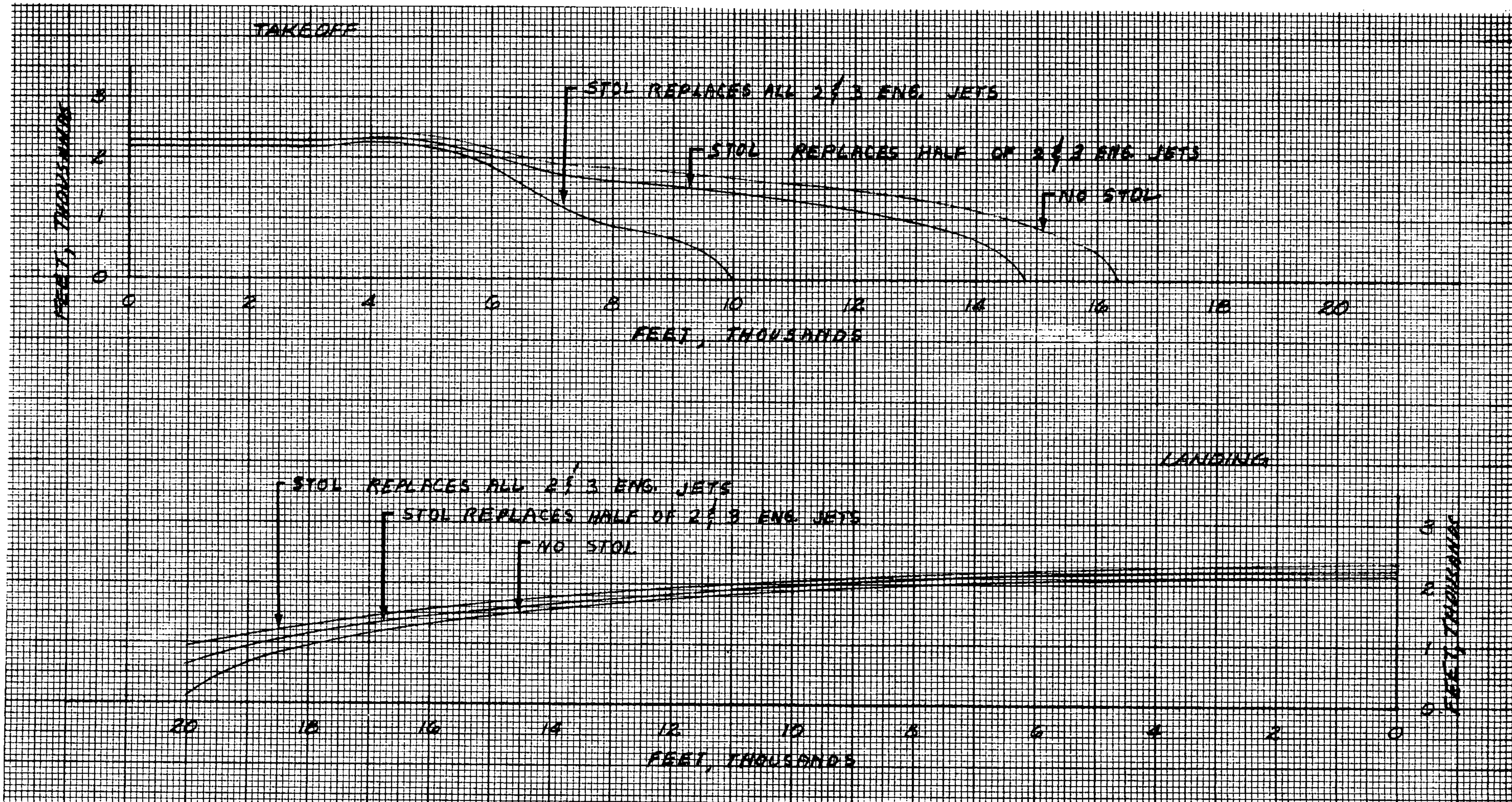


Figure D-15. 1980 Major Domestic Airport

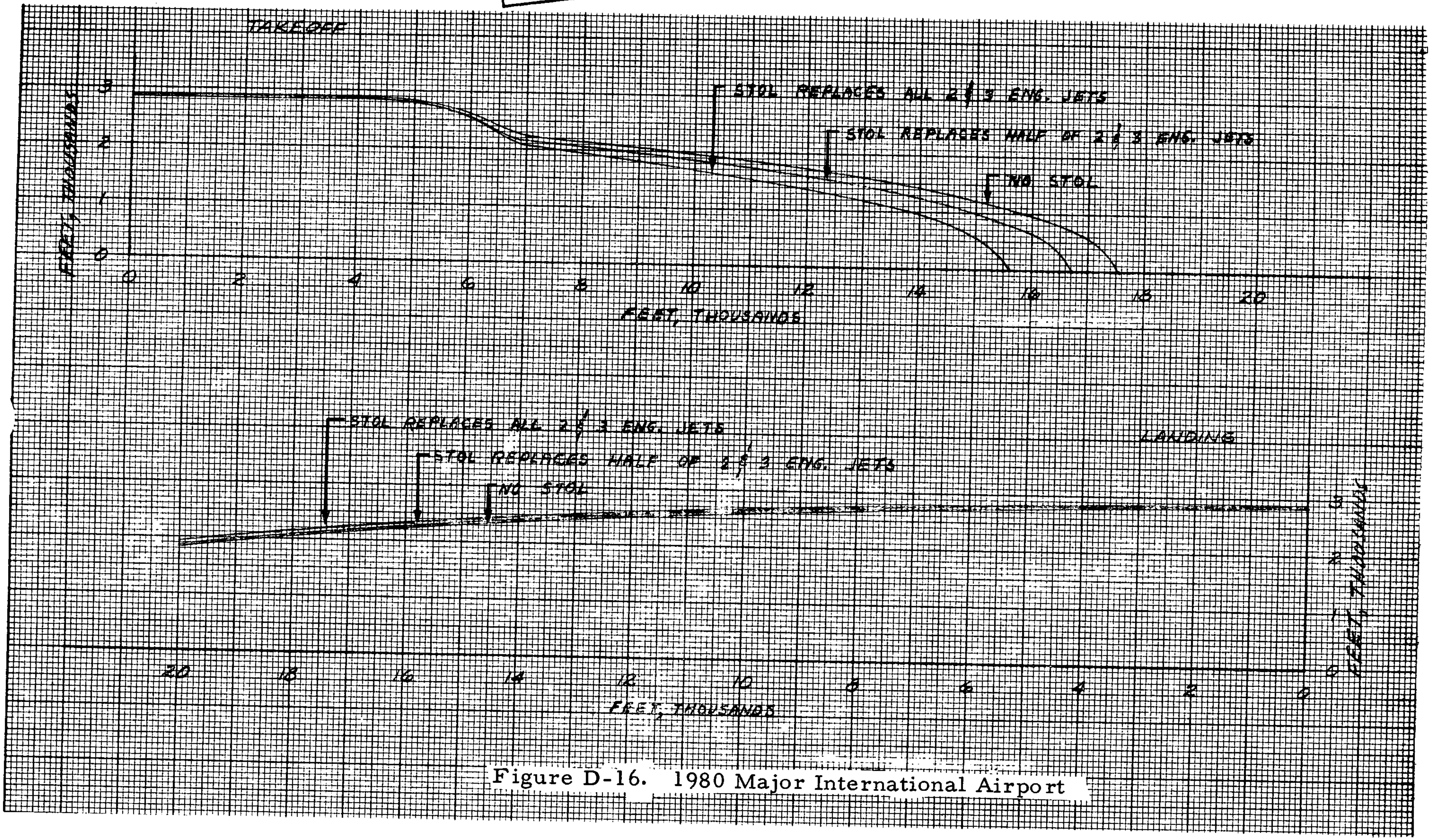


Figure D-16. 1980 Major International Airport

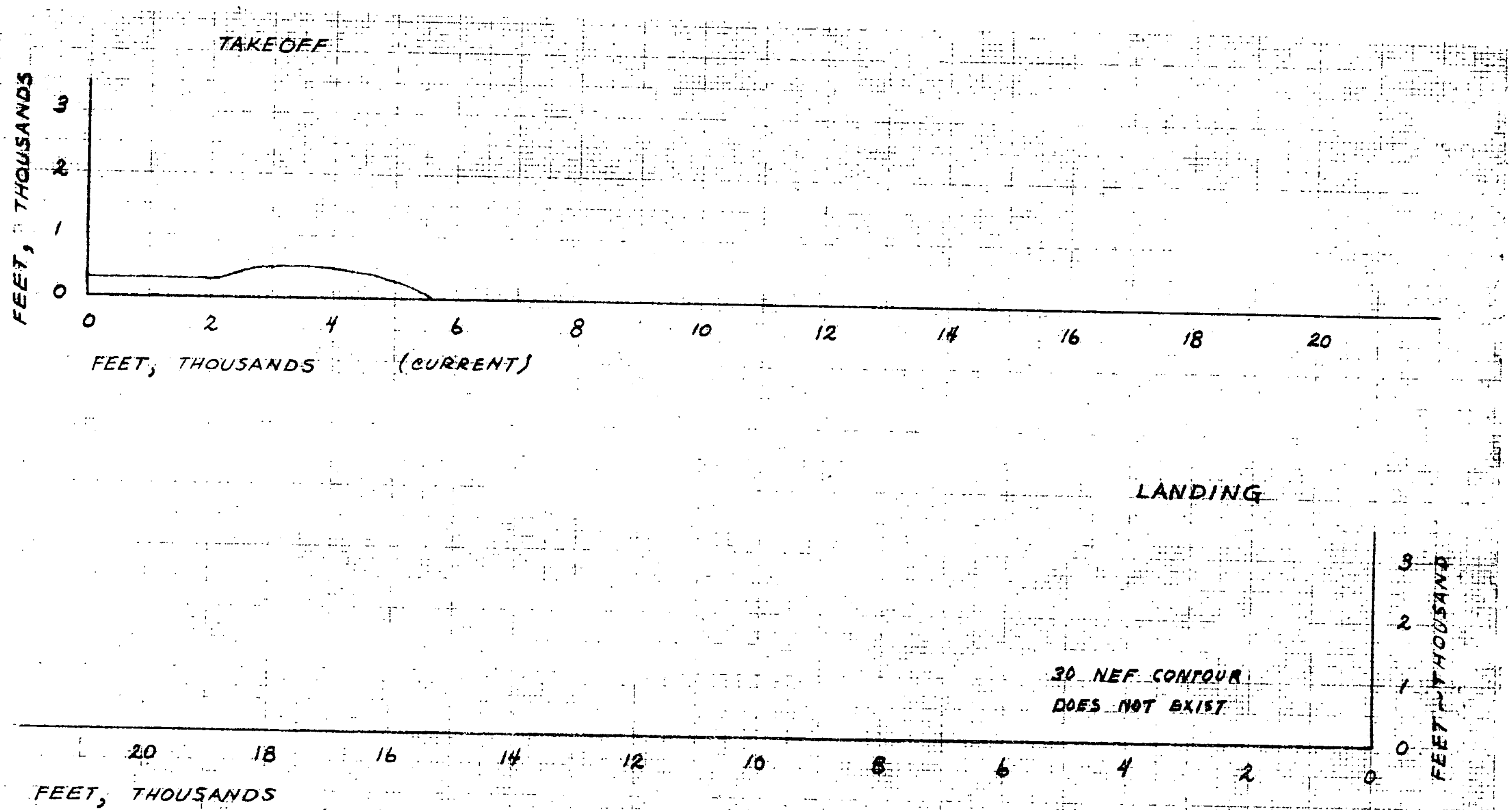


Figure D-17. 1990 Basic Airport 1 - General Aviation

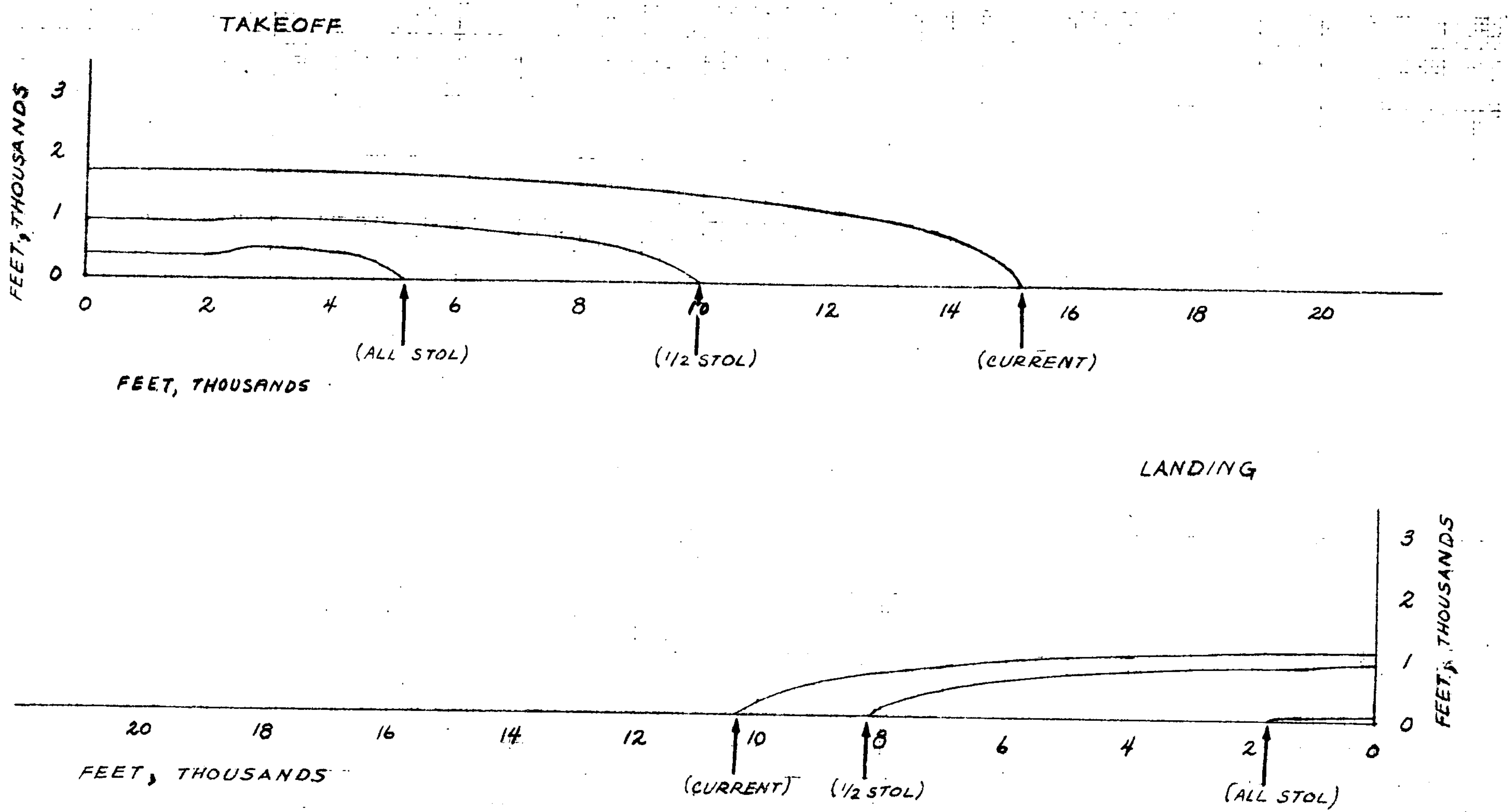


Figure D-18. 1990 Basic Airport 2 - Reliever Airport

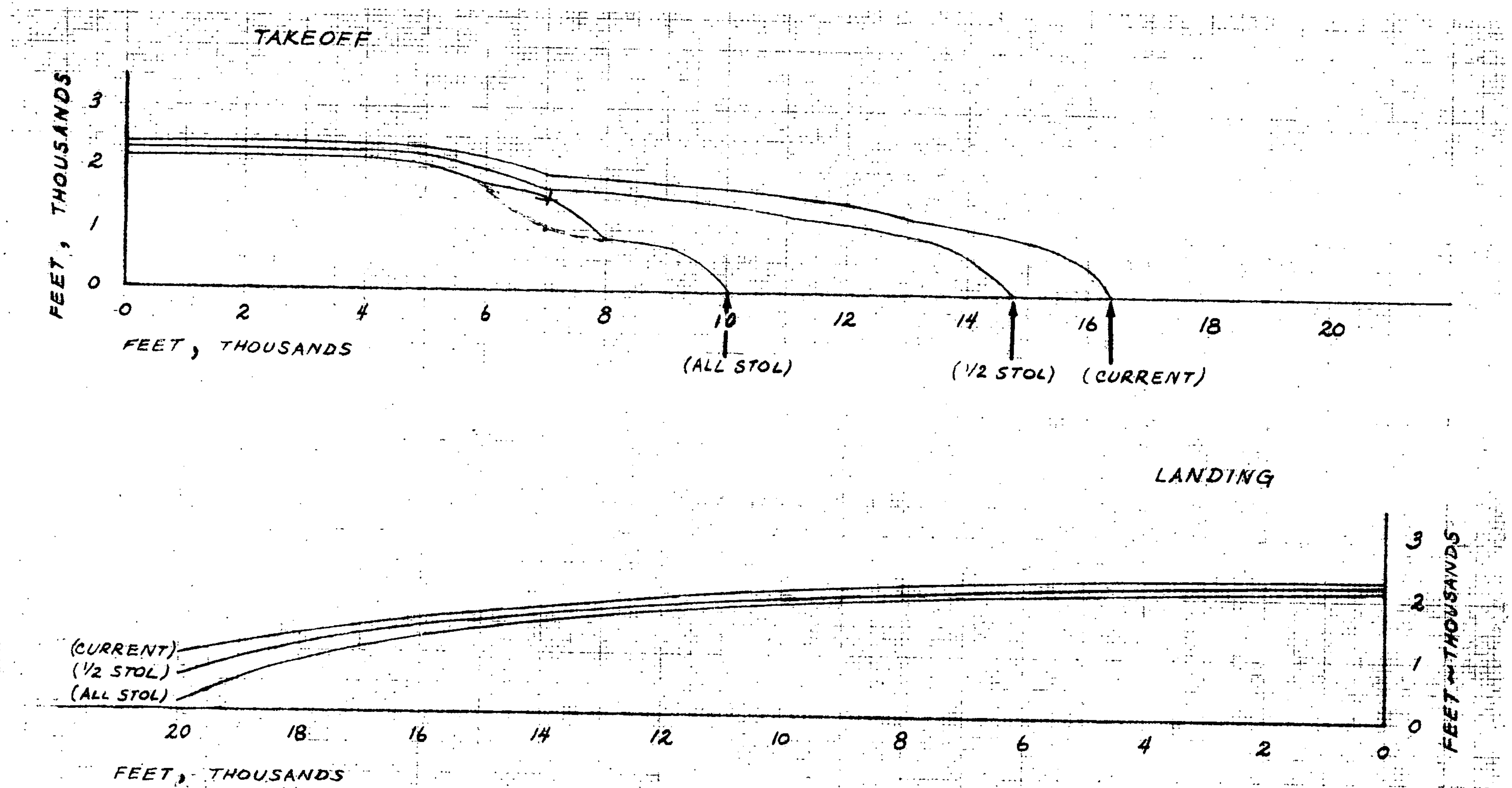


Figure D-19. 1990 Basic Airport 3 - Major Domestic Airport

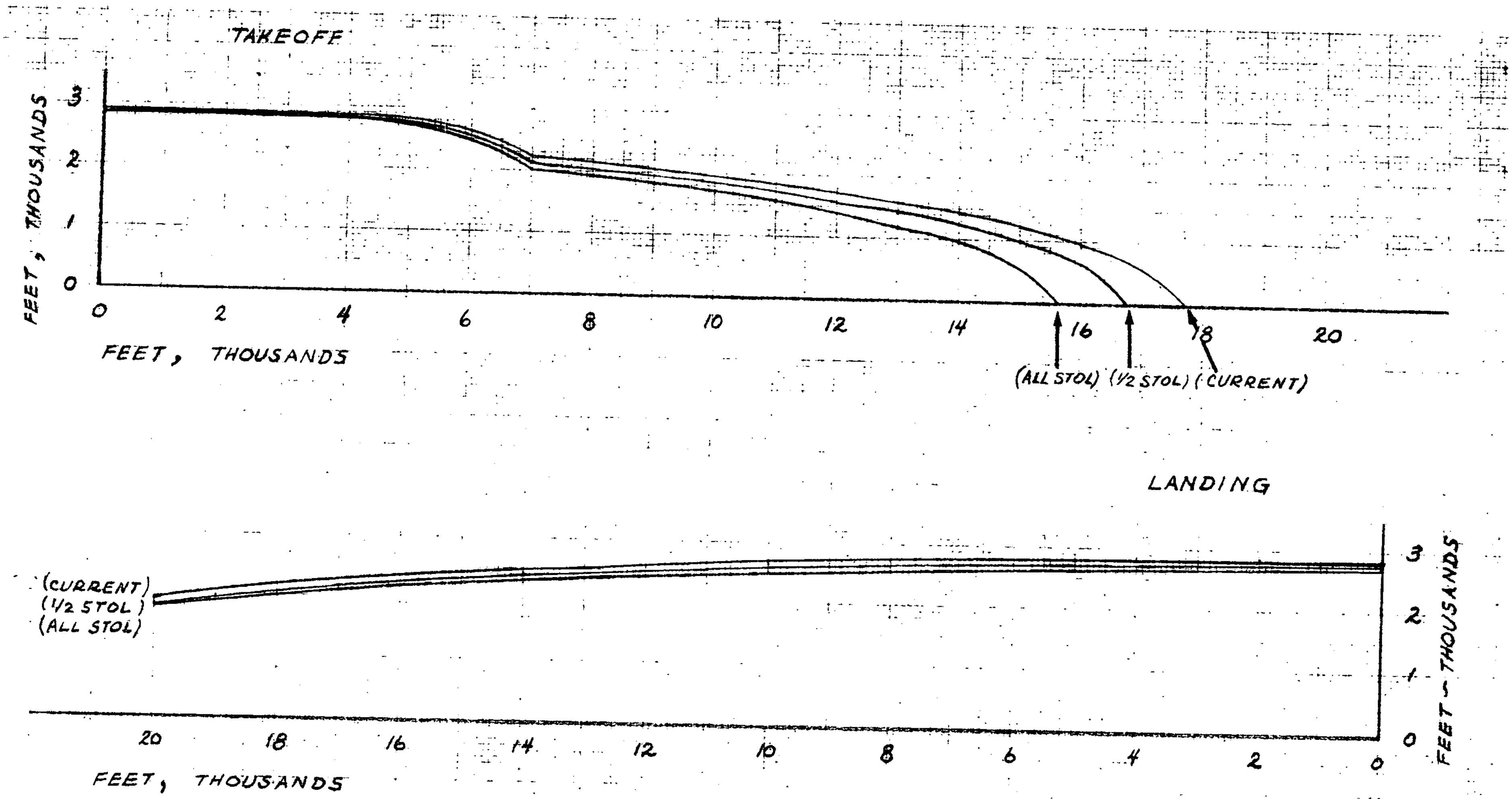


Figure D-20. 1990 Basic Airport 4 - Major International Airport

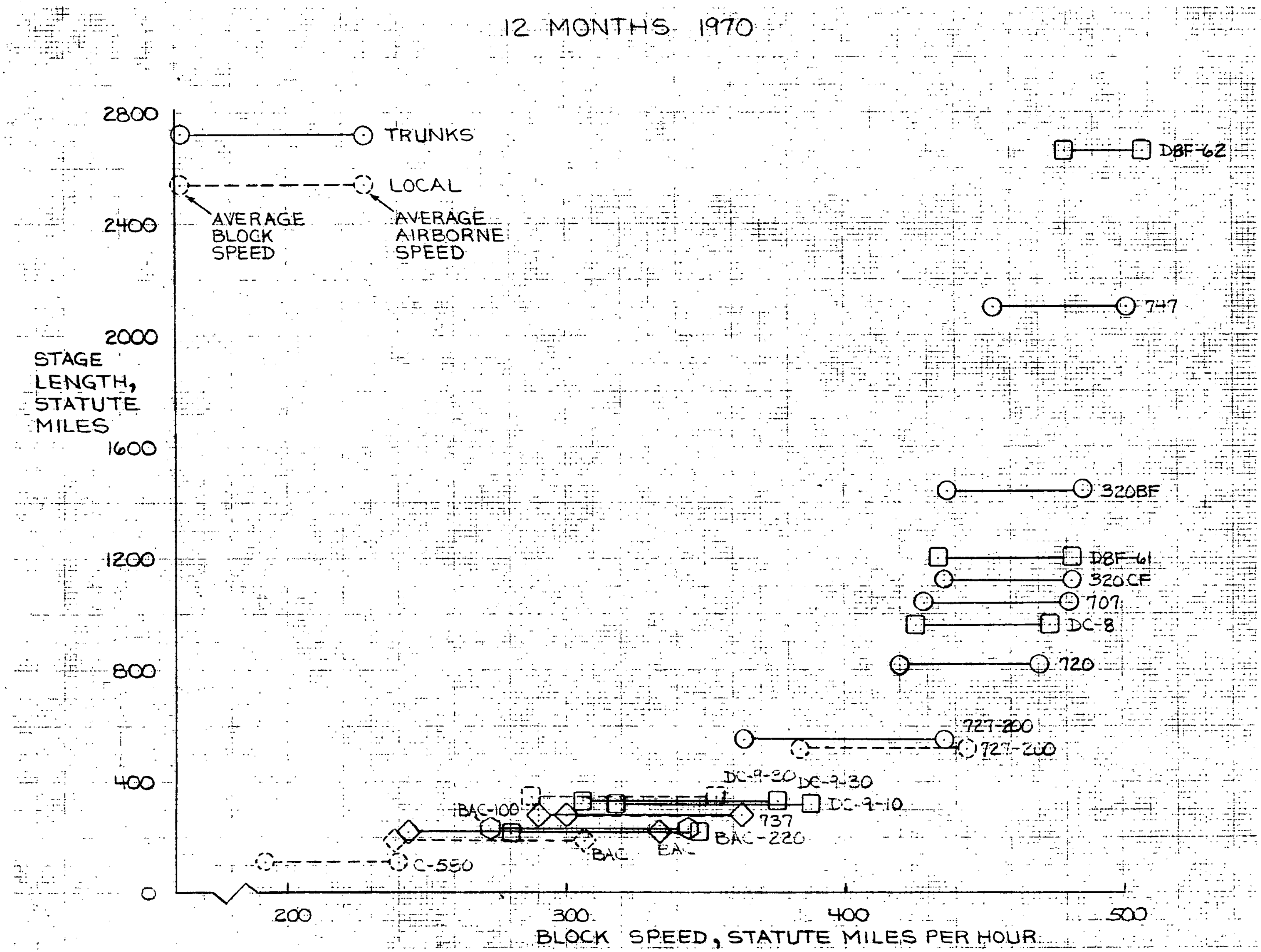


Figure D-21. Effective Block Speed

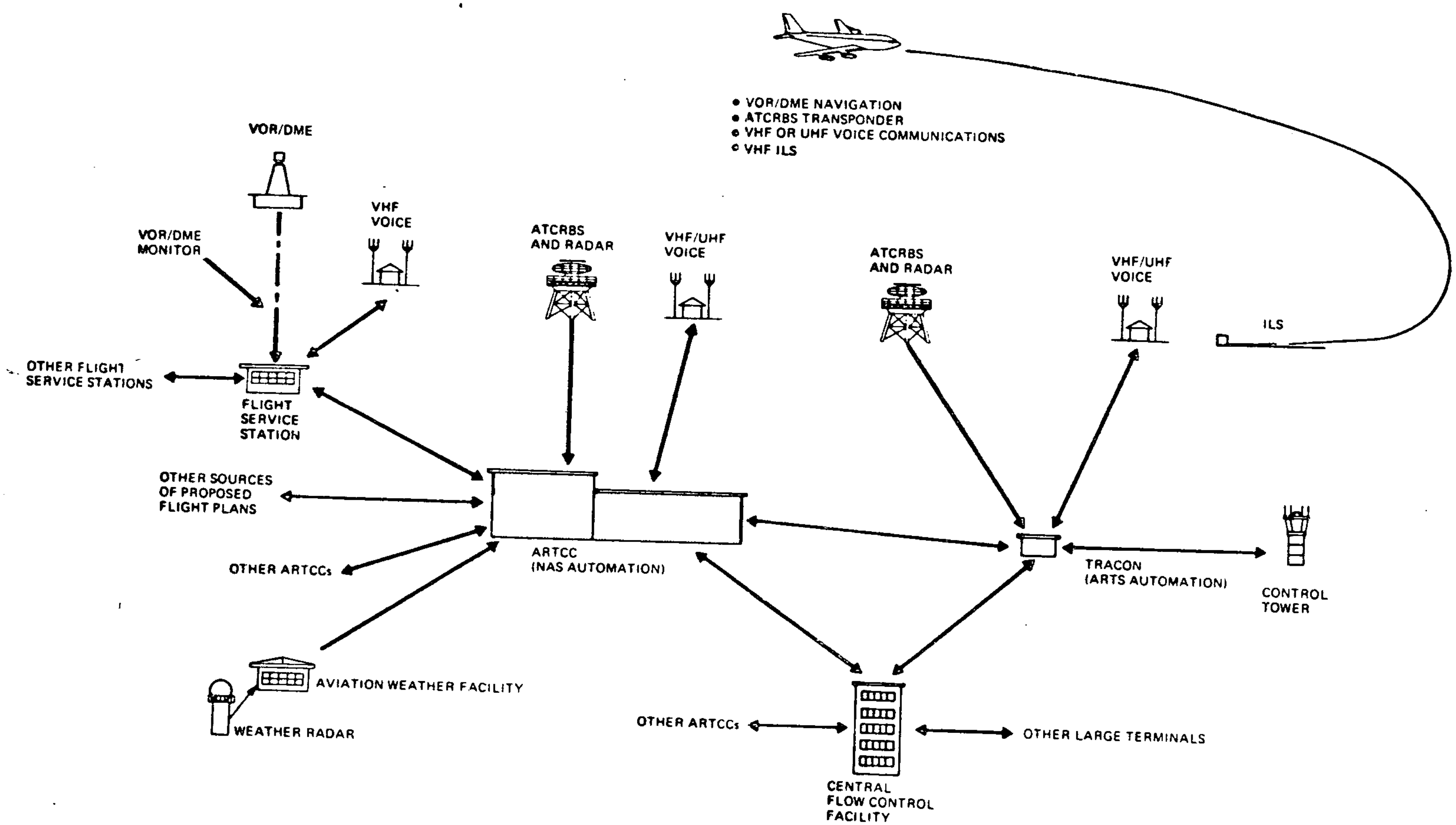


Figure D-22. Upgraded Third Generation CONUS ATC System (Phase 1)

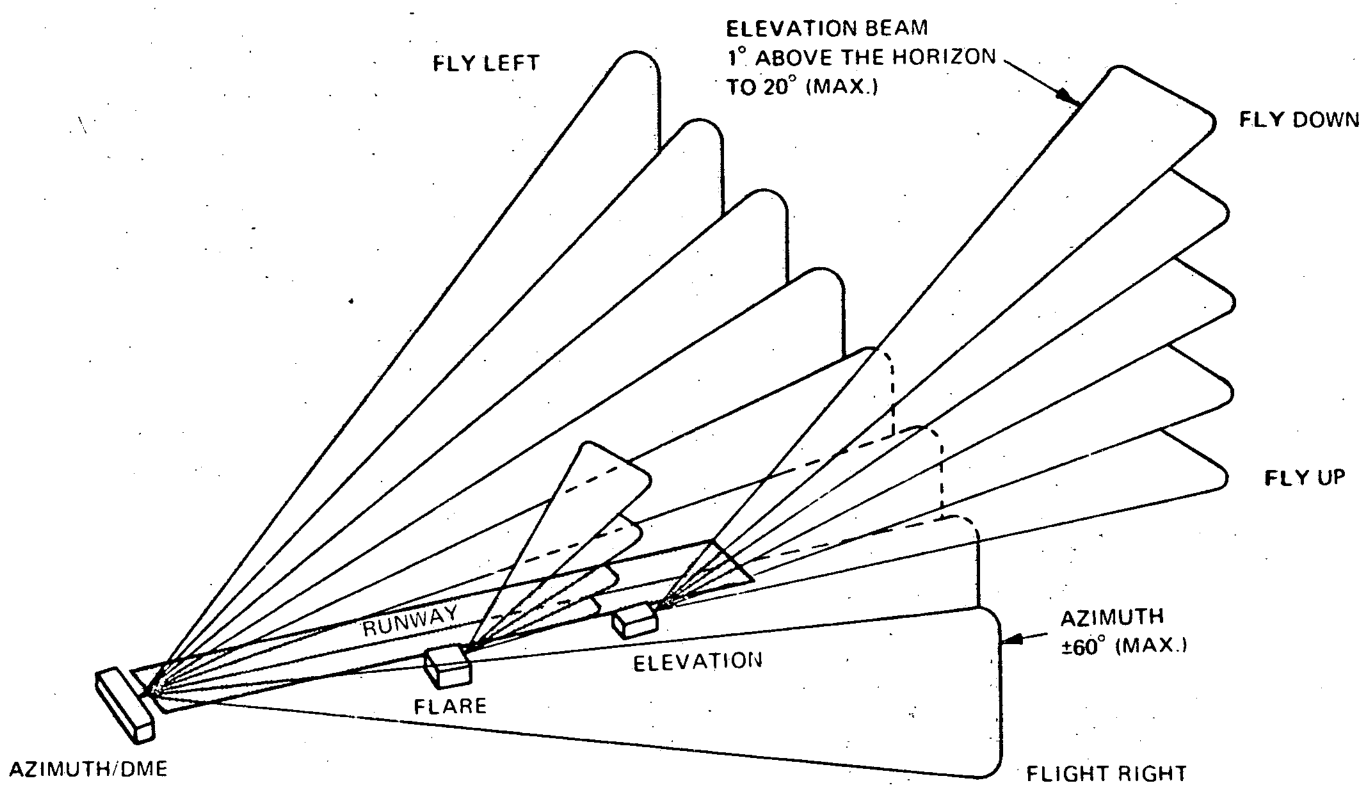


Figure D-23. Scanning - Beam MLS Antenna Radiation Patterns

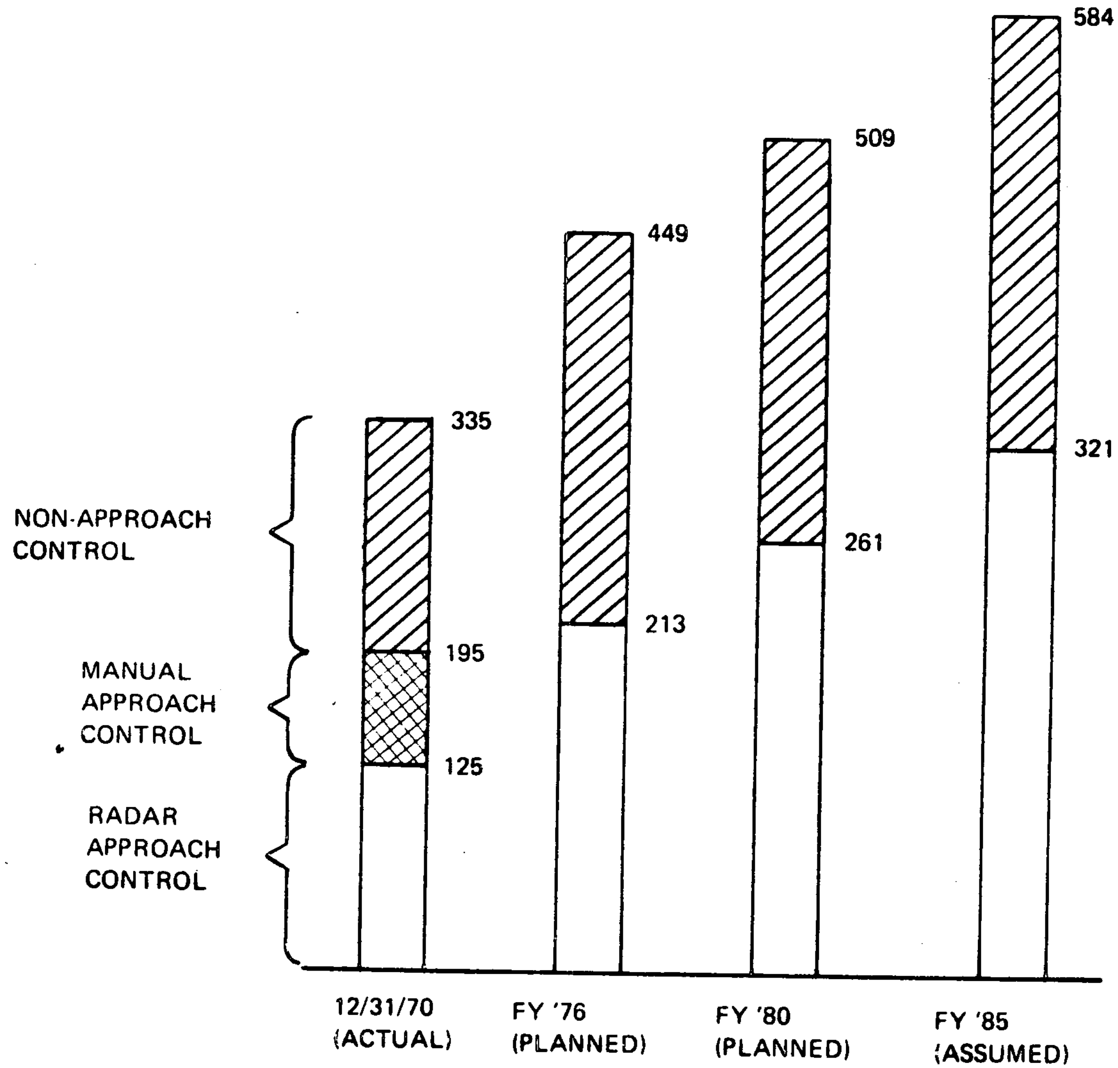


Figure D-24. Expected Number of Terminal Facilities

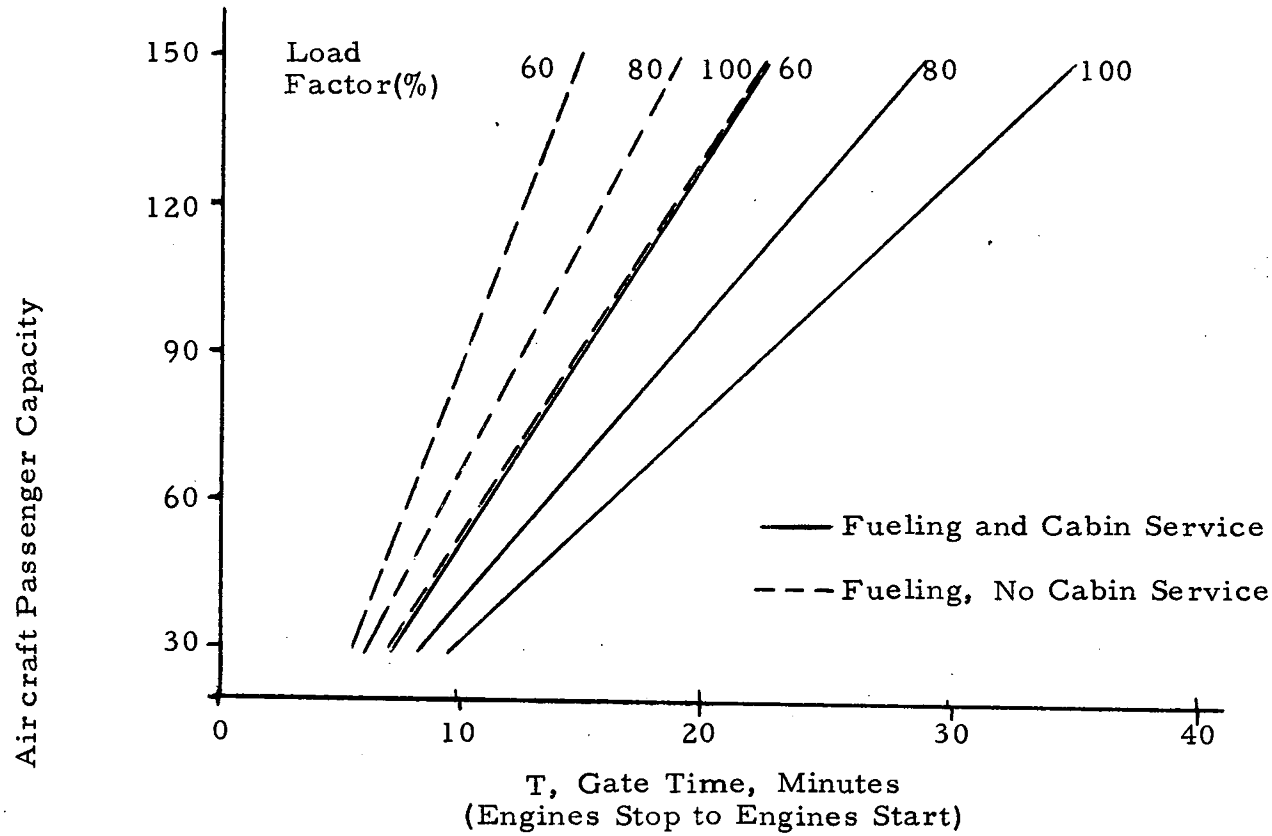


Figure D-25. Variation in Aircraft Gate Time With Passenger Capacity, Load Factor, and Servicing

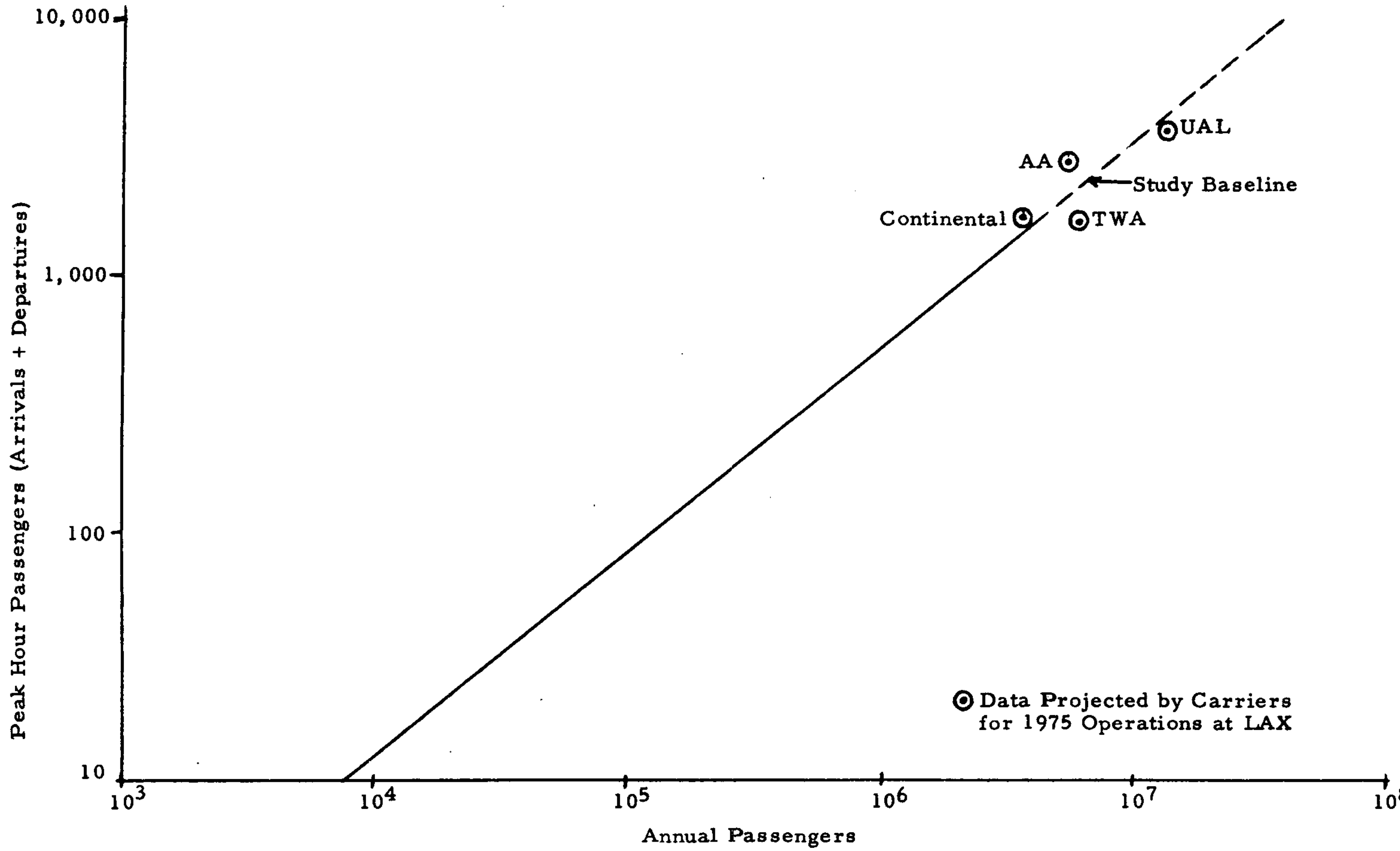


Figure D-26. Peak Hour Passengers in Terms of Annual Passengers (FAA)

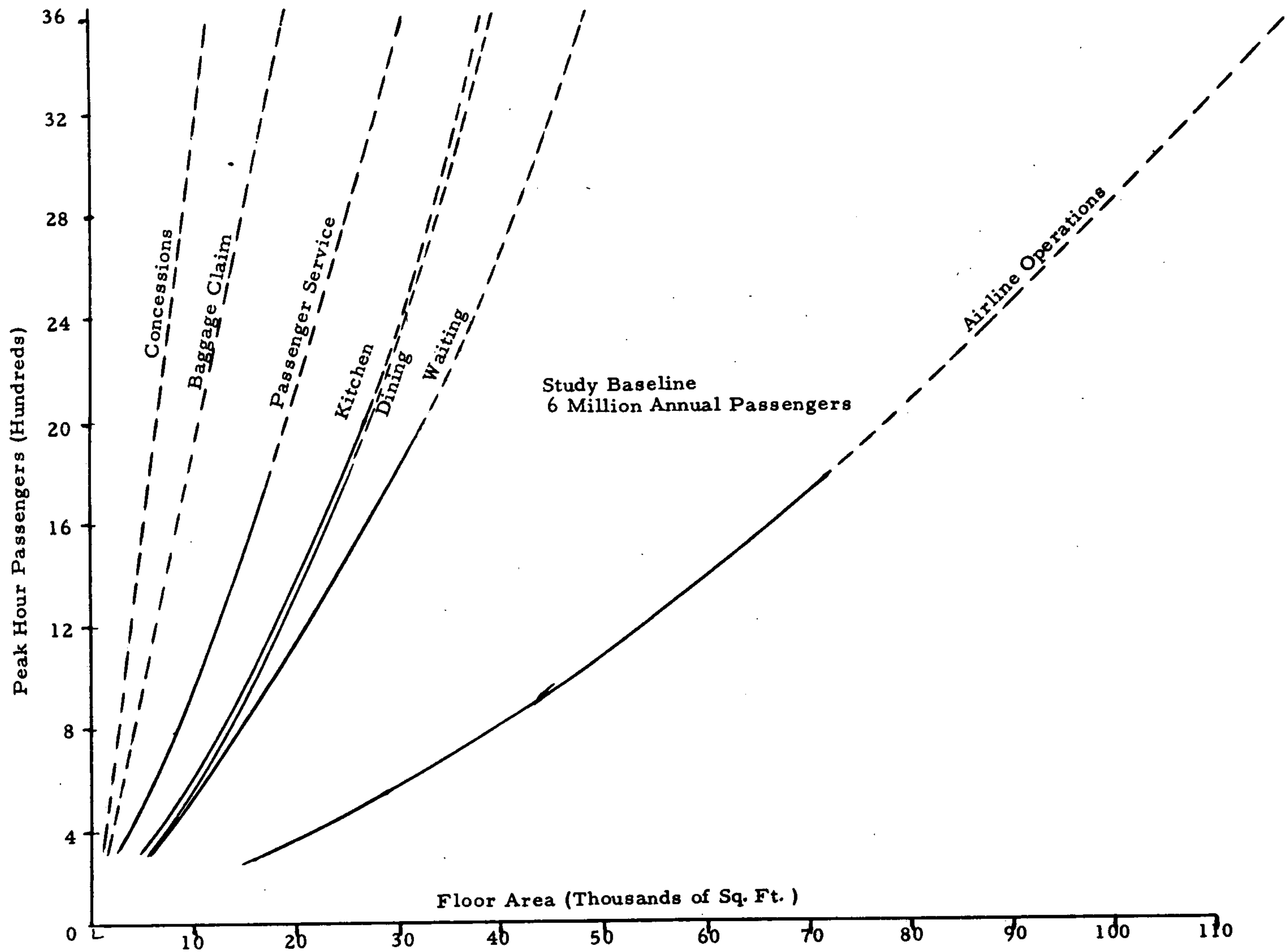


Figure D-27. Terminal Building Floor Area Requirements (FAA)

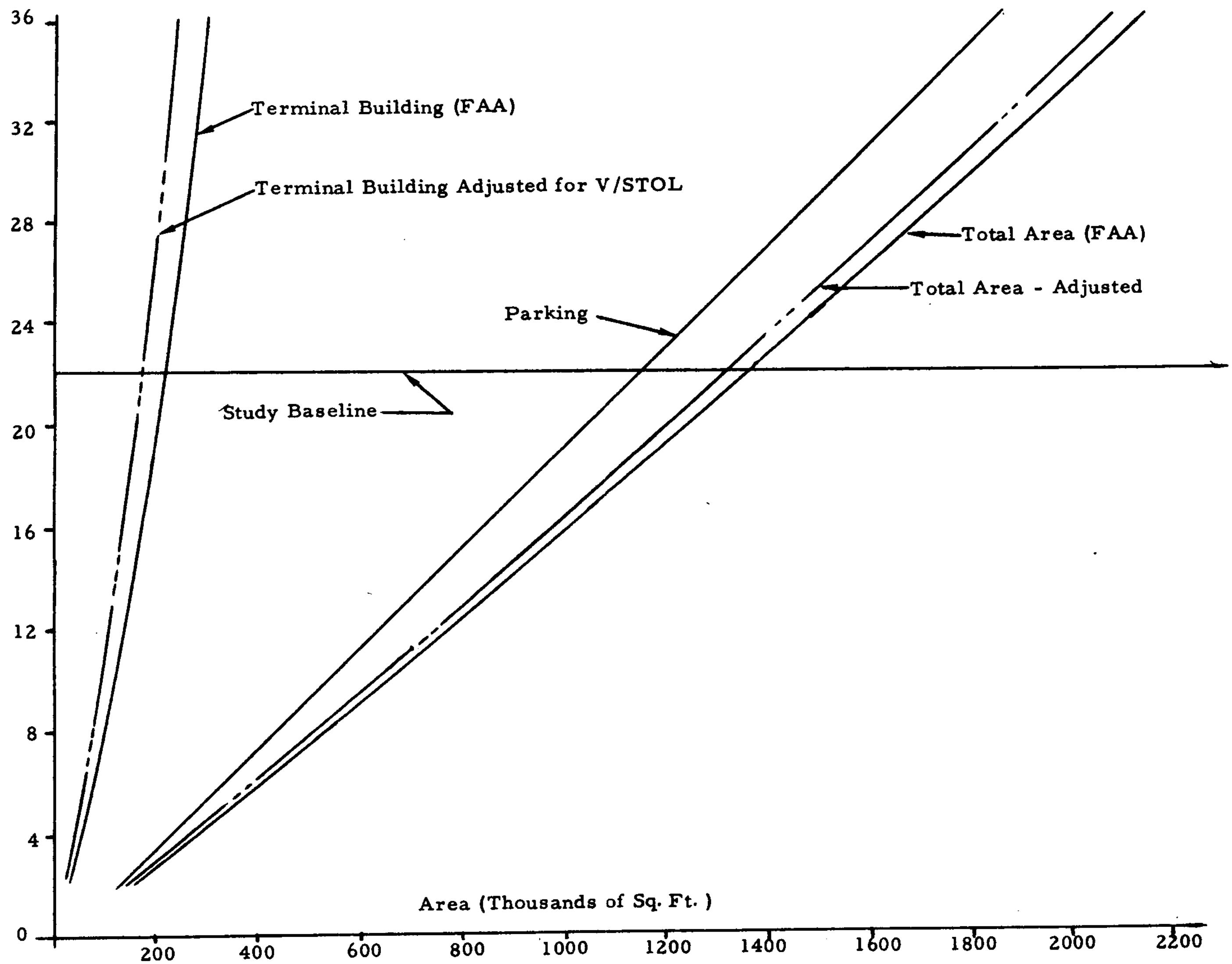


Figure D-28. Terminal Building and Parking Area Requirements

Table D-1. Los Angeles-San Francisco Service Path Selection Data, Percent Total Demand (Service Paths 16, STOL frequency of service 1 flight/hour)

STOL Fare $16.00, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	3.56	4.68	2.28	2.8	13.32
Palo Alto	4.32	3.44	2.0	2.64	12.40
Concord	2.36	1.96	.72	1.04	6.08
Marin	1.48	1.16	.64	.92	4.2
Total	11.72	11.24	5.64	7.4	36.0

STOL Fare $21.60, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	1.32	1.72	1.16	.96	5.16
Palo Alto	1.32	1.04	.76	.52	3.64
Concord	1.04	1.0	.40	.28	2.72
Marin	.88	.36	.44	.36	2.04
Total	4.56	4.12	2.76	2.12	13.56

Table D-2. Los Angeles-San Francisco Service Path Selection Data, Percent Total Demand (Service Paths 10, STOL freq of serv 0.73 flt/h)

STOL Fare $16,00, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	7.68	5.20	3.16	3.28	19.32
Palo Alto	4.16	3.08	1.72	2.00	10.96
Concord	3.08	2.36	-	-	5.44
Marin	-	-	-	-	-
Total	14.92	10.64	4.88	5.28	35.72

STOL Fare $21.60, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	2.40	2.16	1.60	1.20	7.36
Palo Alto	1.04	.92	.64	.44	3.04
Concord	1.08	1.24	-	-	2.32
Marin	-	-	-	-	-
Total	4.52	4.32	2.24	1.64	12.72

Table D-3. Los Angeles-San Francisco Service Path Selection Data, Percent Total Demand (Service Paths 7, STOL freq of serv 0. 73 flt/h)

STOL Fare $16.00, incl tax

S.F. Ports \ L.A. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	7.84	6.16	3.80	3.44	21.24
Palo Alto	5.52	3.48	-	-	9.00
Concord	4.08	-	-	-	4.08
Marin	-	-	-	-	-
Total	17.44	9.64	3.80	3.44	34.32

STOL Fare $21.60, incl tax

S.F. Ports \ L.A. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	2.44	2.56	1.72	1.20	7.92
Palo Alto	1.20	1.16	-	-	2.36
Concord	1.52	-	-	-	1.52
Marin	-	-	-	-	-
Total	5.16	3.72	1.72	1.20	11.80

Table D-4. Los Angeles-San Francisco Service Path Selection Data, Total Percent Demand (Service Paths 4, STOL freq of serv 0.73 flt/h)

STOL Fare $16.00, incl tax

S.F. Ports \ L.A. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	12.80	7.44	-	-	20.24
Palo Alto	6.36	3.88	-	-	10.24
Concord	-	-	-	-	-
Marin	-	-	-	-	-
Total	19.16	11.32	-	-	30.48

STOL Fare $21.60, incl tax

S.F. Ports \ L.A. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	3.68	2.88	-	-	6.56
Palo Alto	1.40	1.24	-	-	2.64
Concord	-	-	-	-	-
Marin	-	-	-	-	-
Total	5.08	4.12	-	-	9.20

Table D-5. Los Angeles-San Francisco Service Path Selection Data, Percent Total Demand (Service Paths 2, STOL freq of serv 0.73 flt/h)

STOL Fare $16.00, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	-	13.24	-	-	13.24
Palo Alto	10.96	-	-	-	10.96
Concord	-	-	-	-	-
Marin	-	-	-	-	-
Total	10.96	13.24	-	-	24.20

STOL Fare $21.60, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	-	4.12	-	-	4.12
Palo Alto	1.88	-	-	-	1.88
Concord	-	-	-	-	-
Marin	-	-	-	-	-
Total	1.88	4.12	-	-	6.00

Table D-6. Los Angeles-San Francisco Service Path Selection Data, Percent Total Demand (Service Paths 1, STOL freq of serv 0.73 flt/h)

STOL Fare $16.00, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	20.44	-	-	-	20.44
Palo Alto	-	-	-	-	-
Concord	-	-	-	-	-
Marin	-	-	-	-	-
Total	20.44	-	-	-	20.44

STOL Fare $21.60, incl tax

L.A. Ports / S.F. Ports	Chavez Ravine	Fullerton	Morrow	Van Nuys	Total
Crissy Field	5.04	-	-	-	5.04
Palo Alto	-	-	-	-	-
Concord	-	-	-	-	-
Marin	-	-	-	-	-
Total	5.04	-	-	-	5.04

Table D-7. Typical Available Airport Complexes

Chicago	O'Hare, Midway and Meigs represent a CTOL, STOL reliever and STOL CBD complex.
New York	Kennedy and LaGuardia are major CTOL, a number of available STOL reliever, no STOL CBD site.
Boston	Logan, major CTOLport is located near CBD, Hanscom provides STOL reliever.
Detroit	Has CTOLport at Detroit Metro and STOL reliever at Detroit City, also near CBD.
Houston	Hobby provides STOL reliever, but no CBD site available.
Kansas City	K. C. International, well out of town, STOL reliever not required, but K. C. Municipal provides CBD and so is used for convenience.
Minneapolis/St. Paul	Reliever ports are available, but are not more convenient and STOL traffic does not justify.

Table D-8. Existing Facilities at the 71 Selected 1980 Reliever Ports

Airport	Tower	ILS	Lighting	Approach Lights
Albany County, NY	Yes	Yes	Yes	Yes
Fulton County, GA	Yes	Yes	Yes	No
Robert Mueller Muni, TX	Yes	Yes	Yes	Yes
Friendship Intl, MD	Yes	Yes	Yes	Yes
Logan Intl, MA	Yes	Yes	Yes	Yes
LG Hanscom Fld, MA	Yes	Yes	Yes	Yes
Greater Buffalo Intl, NY	Yes	Yes	Yes	Yes
Meigs Field, IL	Yes	No	Yes	No
Midway, IL	Yes	Yes	Yes	Yes
Lunken Field, OH	Yes	Yes	Yes	Yes
Burke Lakefront, OH	Yes	Yes	Yes	No
Port Columbus Intl, OH	Yes	Yes	Yes	Yes
Dallas Love Field, TX	Yes	Yes	Yes	Yes
James Cox-Dayton Muni, OH	Yes	Yes	Yes	Yes
Stapleton Intl, CO	Yes	Yes	Yes	Yes
Des Moines Muni, IO	Yes	Yes	Yes	Yes
Detroit City, MI	Yes	Yes	Yes	No
Fresno Air Terminal, CA	Yes	Yes	Yes	Yes
Bradley Intl, CT	Yes	Yes	Yes	Yes
William P. Hobby, TX	Yes	Yes	Yes	Yes
Weir Cook, IN	Yes	Yes	Yes	Yes
Jacksonville Intl, FL	Yes	Yes	Yes	Yes
Kansas City Muni, MO	Yes	Yes	Yes	No
McCarran Intl, NV	Yes	Yes	Yes	Yes
Long Beach, CA	Yes	Yes	Yes	No
Hollywood-Burbank, CA	Yes	Yes	Yes	Yes
Hawthorne Muni, CA	Yes	No	Yes	No
Ontario Intl, CA	Yes	Yes	Yes	Yes

Table D-8. Existing Facilities at the 71 Selected 1980 Reliever Ports (Continued)

Airport	Tower	ILS	Lighting	Approach Lights
Orange County, CA	Yes	Yes	Yes	Yes
Standiford Field, KY	Yes	Yes	Yes	Yes
Memphis Intl, TN	Yes	Yes	Yes	Yes
Opa Locka, FL	Yes	No	Yes	No
Gen Mitchell Fld, WI	Yes	Yes	Yes	Yes
Minn-St Paul Intl, MN	Yes	Yes	Yes	Yes
Lakefront, LA	Yes	No	Yes	Yes
Teterboro, NJ	Yes	Yes	Yes	No
Newark, NJ	Yes	Yes	Yes	Yes
Westchester Co, NY	Yes	Yes	Yes	Yes
Norfolk Regional, VA	Yes	Yes	Yes	Yes
Will Rogers World, OK	Yes	Yes	Yes	Yes
Eppley Airfield, NE	Yes	Yes	Yes	Yes
North Philadelphia, PA	Yes	Yes	Yes	Yes
Allegheny County, PA	Yes	Yes	Yes	Yes
Sky Harbor Intl, AZ	Yes	Yes	Yes	Yes
Portland Intl, OR	Yes	Yes	Yes	Yes
T. F. Green State, RI	Yes	Yes	Yes	Yes
Raleigh-Durham, NC	Yes	Yes	Yes	Yes
Reno Intl, NV	Yes	Yes	Yes	Yes
R. E. Byrd Intl, VA	Yes	Yes	Yes	Yes
Rochester-Monroe Co, NY	Yes	Yes	Yes	Yes
Sacramento Executive, CA	Yes	Yes	Yes	No
Monterey Peninsula, CA	Yes	No	Yes	Yes
Salt Lake City Intl, UT	Yes	Yes	Yes	Yes
San Antonio Intl, TX	Yes	Yes	Yes	Yes
San Diego Intl-Lindberg Fld, CA	Yes	Yes	Yes	Yes

Table D-8. Existing Facilities at the 71 Selected 1980 Reliever Ports (Continued)

Airport	Tower	ILS	Lighting	Approach Lights
San Francisco Intl, CA	Yes	Yes	Yes	Yes
Metropolitan Oakland Intl, CA	Yes	Yes	Yes	Yes
San Jose Muni, CA	Yes	Yes	Yes	Yes
Boeing Field Intl, WA	Yes	Yes	Yes	No
Spokane Intl, WA	Yes	Yes	Yes	Yes
Weiss, MO	No	No	Yes	No
Syracuse Hancock Intl, NY	Yes	Yes	Yes	Yes
Tampa Intl, FL	Yes	Yes	Yes	Yes
Tucson Intl, AZ	Yes	Yes	Yes	Yes
Washington Natl, DC	Yes	Yes	Yes	Yes
Greensboro-High Point/ Winston-Salem Regional, NC	Yes	Yes	Yes	Yes
Lihue-Kauai, HI	Yes	Yes	Yes	Yes
Honolulu Intl, HI	Yes	Yes	Yes	Yes
Hilo, HI	Yes	Yes	Yes	Yes
Ke Ahole, HI	Yes	Yes	Yes	Yes
Kahului, HI	Yes	Yes	Yes	Yes
La Guardia, NY	Yes	Yes	Yes	Yes

Table D-9. Airport/Aircraft Operations Mix
FAA 1980 Projection

AIRPORT CATEGORY	TYPICAL AIRPORTS	TYPE AIRCRAFT - PERCENT DISTRIBUTION			
		4 ENGINE JET	2 OR 3 ENGINE JET	EXEC. JET OR 2 ENGINE PISTON	1 OR 2 ENG. LIGHT PISTON AIRCRAFT
1	VAN NUYS, OPA LOCKA-MIAMI	0	0	10	90
2	SANTA FE, WICHITA MUNI	0	30	30	40
3	GREATER CINCINNATI, K.C. INT'L	20	40	20	20
4	L.A. INT'L., J.F. KENNEDY, O'HARE	60	20	20	0

Table D-10. Airport/Aircraft Operations Mix For 1980 STOL Introduction

AIRPORTS	OPERATING MIX, PERCENT				
	4 ENGINE JETS	2 OR 3 ENGINE JETS	STOL	EXEC. JETS 4 ENG. PISTON	1 OR 2 ENGINE JETS
CATEGORY -2	0	30	0	30	40
	0	15	15	30	40
	0	0	30	30	40
CATEGORY -3	20	40	0	20	20
	20	20	20	20	20
	20	0	40	20	20
CATEGORY -4	60	20	0	20	0
	60	10	10	20	0
	60	0	20	20	0

Table D-11. 1980 CTOL Airport Relief

Hub	Total Annual Aircarrier Operations (000)	Maximum Annual STOL Operations (000)	CTOL Ports PANCAP (000)	Maximum Peak Hour Passengers Diverted to STOL Ports
New York	887.5	186.0	740	3,945
Chicago	700.8	138.0	640	3,372
Los Angeles	468.4	186.0	560	4,260
Atlanta	412.4	21.5	440	784
San Francisco	390.9	113.5	370	2,717
Washington	320.2	39.9	330	680
Dallas	305.2	51.1	390	1,547
Miami	264.0	20.0	390	696
Boston	241.1	25.0	340	692
Philadelphia	220.6	58.1	275	1,709
Detroit	206.5	68.7	395	1,950
Pittsburgh	206.0	52.7	360	1,583
Houston	162.3	26.6	310	926
Cleveland	142.0	43.9	395	1,372
Seattle	134.2	16.4	295	635
Kansas City	130.8	21.4	310	780
	5,192.9	1,068.3		27,648

Table D-12. Atlanta Aircraft Movements (000)

1971				1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total	--	387.8	689.9	14.1	21.5	437.4	--	750
Atlanta Int'l	3	387.8	438.7	0	0	412.4	3	440
Fulton Co.	1	0	251.2	14.1	21.5	25	2	310

Table D-13. Boston Aircraft Movements (000)

	1971			1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		214.3	603.6	63.7	85	241.7	--	535
Logan	3	213.6	316.7	44	60	215.7	3	340
Hanscom	1	.7	286.9	19.7	25	26	2	195

Table D-14. Chicago Aircraft Movements (000)

1971				1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total	--	620.9	928.5	90.3	138.0	700.8	--	1,185
O'Hare	4	565.8	641.4	0	0	515	4	640
Midway	2	51.7	204.2	55	85	120	2	330
Meigs	1	3.3	82.8	55	50	65	2	195

Table D-15 Cleveland Aircraft Movements (000)

	1971			1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		125.9	334.6	33.2	43.9	142.0		725
Hopkins Int'l.	3	125.9	272.9	0	0	98	3	395
Burke Lakefront	1	0	61.7	33.2	43.9	44	2	330

Table D-16 Dallas Aircraft Movements (000)

	1971			1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		270. 6	933. 6	31. 8	51. 1	305. 2		1135
Love Field	2	270. 6	387. 1	31. 8	51. 1	305. 2	3	390
Red Bird		0	17. 0	0	0	0	1	220
Addison		0	229. 3	0	0	0	1	215
Ft. Worth Mecham		0	300. 2	0	0	0	2	310

Table D-17 Detroit Aircraft Movements (000)

	1971			1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		177.3	641.0	48.7	68.7	200.0		900
Detroit Metro	3	177.3	259.1	0	0	140	3	395
Detroit City	1	0	208.4	48.7	68.7	60	2	310
Detroit Willow Run	1	5	173.5	0	0		1	195

Table D-18 Honolulu Aircraft Movements (000)

1971				1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Honolulu Int'l.	4	129.5	325.3	21.9	62.4	146.1	4	365

Table D-19 Houston Aircraft Movements (000)

	1971			1980				
Airport	Airport Category	Operations		Air Carrier Operations			Proposed Airport Category	Practical Annual Capacity (PANCAP)
		Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL		
Hub Total		143. 9	430. 6	16. 5	26. 6	162. 3		620
Houston Inter-continental	3	143. 2	185. 8	0	0	132. 3	3	310
Hobby	1	. 7	244. 8	16. 5	26. 6	30	2	310

Table D-20 Kansas City Aircraft Movements (000)

	1971			1980				
		Operations		Air Carrier Operations				
Airport	Airport Capacity	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		116.0	332.9	15.9	21.4	130.8		505
Municipal	3	115.5	230.6	15.9	21.4	30	2	195
Kansas City Int'l	2	.5	102.3	0	0	100.8	3	310

Table D-21 Los Angeles Aircraft Movements (000)

1971				1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		464.7	2330.8	146	186	524.2	--	1770
L. A. Int'l	4	373.8	493.2	0	0	324.2	4	560
Long Beach	1	10.2	587.8	29.2	37.2	40	2	430
Hollywood/ Burbank	2	30.8	223.5	29.2	37.2	40	2	195
Hawthorne	1	0	228.6	29.2	37.2	40	2	195
Ontario	2	28.0	141.8	29.2	37.2	40	3	195
Orange Co.	2	21.9	555.9	29.2	37.2	40	2	195

Table D-22 Miami Aircraft Movements (000)

Airport	1971 Airport Category	1971 Operations: Scheduled Air Carrier	1971 Operations: Total	1980 Air Carrier Operations: STOL Min.	1980 Air Carrier Operations: STOL Max.	1980 Air Carrier Operations: Total Including STOL	1980 Proposed Airport Category	1980 Practical Annual Capacity (PANCAP)
Hub Total		234. 0	693. 0	10. 9	18. 5	264. 0		790
Miami Int'l.	3	234. 0	343. 2	0	0	244. 0	3	390
Opa-Locka	1	0	349. 8	10. 9	18. 5	20	2	400

Table D-23. Milwaukee Aircraft Movements (000)

1971				1980				
Airport	Airport Category	Operations		Air Carrier Operations			Proposed Airport Category	Practical Annual Capacity (PANCAP)
		Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL		
Hub Total		78. 6	342. 4	6. 6	10. 0	88. 7		495
Mitchell	2	78. 6	224. 3	6. 6	10. 0	88. 7	3	275
Timmerman	1	0	118. 1	0	0	0	1	220

Table D-24. New York Aircraft Movements (000)

1971				1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		786. 8	1, 236. 8	182	266	887. 5		1, 545
JFK Int'l	4	333. 6	380. 0	0	0	300	4	380
La Guardia	3	287. 2	363. 5	55	80	277. 5	3	360
Newark	3	166. 1	223. 8	36	53	160	3	225
Teterboro	1	0	269. 5	55	80	90	2	270
Westchester Co.	1	5. 7	281. 5	36	53	60	2	310

Table D-25 Philadelphia Aircraft Movements (000)

Airport	Airport Category	1971 Operations: Scheduled Air Carrier	1971 Operations: Total	1980 Air Carrier Operations: STOL Min.	1980 Air Carrier Operations: STOL Max.	1980 Air Carrier Operations: Total Including STOL	1980 Proposed Airport Category	1980 Practical Annual Capacity (PANCAP)
Hub Total		195.6	458.7	36.1	58.1	220.6		470
Philadelphia Int'l	3	191.2	292.3	0	0	170.6	3	275
North Philadelphia	1	4.4	166.4	36.1	58.1	50	2	195

Table D-26 Pittsburgh Aircraft Movements

	1971			1980				
Airport	Airport Category	Operations		Air Carrier Operations			Proposed Airport Category	Practical Annual Capacity (PANCAP)
		Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL		
Hub Total		182.6	464.8	34.6	52.7	206.0		555
Gr. Pittsburgh	3	182.6	276.3	0	0	151.0	3	360
Allegheny Co.	1	0	188.5	34.6	52.7	55	2	195

Table D-27 San Diego Aircraft Movements (000)

1971				1980				
		Operations		Air Carrier Operations				
Airport	Airport Category	Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL	Proposed Airport Category	Practical Annual Capacity (PANCAP)
Hub Total		74. 73	742. 41	29. 1	32. 7	84. 2		1040
Lindberg	3	74. 73	202. 99	29. 1	32. 7	84. 2	3	180
Montgomery		0	260. 99	0	0	0	1	430
Gillespie		0	278. 43	0	0	0	1	430

Table D-28 San Francisco Aircraft Movements (000)

1971				1980				
Airport	Airport Category	Operations		Air Carrier Operations			Proposed Airport Category	Practical Annual Capacity (PANCAP)
		Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL		
Hub Total		392.6	1134.2	118.4	151.3	442.9	--	1065
S. F. Int'l	4	286.3	366.8	29.6	37.8	322.9	4	370
Oakland	2	60.0	359.1	45.0	57.5	60	2	400
San Jose	2	46.3	408.3	43.8	56.0	60	3	295

Table D-29 Seattle Aircraft Movements (000)

1971				1980				
Airport	Airport Category	Operations		Air Carrier Operations			Proposed Airport Category	Practical Annual Capacity (PANCAP)
		Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL		
Hub Total		119.0	488.5	9.3	16.4	134.2		590
Seattle-Tacoma	3	114.4	155.1	0	0	117.8	3	295
Boeing Field	1	4.6	333.4	9.3	16.4	16.4	2	295

Table D-30 Washington/Baltimore Aircraft Movements (000)

1971				1980				
Airport	Airport Category	Operations		Air Carrier Operations			Proposed Airport Category	Practical Annual Capacity (PANCAP)
		Scheduled Air Carrier	Total	STOL Min.	STOL Max.	Total Including STOL		
Hub Total		385.5	748.3	80.9	118.6	434.8	--	980
Washington National	3	222.7	330.0	52.5	78.7	251.2	3	330
Baltimore Friendship	3	101.9	223.7	28.4	39.9	114.9	3	275
Dulles	4	60.9	194.6	0	0	68.7	4	375

Table D-31. 1980 Airport Capacity Prediction (Maximum Number of Operations)

Airport Category	Traffic	Single Runway
1	PANCAP ($x10^3$)*	213
	Daily	584
	Day/Night	584/0
2	PANCAP ($x10^3$)*	194
	Daily	531
	Day/Night	531/0
3	PANCAP ($x10^3$)*	180
	Daily	493
	Day/Night	444/49
4	PANCAP ($x10^3$)*	170
	Daily	466
	Day/Night	419/47

*PANCAP - Practical Annual Capacity

Table D-32. Noise Analysis Flight Conditions

AIRCRAFT TYPE	STOL	CTOL
$V_{T.O.}$ KNOTS	90	130
V_{APP} KNOTS	90	130
T.O. PROFILE (CLIMB-OUT ANGLE)	10°	6°
APPROACH PROFILE (DESCENT ANGLE)	8°	3°
OPERATIONS MIX	AS INDICATED ON OPERATIONS MIX CHARTS	
NUMBER OF OPERATIONS	AS INDICATED ON CAPACITY CHART	

Table D-33. Major Elements of ATC System

Area Navigation	
RNAV - 3D	Guidance between way points "Pinpoints horizontal position and altitude."
RNAV - 4D	"Adds dimenstion of time, thus eliminating holding pattern delays, permits precise control of arrival time."
Terminal System Guidance "Advance Radar Terminal System"	
ARTS-III	"Monitors all beacon aircraft within 55 mile radius of terminal, controlled display includes: aircraft identification, altitude, ground speed, etc." "Modular expandable."
Advance ARTS-III	"62 systems by 1973, 200 systems by 1980."
Instrument Landing System	
MILS	"Universal MILS, operate principally ATC band, with K_4 band employed for final flare out guidance, if required."
MLS	"FAA STOL office believes advance MLS should have segmented or curvilinear approach capability."

Table D-34. ATC System Generations

	Generation: Second	Generation: Third	Generation: Upgraded Third, Phase I	Generation: Upgraded Third, Phase II
DEPLOYMENT YEARS	1950-1970	1970-1975	1975-1978	1978-1985
NAVIGATION				
Airborne	Point-to-Point	Same plus some area navigation	More area navigation applications	Same
Ground stations	VOR/DME/TACAN	Same plus more accurate VOR	Same plus higher capacity DME	Same
Landing and Terminal	VHF ILS (Category II)	Same plus limited Category II and III plus interim V/STOL	Same plus initial MLS	Increased numbers of MLS runways
AIRPORTS				
Runway Operations	Parallel ILS (6000 ft)	Same	Dual lane runways	Precision MLS approaches to closed-spaced parallel runways (2500 ft)
Ground Guidance and Control	Airport surface detection equipment	Initial Airport Ground Traffic Control (AGTC)	Improved Airport Ground Surveillance & Guidance	Comprehensive Airport Ground Traffic Control
DATA ACQUISITION, AIR-GROUND				
Primary surveillance	Radar	Beacon (4096 code for altitude and identity)	Same	Discrete Address Beacon System (DABS) introduced
Secondary surveillance	Beacon (64 code)	Radar	Same	Same
DATA TRANSMISSION				
Primary communications	VHF/UHF Voice	Same	Same	DABS data link and VHF/UHF Voice
Secondary communications: Ground	None	Backup emergency communications (BUEC)	Same	Same
Airborne	Emergency Beacon Code	Same	Same	UHF/VHF Voice
DATA PROCESSING AND CONTROL				
Flow Control	Decentralized	Centralized-manual	Centralized-automated	Centralized-automated
Clearance processing	Manual	Simplified manual procedure	Automatic Generation	Automatic Delivery via Data Link
Separation & Sequencing	Manual	Automated aids to controller	Automated conflict detection & resolution	Automatic safety commands via data link: IPC to VFR ATC to IFR
Metering & Spacing (precise time scheduling)	Manual, when performed	Same	Automated-voice control	Automated - data link control
CONTROL COORDINATION				
Intrafacility	Voice	Via controller display or voice	Fully automated or via controller display or voice	Same
OCEANIC NAV & ATC				
Surveillance	Pilot reports-voice	Same	Same plus some automatic reports	Automatic reports via data link/satellite surveillance
Communications	LF/MF voice (non-ATC)	Same plus some dedicated VHF	Same	Same plus "L" band data link via satellite
Control	Manual	Manual-some computer aids	More computer aids to controller	Same
Navigation	Self-contained air-borne plus LORAN	Same	Primarily inertial	Inertial and LORAN/OMEGA
FLIGHT SERVICES	Manual	Manual-reconfigured	Automated aids to FSS specialists	Pilot self-service automation (flight plan filing & briefing)

Table D-35. Airport Auto Traffic Per Enplaned Passenger

	Inbound Vehicles Per Enplaned Passenger
Los Angeles	2.55
Washington Natl	1.56
Boston	1.88
Philadelphia	1.83
Pittsburgh	1.85
Denver	2.41
St. Louis	2.32
Minneapolis	2.38
Seattle	2.76
Baltimore	1.76
Phoenix	1.68
Washington Dulles	2.01
Weighted Average	2.12

REFERENCES

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APPENDIX E

ROLES AND RESPONSIBILITIES

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FIGURES

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APPENDIX E

ROLES AND RESPONSIBILITIES

An airport and its accompanying operations can radically change the environment of a large contiguous territory and may even influence property and persons only remotely connected to it geographically. As a consequence, vigorous and serious debates frequently result over whether an airport is needed, how it is to be developed, the kind of equipment it is to use, how it is to operate, the nature and extent of its environmental and economic influence, and the extent of compensation to be awarded to those persons claiming losses from the introduction of the airport and its operations into the community. In response to such issues, laws and regulations have emanated at the local, regional, state and national level to help bring about orderly and effective development of air transportation. These laws and regulations establish the roles of the various government agencies. Some of these laws and regulations may constitute V/STOL airport and aircraft design objectives or constraints. Other laws affect the operations of the airport and the aircraft and, just as importantly, other laws establish roles and responsibilities to foster air transportation.

In view of the widespread and important impact of air operations, it is not surprising that a great number of government organizations have interests, of varying degrees and kinds, in air transportation activities. These organizations exist at the national, state, regional and local levels. The roles and responsibilities of the various agencies are of critical importance. The timing of their actions may be equally significant because of the interdependence of the agencies with each other and with aircraft manufacturers, the airlines, airport authorities, and those responsible for surface access.

In the following paragraphs, the roles and responsibilities of selected key organizations will be discussed in terms of their impact on airports, airport access, aircraft development, air traffic control and landing aids, and airline operations.

E.1 PRINCIPAL ROLES AND RESPONSIBILITIES APPLIED TO VARIOUS ASPECTS OF V/STOL APPLICATIONS

As can be seen from Table E-1, the organizations having defined responsibilities toward air transportation are both numerous and varied.[E-1] However, the nature and importance of the responsibilities differ. In the cases of the Civil Aeronautics Board and Federal Aviation Administration, aeronautical activities constitute the primary rationale for the organizations' existence and the corresponding air transportation responsibilities they bear overshadow those of other organizations. In some instances, such as the National Aeronautics and Space Administration and the Congress, other organizational responsibilities are borne in addition to the specific ones related to air transportation. Congress, for example, affects virtually all aspects of civil aviation through the legislative powers to define the regulatory authority, to grant or deny appropriations that fix expenditure levels and to investigate the performance of, as well as needed changes in, legislation and organizational responsibilities. In some cases, organizational responsibilities are relatively minor, as in the cases of the Interior Department and Agriculture Department which bear air transportation responsibilities only when national park or forest lands are involved.

For the purpose of this report, major discussion is to be focused upon a selected set of organizations considered to be of special importance to air transportation, in general, and V/STOL applications in particular. At the Federal level, these include the National Aeronautics and Space Administration, the Civil Aeronautics Board, and the Federal Aviation Administration. At the state level, the organizations to be concentrated upon are organizations such as the departments of aeronautics. At the regional level, the discussion will be limited to those regional organizations whose specific purpose relates to air transportation. At the local level, the discussion will center upon organizations such as the airport authority, the planning agencies, and agencies concerned with surface access to the airport.

It can be seen in Figure E-1 that government agencies at all levels interrelate with airlines and airline operations. The principal agencies to be considered here are the CAB, the FAA, and various agencies at the state, regional and local level.

A variety of traveler and community needs seem to be served by the various agencies in carrying out their functions. Thus, the costs to the traveler are regulated for interstate travel by the CAB; schedules are controlled by the CAB to assure accessibility; safety of airline operations is provided through certification of aircraft, crews and maintenance personnel by the FAA; and passenger comfort is considered among the many criteria leading to aircraft certification by the FAA. Various government agencies such as the CAB and FAA seek to encourage economic growth as a consequence of improvements in air service. NASA and the FAA are actively engaged in programs to reduce noise and air pollution. The FAA and CAB are both concerned with the reduction of air space congestion for a variety of reasons.

Agency responsibilities concerning airports are also of importance. Any significant alteration of airport characteristics, operations and location may affect a wide variety of community, as well as traveler, needs. For example, the decision to use reliever airports in conjunction with hub airports for the 1980 STOL should provide an increased accessibility for significant parts of the traveling population. The increased accessibility is significant in reducing the individual's total travel time through a reduction in the amount of time spent on surface travel. Correspondingly, total travel costs may be reduced since the traveler may benefit directly from the lower surface fares as well as from the reduced time spent on surface modes. The environmental impact of an airport is a matter of concern for local, regional, and state agencies as well as the Federal Environmental Protection Agency.

NASA, the FAA and the CAB bear major Federal responsibilities for aircraft development, airports, airlines, and airways; however, the responsibilities for airport access, frequently a limiting factor in the effectiveness of these agencies, fall almost entirely outside their purview. Other agencies at the Federal level do play critical roles. These include the Aviation Advisory Commission, the Office of the Secretary of Transportation, the Urban Mass Transportation Agency, the Federal Highway Administration, and the Department of Housing and Urban Development. Important roles and responsibilities are also carried out by government agencies at the state, regional and local levels.

a. National Aeronautics and Space Administration

(1) V/STOL Aircraft and Related Equipment Manufacturers.

NASA's roles and responsibilities for V/STOL aircraft research and development evolve from the National Aeronautics and Space Act of 1958, as amended.[E-2] One of the assigned statutory functions of NASA described by the Act is to conduct research for the solution of the problems of flight and the development, construction, test, and operation of aeronautical vehicles. Its relationships with the aeronautical industry are extensive since the Act calls for the widest practicable and appropriate dissemination of information concerning NASA's activities and their results. While planning, coordination, and control of NASA's programs are vested in Headquarters Directorate of NASA's field centers, other NASA installations, such as the Ames Research Center, are responsible for execution of NASA's programs, largely through contracts with research, development, and manufacturing enterprises.

One such contract, under Ames Research Center's project responsibility, is the QUESTOL program -- an acronym for quiet, experimental, short-takeoff-and-landing aircraft. Lockheed Aircraft Corporation, McDonnell Douglas Corporation and Grumman Aerospace Corporation are sponsored by NASA for the initial phase of QUESTOL design and development. The objective of the program is to provide propulsive and lift technology required for the development of quiet STOL transport aircraft that can help reduce community noise, ease airport congestion and improve short haul air transportation. Subsequent contracts will provide for industry fabrication of two aircraft to be delivered to NASA for testing as experimental transports. Data from the program will then be made available to the aircraft industry for use in the development of V/STOL aircraft.

Other NASA technological research and development activities of relevance to potential V/STOL manufacturers include the quiet engine, jet augmentation wing and lift fan, and externally blown flap programs. Its basic research on aerodynamic noise is of particular relevance in view of the critical importance of aircraft noise for the future of V/STOL applications.

Since non-technical considerations frequently constrain or modify aircraft development, NASA also engages in non-technological research of relevance to V/STOL applications. These activities include studies of aircraft in short haul transportation systems, noise considerations for V/STOL air transports, and time-value analysis of short haul passenger transportation.

NASA's support of industrial research and development activities along with its in-house R&D activities is supplemented by the availability of various government facilities, such as wind tunnels at NASA field installations, to potential V/STOL manufacturers.

(2) Airways and Air Traffic Control

NASA's research and development activities, of relevance to airways and air traffic control, include programs to provide automatic landing systems for V/STOL aircraft, communications systems, and the launching of meteorological, navigation and communications satellites.

b. Federal Aviation Administration

(1) Aircraft and Related Equipment Manufacturers

The FAA interactions with V/STOL aircraft and related equipment manufacturers may significantly influence the characteristics of any V/STOL aircraft manufactured for the airline industry. The FAA roles and responsibilities include the sponsorship of aircraft research and development, the establishment of certification standards for V/STOL aircraft, and type and prototype certification.[E-3]

(2) Airports

The Administrator of the FAA administers programs to identify the type and cost of development of public airports required for a national airport system and provides grants of funds to assist public agencies in airport system planning, airport master planning, and public airport development. The Airport and Airway Development Act of 1970 constitutes a comprehensive effort by the Congress to provide for the expansion and improvement of the airport and airway system in the United States. It provides that the Secretary of Transportation is to formulate and to recommend to Congress a National Transportation Policy. In revising and formulating the national airport system plan, the Secretary is to take into consideration the relationship of each airport to the rest of the transportation system in the particular area, its relationship to the forecasted technological developments in aeronautics, and the relationship to other developments such as those in intercity transportation. These considerations are of particular significance to V/STOL applications since potential travelers between cities, particularly for relatively closely spaced cities, are faced with a choice among travel modes.

The FAA engages in a number of research and development activities of immediate significance to airports. It is engaged in technological R&D on airport and airways traffic capacity. It provides aviation forecasts for approximately ten years into the future. It forecasts the composition of the National Airport System, again for about ten years into the future. The FAA studies the problem of airport congestion for approximately five years into the future. It engages in studies on the influence of the airport on the local communities. It establishes criteria relating to airport development grants and studies problems of airport expansion and long range planning.

Since only the use of existing airports is envisioned by this study for the 1980 STOL, many of the problems associated with the development of an entirely new airport are eased. In particular, the high cost of "landside" development diminish. With the Airport and Airways Development Act of 1970 providing for matching funds on a 50-50 basis for "airside" developments, the problems of persuading the local communities to help create a 1980 STOL capability are eased somewhat further.

(3) Airlines and Airline Operations

The FAA, along with the CAB, plays perhaps the more significant of the government roles regulating airlines and airline operations.

The FAA participates in the CAB route proceedings. It issues and administers air safety regulations and certifies the safety of aircraft for operations. The FAA establishes the standards, gives the appropriate tests and issues licenses for airmen and maintenance personnel. It provides also preflight and enroute briefings to airline personnel.

The FAA's aviation forecasts provide useful market data to airline planners. Through the establishment of uniform safety standards, the FAA permits both manufacturers and airlines to be assured that sacrifices in safety features by competitors will not allow them unfair competitive advantage.

(4) Airways and Air Traffic Control (ATC)

While the responsibilities for other aspects of V/STOL applications are generally allocated to a number of Federal and non-Federal agencies, the Federal Aviation Administration bears almost sole responsibility for the Federal Airways System. Its research and development are supplemented by those of NASA.

The FAA plans, finances, owns and operates the Federal Airways System. It operates the air traffic control towers and trains the ATC personnel.

FAA's research and development programs include R&D of a semi-automatic ATC system, improved long-distance navigation, large screen displays for ATC, and improvements in its Airport Surveillance Radar.

Currently planned FAA equipment and facilities have an inherent capability for handling a 1980 STOL. However, in the absence of firm definitions of the 1980 STOL, increased FAA attention to the uses of the equipment and facilities may be required in order to exploit the potential benefits of a STOL system.

c. Civil Aeronautics Board

(1) Airports

The CAB also fulfills important roles and responsibilities with respect to airports.[E-4] It approves particular airports to serve particular areas with air service. It authorizes routes which influence airport planning and design. With the Interstate Commerce Commission, the CAB establishes air cargo zones and ground pickup zones.

Like the FAA, the CAB actively undertakes or sponsors a variety of research activities of significance to STOL and V/STOL applications. It has studied problems of airport congestion by 1975. It forecasts the growth of scheduled domestic passenger air traffic. It conducts origin-destination surveys of airline passenger traffic.

(2) Airlines and Airline Operations

The CAB plays a particularly important role in terms of its regulation of airlines and airline operations. Under the terms of the Federal Aviation Act of 1958, particularly Title X of the Act, the Civil Aeronautics Board has powers to regulate virtually every facet of the airline industry's structure, operations, and relationships to other industries. The CAB's powers include: licensing or granting of operating authority; regulation of airline rates; enforcement of laws, regulations and procedures; the regulation of relationships among air carriers and between air carriers, common carriers, and other aeronautical firms.

In carrying out its responsibilities the CAB studies are important to airline and airline operations as well as airports. The CAB studies of special relevance to airlines and airline operations include: airport congestion, air travel demand, forecasts of the growth of scheduled domestic passenger air traffic; fare structures and effects of competition in selected areas; air carrier financial and traffic statistics; local service air carrier costs; and studies of freight rates.

d. Secretary of Transportation

(1) Airport Access

The Airport and Airways Development Act of 1970 authorizes the Secretary of Transportation to grant funds to planning agencies for airport system planning and to public agencies for airport master planning. The terms of the act make approval of a project conditional upon its being reasonably consistent with existing planning agency projects for development of the area where the airport is located. The Secretary is also required to withhold approval unless the Secretary is satisfied that fair consideration is given to the interests of communities in which or near which the project may be located. Nor is the Secretary to authorize airport development projects which he determines will have an adverse effect upon the environment, unless there is no feasible alternative. If there is no feasible alternative, the Secretary is to assure that all possible steps are taken to minimize the adverse effect. No airport development project is to be approved unless the public agencies sponsoring the project certify that the public has been given the opportunity for a hearing. The governor of the state in which the project is located is to certify that the project will comply with proper air and water quality standards.

No Federal funds are to be used under the Act for the cost of construction of public parking facilities for passenger automobiles as part of the airport development project. Similarly, the Act precludes funding of the cost of construction, alteration, or repair of a hangar or of any part of an airport building unless those buildings or parts of buildings are intended to house facilities or activities directly related to the safety of persons at the airport.

e. Urban Mass Transportation Administration

(1) Airport Access

The Urban Mass Transportation Agency (UMTA) of the Department of Transportation provides grants or loans to public bodies for acquiring or improving capital equipment and facilities needed for public or privately operated mass transit systems. While neither these loans, nor UMTA's "demonstration grants" have yet provided an adequate means of solving airport access problems, the potential for such help remains.

f. Federal Highways Administration

(1) Airport Access

The Bureau of Public Roads of the Federal Highway Administration (still another part of the Department of Transportation) provides funds to state highway departments for constructing the interstate highway system and for building or improving primary and secondary roads and streets. Funding for the interstate highway system is authorized by the Congress to be spent from the Highway Trust Fund on a matching basis, with the Federal share being 90% and the State share 10%. The funding for building or improving primary and secondary roads is on a 50-50 basis.

g. State, Regional and Local Agencies

(1) Airports

In view of the very great impact -- for good and for bad -- that an airport may have upon a local community, it is not surprising that a number of agencies at the state, regional and local levels involve themselves in airport activities.

At the state level, the state may provide planning and technical aid for airport development and under some circumstances may assist the local or regional agencies with financial help concerning airport planning and development. The organization at the state level varies from state to state. In some instances, the organization concerned with aeronautical activities functions as part of a higher state organization (e. g., in California the Department of Aeronautics is part of the Business and Transportation Agency) while in other instances the organization concerned with aeronautical activities represents the highest level of government agency (e. g., the Alabama Department of Aeronautics). Responsibilities and roles also vary from state to state. In California, for example, the Department of Aeronautics is assisting in the development of statewide system of airports, including responsibilities concerned with airport site and heliport site approvals. It also cooperates with Federal authorities in the development of a national system of civil aviation and in the coordination of aeronautic activities within the State of California.

Regional agencies also have critical roles and responsibilities concerning airports. In some instances, a regional authority may determine the location for a new airport. In other instances, a regional authority may plan, finance and develop the airport system. In Los Angeles County, for example, the Los Angeles County Aviation Commission makes recommendations to the County Board of Supervisors on the acquisition of sites for County airports and heliports, the establishment of regulations for the management and operation of these facilities, and other such matters. The Commission also makes recommendations to the County Engineer on regulations and plans for developing aviation in the County. These may include proposals for enlarging existing facilities or adding new ones to serve the aviation industry. For a county such as Los Angeles, the development of reliever airports may also call into play the Los Angeles County Engineer who also serves as Director of Aviation for the Los Angeles County.

The Los Angeles Department of Airports has charge, supervision, direction and control over the Los Angeles municipal airports (which include LAX, Van Nuys and Ontario). The Board of Airport Commissioners establishes rules and regulations governing the use of the airports and the operation of aircraft in connection with the airports. The Los Angeles Planning Commission and the City Planning Department provide a master plan for the physical development of the city, including its airports. The City Planning Commission also acts as the Airport Zoning Commission. The Planning Department regulates the use of privately owned property through zoning ordinances and through the approval of proposed subdivisions and passes upon zoning variations, as well as the city's acquisition of land.

(2) Airlines and Airline Operations.

A state may limit aircraft operations to particular areas or times and is empowered to have jurisdiction over intrastate tariffs. A regional authority may seek to specialize a particular airport for a particular kind of air service. Agencies of the local community, in particular the airport authorities, participate with the CAB in the route authority proceedings. The local community may restrict unacceptable aircraft, the hours during which airline operations will be permitted, and the uses to which the airline activities may be directed.

(3) Airport Access

Since each state highway department has considerable discretion in determining what the state's interstate highway, primary and secondary road system should be, the state has the ability to help provide airport access improvements. County planning commissions may administer a "master plan for highways" for the unincorporated areas of a county with various city planning departments bearing similar responsibilities in the urban areas. Other departments are usually charged with making surveys for street improvements and for street maintenance.

(4) State Organizations for Aeronautics

Organizations for aeronautical activities at the state, county and local levels vary from state to state (Table E-2). In some instances, the state organization concerned with aeronautical activities functions as part of a higher state organization (e. g. , in California the Department of Aeronautics is part of the Business and Transportation Agency) while in other instances it represents the highest level of government agency (e.g., the Alabama Department of Aeronatutics). In Colorado and Nevada, separate state organizations for aeronautics are not identified.

(h) Organization of Aeronautical Activities in California

A variety of organizations at the state, county and local level are of significance to aeronautical activity. It is the purpose of this section to describe briefly some of the organizations affecting air operations and airports including airport access in the State of California. While California is not necessarily representative of other states, the description of the organizations and their responsibilities still provide a feel for the problems to be encountered elsewhere.

(1) California Department of Aeronautics

As an example of government organization for aeronautics, the State of California Department of Aeronautics activities include: encouragement of the development of private flying and general use of air transportation, the fostering of air safety, assisting in the development of a statewide system of airports, and providing for cooperation with federal authorities in the development of a national system of civil aviation as well as coordination of aeronautics activities of federal authorities with the State of California.[E-5] It is charged with airport and heliport site approval as well as airport operating permits.

The programs administered by the California Department of Aeronautics to accomplish its objectives include: (a) development of aviation and navigation facilities, (b) aviation safety and education, and (c) administration.

The objective of the aviation and navigation facilities program is to plan for the optimum use of available air space and to provide technical and financial assistance toward the development of aviation and navigational facilities. On-going elements of the program in FY 1970-71 included: (a) allocation of airport assistance revolving funds, (b) regulation of airports and heliports, (c) inspection of schools and state building sites, (d) leasing the navigational system, (e) noise standards for airports, and (f) the State Airport Master Plan.

During the 1969 Session, the California Legislature enacted legislation which required the Department of Aeronautics to develop and adopt noise standards governing the operation of aircraft and aircraft engines for airports operating under a valid permit issued by the department to the extent not prohibited by law. The act, Chapter 1585, Statutes of 1969, established an advisory committee to assist the department in the adoption of standards and directed that the regulations be presented to the Legislature by April 1970; which, in the absence of legislative action they were to become effective January 1, 1971.

The bill provided $50,000 from the General Fund to be repaid by the Airport Assistance Revolving Fund from the revenue realized from a newly imposed tax on aircraft jet fuel.

Further, the bill specifically provided that the counties would be responsible for the enforcement of the regulations and directed that the officer in charge of the airport provide the enforcement authority, to be designated by the county, such information as is required by the noise standard regulations to permit their efficient enforcement.

The objectives of the California Department of Aeronautics aviation and safety program in the fiscal year 1970-1971 were to develop and promote a safety program and to insure the adequacy of training equipment, facilities and procedures in aeronautical activities and schools. Elements within the program included: (a) regulation of parachute jumping, (b) financial responsibility, (c) safety and education, (d) regulation of commercial flight schools, (e) search and rescue, and (f) airmarking.

The Department of Aeronautics in FY 1970-1971 was also in the process of developing the first phase of a two-phase master plan for aviation. When compiled, the plan was to provide a logical basis for the distribution of the Airport Assistance Revolving Fund and was to relate the needs of the state to the potential financing of airport development. The study is a 28-month study which uses regional and local planning data as basic inputs. The Bay Area Regional Airports study is thus a basic component of the statewide master plan. Once developed the study will be drawn into a more general multi-mode plan which will include ground transit as well as aviation.

The California State Master Plan of Aviation is a two-part study involving the air element of the overall transportation picture. When completed, the plan will encompass all 58 California counties. Phase I of the plan is primarily concerned with inventory and data gathering, analysis of the existing system, the forecasted supply and demand, postulated future systems and the evaluation of the proposed alternatives. It will, in effect, describe where California is today with respect to air transportation, what California can expect in the future, and alternative ways of coping with the future.

Phase II is to develop the actual aviation program based on the data and results stemming from the Phase I activity. It will produce an implementation program to be pursued in putting the Master Plan into effect. An additional feature of the Phase II activity will be a computerized information Data Bank which will store all collected and inventoried data assembled during the course of the study. This Data Bank will be updated on a selected element basis, to be available to all types of users as their needs for data arise.

The Department of Aeronautics contends that the long-term plan for future development of an overall Statewide Aviation System is necessary if the Department of Aeronautics is going to carry out its objectives in the State of California. To effect uniformity of the laws and regulations relating to aeronautics in order that persons may engage in every phase of aeronautical activity with the least possible restrictions consistent with the safety and rights of others, a need exists for a means of coordination and cooperation with Federal authorities.

In the development of a national system of civil aeronautics, it is necessary to provide a means for coordination of the aeronautical activities of the Federal authorities in the State of California. A number of needs arise:

- There is a need to develop an economically and technically appropriate system of general aviation airports financed out of user charges as distinct from other sources of funds.
- There is a need to develop a system of reliever airports and airstrips for accommodating the overflow of general aviation and the diversion of training flight operations to maintain capacity at existing airports.
- There is a need to develop a system of recreational airports consistent with recreational values and needs.
- There is a need to determine the need for the Business and Transportation Agency, the Department of Aeronautics, the Aeronautics Board, and possibly the State Transportation Board to administer future state and federally supported aviation trust funds.
- There is a need to establish an information data system for existing and future projected aviation data in a computer based form.
- There is a need to evaluate the adequacy of the system to determine future demands and surplus and to provide optimum alternative systems, recognizing cost effectiveness differences.
- There is a need to formulate an implementation program designed to meet the needs of the physical and policy elements of the California Master Plan including capital improvements, legislative actions, administrative measures and responsibilities, and regulatory implications.
- There is a need for the establishment of a state agency which will be responsible for final accomplishment of the program, including the coordination of the aviation planning, administrative and implementation functions, with other state, regional, local and federal agencies involved in transportation planning.
- There is a need to provide liaison with DOT/FAA as to which airports may qualify for federal grants-in-aid as part of the total airport system within the context of the National Airport System Plan and the State Master Plan of Aviation.

- There is a need to determine and update airport standards relating to physical plan versus facilities, noise, environment and other physical requirements.

(2) California Public Utilities Commission

The California Public Utilities Commission, a constitutional agency composed of five members appointed by the Governor with the advice and consent of the Senate, is responsible for the regulation of privately owned public utilities. The term "public utility" includes such businesses as truck, bus, airline companies and pipeline corporations (comprising the "transportation" group of utilities), telephone, gas and electric companies, and warehouse companies. The commission's primary objective is to insure adequate facilities and services for the public at reasonable and equitable rates consistent with a fair return to the utility on its investment.

The commissions' authorized staff of 807 positions (FY 1971) was organized into six divisions: Administrative, Transportation, Utilities, Finance and Accounts, Examiner, and Legal. The commissions' two major programs are the Regulation of Transportation (receiving about 62 percent of the budgeted funds) and the Regulation of Utilities (receiving about 38 percent of the funds). Direct operating responsibility for these two programs is handled, respectively, by the Transportation Division and the Utilities Division, each of which receives supporting services from the other four divisions.

Operating Procedures. The commission reviews and passes judgment on all changes in operating methods and rate schedules proposed by regulated utilities and transportation companies. It investigates complaints registered against utilities and may initiate an investigation of a utility company on its own volition. In all such cases, data are accumulated by the staff, hearings are held, decisions rendered, and compliance secured through enforcement procedures. No state court may review a commission decision except the California Supreme Court whose review power is limited to questions of law.

An application or complaint presented to the commission by or against a transportation company, for example, would be studied by the Transportation Division. Any financial implications would be reviewed and evaluated by the Finance and Accounts Division. The Legal Division would advise the commission on legal matters and the Examiner Division would conduct the hearings. The Administrative Division provides staff supervision, administers commission policies, and maintains housekeeping services.

Support of the Commission. The commission is supported by the General Fund and the Transportation Rate Fund. The Transportation Rate Fund finances only those commission activities relating to the rates, charges, and practices of motor carriers hauling freight. All other commission functions are supported by the General Fund.

Revenues for the Transportation Rate Fund are derived from a fee paid by the regulated motor carriers which is equal to one-third of one percent of their gross operating revenues. Additional revenue to the Transportation Rate Fund is produced by a $4 quarterly "filing fee" which is paid by all motor and rail freight carriers at the time they file with the commission their reports on gross operating revenue. Other revenues are derived from a miscellany of penalties, application fees for permits and certificates, and from the sale of documents.

Applications to California Air Transportation. The California Public Utilities Commission has the authority to regulate and the responsibility to regulate intrastate air carriers and to regulate intrastate fares of carriers certificated by the Civil Aeronautics Board. The commission also regulates surface carriers which serve the various airports in California, with the exception of those carriers which are operated by other governmental or municipal agencies. It has relations with the Association of Bay Area Governments (San Francisco region) and the Regional Airport Systems Study Committee as it is the commission's belief that it can contribute to the solution of the regional transportation problem by the adoption of a program designed to shape its regulation of air carriers and airport surface transit to comport with an integrated and dispersed usage of the San Francisco Bay area airports.

The Commission has adopted a policy of promoting cooperation with the Civil Aeronautics Board on questions of air carrier service by the establishment of an air team which coordinates their common activities. Although the Commission has full regulatory authority over intrastate airlines, its authority over interstate airlines is limited to the fixing of rates for their intrastate operations. In effect the two regulatory agencies must work harmoniously toward the same objectives to insure the most convenient, economic and balanced utilization of airport facilities. Some phases of cooperation between the two agencies may require additional legislation on both the state and federal levels. Where this is found to be necessary, the respective agencies should take steps to secure the introduction of the appropriate bills.

(3) California Division of Highways

The activities of the California Division of Highways are of special importance to the development of adequate airport access. The Division of Highways is a part of the Department of Public Works which, in turn, is a part of the Business and Transportation Agency. The Highways Division plans, supervises construction of, and maintains the State Highway System. It also issues transportation and encroachment permits. One of its district offices conducts the Los Angeles Regional Transportation Study.

(4) Los Angeles County Board of Supervisors

At the County level organizations vary from county to county. In Los Angeles County the Los Angeles County Board of Supervisors serves as the governing body of the County and many special districts, including Flood Control, Air Pollution Control and Fire Protection Districts. The Board enacts ordinances and rules; determines County and special district policies; supervises activities of the Chief Administrative Officer, County departments and special districts; and sits each July as the County Board of Equalization to hear appeals from property assessments.

It has the unique function of serving as the executive and legislative head of the largest and most complex County Government in the entire United States.

(5) Los Angeles County Regional Planning Commission

The Regional Planning Commission establishes a master plan for Los Angeles County (plans which provide, among other things, for airport locations and related activities); maintains orderly and effective administration of existing plans; and provides comprehensive and precise zoning for unincorporated areas of the County. Its Development Planning Division administers the Master Plan of Highways and reviews public land acquisition for conformity with master plans. The Regional Planning Division's County Wide Planning Division handles all the technical work regarding the creation of master plans, community plans, and special planning assignments involving unincorporated areas of the County distinct from regional plans.

(6) Los Angeles County Aviation Commission

The Los Angeles County Aviation Commission makes recommendations to the County Board of Supervisors on the acquisition of sites for County airports and heliports, the establishment of regulations for the management and operation of these facilities, and other such matters.

The Commission also makes recommendations to the County Engineer on regulations and plans for developing aviation in the County. This may include proposals for enlarging existing facilities or adding new ones to serve the aviation industry. The Commission also recommends programs for the promotion and growth of the aviation industry.

(7) Los Angeles County Engineer -- Aviation Division

The Los Angeles County Engineer is also Director of Aviation for Los Angeles County. The County Engineer's overall functions include the performance of engineering services in the unincorporated area of the county and in contract cities as directed by the Los Angeles County Board of Supervisors.

(8) Los Angeles County Road Department

The Los Angeles County Road Department is responsible for planning, designing, constructing, maintaining, and repairing County highways, roads, bridges, and culverts, and for making the related surveys; design, installation and maintenance of traffic signals; administration, construction and maintenance of County Lighting Districts.

The Road Department also controls right-of-way requirements; determines acceptability of Record of Survey maps and subdivision maps in regard to dedication of streets; issues permits for excavations, construction, and moving of buildings on public highways.

(9) Los Angeles County Air Pollution Control District

The Los Angeles County Air Pollution Control District develops and enforces measures to control air contaminating emissions from stationary sources; administers air monitoring, research, source testing, instruments and methods development, meteorological and control engineering services in support of this basic mission; performs air monitoring projects for State and Federal agencies; provides atmospheric radiological monitoring and protection services for the County.

(10) Los Angeles City Planning Commission

To guide orderly growth the Los Angeles City Planning Commission is appointed to study city growth and recommend policies to the governing body of the city. This usually results in the County Master Plan. They also recommend which particular areas of the city should be used for certain purposes. The planning and zoning laws adopted by the city are for the health and welfare of the public thus serving one of the requisites for the exercise of the police power of the community. Planning commissions usually pass on any new subdivision development to determine that they conform to the overall interests of the community. By law the planning commissions may control street alignment, improvements, size and shape of lots, etc. The commissions usually pass on all subdivision maps before they are presented to the City Council or Board of Supervisors. The City Planning Commission usually works closely with county planning commissions (sometimes called Regional Planning Commissions, as in the case of Los Angeles County) in planning through highways and other matters requiring coordinated action.

(11) Los Angeles City Planning Department

The Los Angeles City Planning Department prepares and maintains a master plan for the physical development of the city including such elements as highways, the Civic Center, public works facilities, branch administrative centers, schools, recreational facilities, airports and the shore line. All matters which would affect any portion of this plan must be approved by the City Planning Commission (which also acts as the Airport Zoning Commission). The Department regulates the use of privately owned property through zoning ordinances and through the approval of proposed subdivisions. The Department investigates and reports on applications for amendments to the zoning ordinances and passes upon zone variance applications. The acquisition of land by the City of Los Angeles for public use must be approved by the City Planning Department.

(12) Los Angeles Department of Airports

The Los Angeles Department of Airports has charge, supervision, direction, and control over the Los Angeles municipal airports. The Board of Airport Commissioners establishes rules and regulations governing the use of the airports and the operation of aircraft in connection with the airports. The municipal airports include Los Angeles International Airport, the Van Nuys Airport and the Ontario Airport.

(13) Los Angeles City Engineering Bureau

The Los Angeles City Engineering Bureau, a part of the Public Works Department, prepares surveys and engineering plans for street improvements, bridges, sewers, storm drains, and other public works, and is the custodian of all maps, plans and records pertaining to such work.

(14) Los Angeles Right of Way and Land Bureau

The City of Los Angeles Right of Way and Land Bureau acquires rights-of-way, makes appraisals and purchases property required for public use. It examines property titles, maintains records, and collects rentals for the use of City-owned land and improvements.

(15) Los Angeles Streets

In Los Angeles, streets are primarily the responsibility of the city. Three agencies of the city -- the Planning Department, the Traffic Department, and the Public Works Department -- are involved in the provision and maintenance of the city streets. The Planning and Traffic Departments evaluate capabilities of existing streets and define requirements for future streets, while the Public Works Department is responsible for construction and maintenance. Each of these departments is, in turn, responsible to a citizen's commission, or board, which is in turn responsible to the City Council and Mayor for the activities of these departments.

E. 2 TIMING OF V/STOL IMPLEMENTATION ACTIVITIES

Whatever the importance of the roles and responsibilities of the government agencies for V/STOL applications, the timing of their activities is a critical determinant of the future of V/STOL applications. The webs of interdependency are such that the action of one group is frequently dependent upon the prior completion of some other activity by another group. Unfortunately, in some instances a considerable period of inactivity results because each is awaiting the other's move. This may be at least partially descriptive of V/STOL activities. The manufacturers are unwilling to commit funds and resources to the development of a V/STOL aircraft in the absence of firm aircraft purchase orders. The aircraft purchases from the manufacturers are withheld pending granting of route authority to the airline by the CAB for a particular V/STOL route. Also, delivery of the aircraft may be held up pending certification of the aircraft by the FAA. The CAB, on the other hand, may be hesitant to provide route certification in the absence of firm information about the number and type of aircraft to be used, the scheduling of the airline operations, the characteristics of the aircraft, the nature of the market, and the effects upon other transportation activities. Similarly, local agencies may be hesitant to accord support for a V/STOL applications program in the absence of firm data about the noise and air pollution likely to be produced by the aircraft as well as its impact upon both air and surface congestion.

Figure 32, Volume I, depicts in summary fashion some of the time-related interdependencies. In each facet of V/STOL applications many of the decisions and implementing acts are dependent upon some preceding act. Thus, in the aircraft category, the availability of the 1980 STOL depends upon prior STOL certification by the FAA, the FAA certification of a STOL, prior flight tests of the STOL aircraft, and so forth. Time-related dependencies span categories. Thus, with respect to the airline category STOL aircraft revenue service depends upon the availability of certified STOL aircraft (from the aircraft category line) and STOL landing aids (from the air traffic control line).

It is important to bear in mind that the time requirements for the decisions and implementation acts are subject to considerable variations. In some instances, the time requirements are established by law, as in the stipulation that a certain number of days will elapse between notice of a CAB hearing and the hearing itself. In other cases, the time requirements cannot be defined with any precision because of uncertainties associated with technical developments of a revolutionary nature. Often, however, the times are difficult to define because of an agency's caution in making a decision in order to safeguard all interested parties.

a. V/STOL Aircraft and Related Equipment Manufacturers

The dependence of V/STOL aircraft and related equipment manufacturers for funding of research in the manufacturer's facilities and information resulting from sponsored research and in-house government research was described earlier. The manufacturers may delay their own work on the development of a V/STOL aircraft pending the completion of such R&D activities. But the aircraft manufacturer is also likely to wait for government endorsed definitions of a market particularly as a result of CAB route authorization and airline interests in an aircraft to service that market. And if it does develop the aircraft, the manufacturer is dependent upon meeting FAA standards in order to have its aircraft certified. Figure 11, Volume I, gives an example of the time requirement for STOL development as a composite of the time requirement for the NASA QUESTOL, plus the time required for the DC-10 development, plus one additional year between the two programs for contingencies.

b. Airports

This study does not envision the creation of new airports for the 1980 STOL, although new airports may be required to implement 1990 VTOL.

Since no new airport is to be developed for the 1980 STOL, problems related to decision and implementation are greatly minimized principally since costly and time-consuming land acquisition procedures are avoided. However, for new airports to be developed for a 1990 V/STOL site, selection studies and air space determination should be initiated by 1982.

c. Airline Operations

In view of the unwillingness of manufacturers to design and develop V/STOL aircraft prior to the establishment of a market and the CAB's route authorization, the speeding of government decisions in these areas may greatly accelerate the V/STOL applications process. A speeding up of CAB's decision making process would permit earlier decisions of STOL routes to be made. If such decisions are made, airlines may then firm up their plans on the number and type of aircraft required to service the new markets. The manufacturers would then be in greatly improved positions to move ahead with the development of aircraft to satisfy the airline needs. Communities concerned with planning for airport developments would then be in a position of having firm data on operational characteristics of the airplanes programmed to service their communities. The difficulties of the CAB should not be minimized, however. It is required to protect the interests of a variety of parties and in order to do so it must generally follow a set of time consuming procedures. Figure 30, Volume I, shows the times required for three different CAB decisions. While the current law does not permit basic changes in the procedures, significant speedups could occur in the scheduling time requirements if the judge's and the board's decisions could be speeded.

d. Airways and Air Traffic Control

Since ownership and control of the Federal Airways System is vested in the FAA, no delays are expected in implementing V/STOL applications as a consequence of the necessity for air space studies or for the construction of whatever additional ATC and landing aids might be required.

e. Airport Access

Significant improvements in existing airport access are generally time consuming and costly. If new rapid transit systems are to be constructed for airport access, the time delays are indeed very great. Figure E-2 shows the time requirements for the San Francisco BARTS program, and for the Washington, D. C. subway. If freeways are to be developed to provide airport access, the State of California experience has shown optimistic scheduling to require about seven years (Figure E-3). The development of surface street improvements, particularly if rights of way have already been acquired, provides the speediest solution if not the best long-term solution.

Fortunately, the 1980 STOL and the 1990 V/STOL envision reliever airports being used in conjunction with the hub airports. The use of the reliever airports may serve to reduce airport congestion at the hub airports while adding acceptable levels of increased traffic at the reliever airports.

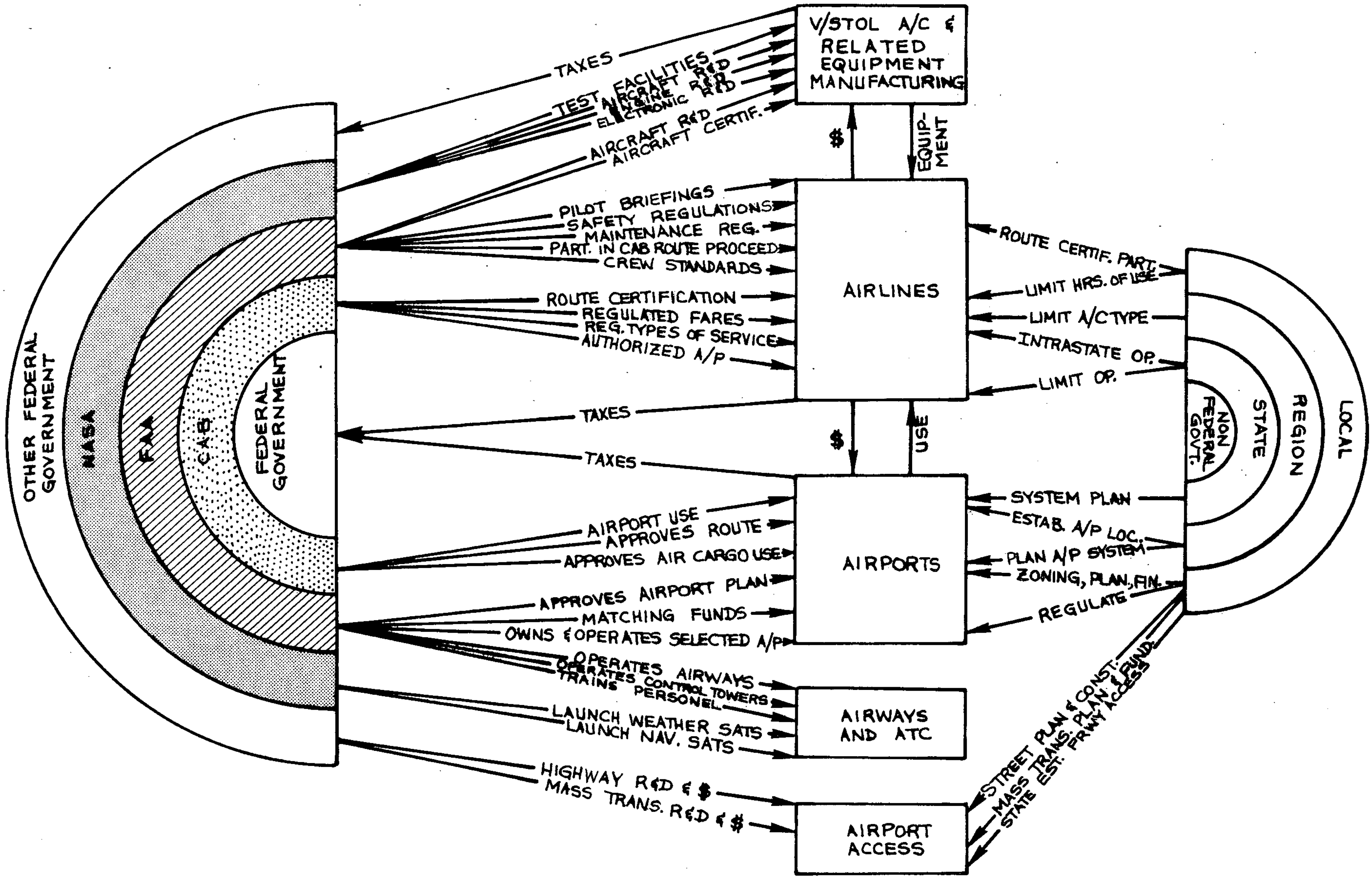

Figure E-1. Principal Role Interactions

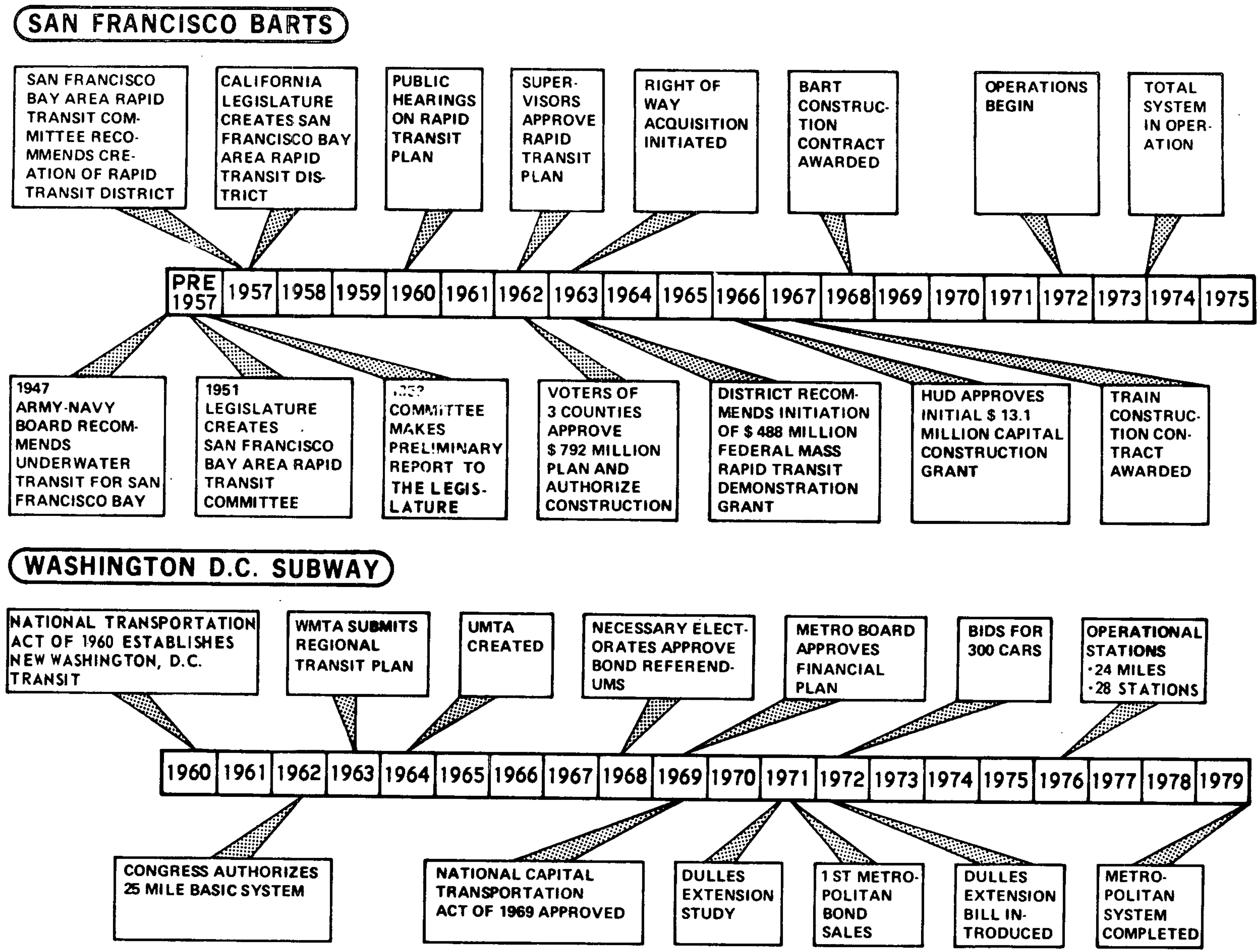

Figure E-2. Rapid Transit Milestones

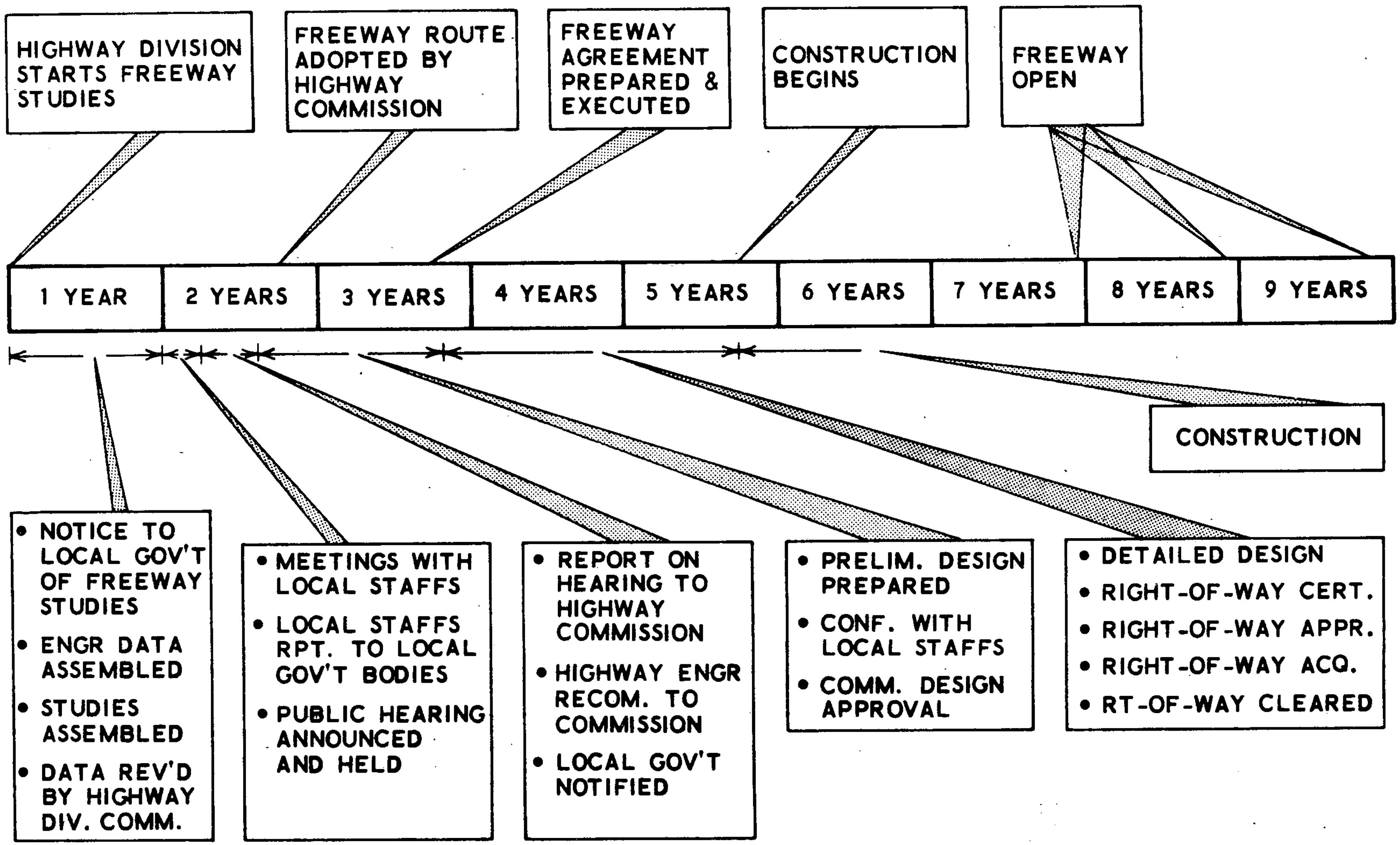

Figure E-3. California Freeway Development Milestones

Table E-1. Sources of Laws and Regulations Pertinent to V/STOL Applications

	Federal																															State						County			City						Region
	Congress (And GAO)	Judicial	CAB	Eq. Empl. Oppor. Bd.	Exp-Impt. Bank	FCC	Gen. Serv. Adm.	ICC	NASA	NLRB	Nat. Media. Bd.	SEC	Postal Service	Pres. Exec. Offices	NASC	Off. Sc. & Tech.	HUD D.	State D.	Treasury D.	Defense D.	Justice D.	Interior D.	Agriculture D.	Commerce D.	Labor D.	HEW D.	EPA	DOT FAA	DOT Highways	DOT UMTA	DOT NTSB	Legislative	Judicial	Aero. Div.	Public Works	Roads	Air Resources Bd.	Region. Plan. Com.	Board of Super.	County Engr.	Mayor	Council	Plan. Com. & Dept.	Airport Com. & Mgr.	Public Works	Traffic Commission	
AIRPORT SYSTEMS																																															
Location, Selection, Use	x	x	x				x					x		x	x	x				x		x	x	x	x		x	x						x				x		x	x	x	x	x	x	x	x
Devel. (Plan., Fin., Tech. Aid)	x	x	x	x	x								x	x	x	x	x	x		x	x	x	x	x	x		x	x				x		x				x		x	x	x	x	x	x	x	x
Administration	x	x												x	x				x	x	x	x	x					x										x		x	x	x		x			x
Rates and Charges	x	x	x										x	x	x			x		x	x	x	x					x										x			x	x		x			x
Reg. & Protection, (Incl. Zoning)	x	x				x								x	x		x			x	x	x	x			x	x	x				x						x			x	x		x			x
Ownership and Operation	x	x		x			x			x			x	x	x					x		x	x			x		x										x			x	x		x			x
AIRPORT ACCESS SYSTEMS																																															
Planning	x	x	x				x	x					x	x	x	x				x		x	x				x		x	x				x	x	x		x	x		x	x	x	x	x	x	x
Financing	x	x			x							x	x	x	x					x		x	x						x	x				x		x			x		x	x		x			x
Ownership and Operation	x	x		x				x		x			x	x	x	x						x	x						x	x						x				x				x			x
AIRSPACE																																															
Rules and Procedures of Usage	x	x				x			x					x		x				x	x							x																			x
Nav. Aids & Syst. Planning	x	x							x					x		x		x		x			x	x				x						x													x
Nav. Aids & Syst. Financing	x	x	x											x				x		x			x	x				x																			x
Nav. Aids & Syst. Own. & Oper.	x	x		x			x		x					x				x		x								x																			x
AIR SAFETY SYSTEMS																																															
Weather, Terrain & Hazard Info.																																															
Data Collec., Anal., & Present.	x	x							x					x	x			x		x				x				x																			
Briefing & Enroute Intelligence	x	x				x			x					x	x			x		x				x				x																			
Air Accident Cause--Ident. & Prev.	x	x							x					x	x			x		x								x			x																x
Air Safety--Regul. & Enforcement	x	x												x	x						x							x			x																x

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Table E-1. Sources of Laws and Regulations Pertinent to V/STOL Applications (Continued)

	Federal																															State						County			City						Region
	Congress (And GAO)	Judicial	CAB	Eq. Empl. Oppor. Bd.	Exp-Impt. Bank	FCC	Gen. Serv. Adm.	ICC	NASA	NLRB	Nat. Media. Bd.	SEC	Postal Service	Pres. Exec. Offices	NASC	Off. Sc. & Techn.	HUD D.	State D.	Treasury D.	Defense D.	Justice D.	Interior D.	Agriculture D.	Commerce D.	Labor D.	HEW D.	EPA	DOT FAA	DOT Highways	DOT UMTA	DOT NTSB	Legislative	Judicial	Aero. Div.	Public Works	Roads	Air Resources Bd.	Region. Plan. Com.	Board of Super.	County Engr.	Mayor	Council	Plan. Com. & Dept.	Airport Com. & Mgr.	Public Works	Traffic Commission	
AIRMEN, MECHANICS & RELATED EQUIP																																															
Perform. Require. & Licensing	x	x		x										x	x	x				x								x																			
Training Provisions	x	x		x										x	x	x		x		x					x			x																			
Training Standards & Licensing	x	x		x					x					x	x	x		x		x								x																			
AIRCRAFT																																															
Research and Development	x	x		x					x			x		x	x	x				x	x	x	x	x				x																			
Performance Stand. & Licensing	x	x	x							x				x						x	x			x				x																			
Use of Airports and Airways	x	x	x											x						x		x					x	x					x		x			x			x				x			x
Procurement	x	x			x		x					x		x					x	x																											
NON-COMMERCIAL CIVIL AIR TRANSPN																																															
Performance Standards	x	x												x																																	
Permits and Licensing	x	x												x																																	
Use of Airports and Airways	x	x												x				x	x			x					x						x		x			x			x				x			x
Procurement		x			x			x											x																												
COMMERCIAL AIR TRANSPORTATION																																															
Routes and Points Served	x	x	x										x	x				x	x	x	x	x	x	x		x		x																x			x
Agree. & Coop. Working Arrangements	x	x	x									x		x							x	x	x																					x			x
Interlock. Relat., Merg. & Acquisitions	x	x	x									x		x							x																							x			
Labor Conditions	x	x	x	x						x				x											x																			x			
Use of Airports and Airways	x	x	x			x							x	x			x	x	x	x		x	x			x		x																x			x
Tariffs and Tariff Agreements	x	x	x			x							x	x				x		x	x																							x			x
Sched., Capacity & Serv. Adequacy	x	x	x	x		x							x	x					x	x					x																			x			x

Table E-2. State Organizations for Aeronautics

Highest Level of State Organ.		Subsumed under Other Organ.		No. Ident. Org.
Alabama	Dept. of Aeronautics	Alaska	Division of Aviation	Colorado
Arizona	Dept. of Aeronautics		Dept. of Public Works	Nevada
Arkansas	Dept. of Aeronautics	California	Dept. of Aeronautics	
Idaho	Dept. of Aeronautics		Bus. & Trans. Agency	
Illinois	Dept. of Aeronautics	Connecticut	Bureau of Aeronautics	
Indiana	Aeronautics Commission		Dept. of Transportation	
Iowa	Aeronautics Commission	Delaware	Div. of Transportation	
Kentucky	Dept. of Aeronautics		Dept. of High. & Transp.	
Maine	Dept. of Aeronautics	Florida	Div. of Public Transp.	
Maryland	Aviation Commission		Dept. of Transportation	
Massachusetts	Aeronautics Commission	Georgia	Division of Aviation	
Michigan	Aeronautics Commission		Dept. of Industry & Trade	
Minnesota	Dept. of Aeronautics	Hawaii	Dept. of Transportation	
Mississippi	Aeronautics Commission	Kansas	Aviation Division	
Montana	Aeronautics Commission		Dept. of Econ. Devel.	
Nebraska	Dept. of Aeronautics	Louisiana	Aviation Division	
New Hampshire	Aeronautics Commission		Dept. of Public Works	
New Mexico	Aviation Department	Missouri	Aviation Section	
North Dakota	Aeronautics Commission		Div. of Comm. & Ind. Dev.	
Ohio	Division of Aviation	New Jersey	Division of Aeronautics	
Oklahoma	Aeronautics Commission		Dept. of Transportation	
Oregon	Board of Aeronautics	New York	Aviation Section	
South Carolina	Aeronautics Commission		Department of Transportation	
South Dakota	Aeronautics Commission	North Carolina	Dir. of Aviation	
Tennessee	Aeronautics Commission		Div. of Comm. & Ind.	
Texas	Aeronautics Commission		Dept. of Conser. & Dev.	
Utah	Division of Aeronautics	Pennsylvania	Bureau of Aviation	
Vermont	Board of Aeronautics		Dept. of Transp.	
Washington	Aeronautics Commission	Rhode Island	Division of Airports	
West Virginia	Aeronautics Commission		Dept. of Transportation	
Wyoming	Aeronautics Commission	Virginia	Division of Aeronautics	
			Corporation Commissioner	
		Wisconsin	Division of Aeronautics	
			Dept. of Transportation	

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E. 1 Bernard A. Schreiver and William W. Seifert, Cochairmen. Air Transportation 1975 and Beyond - A Systems Approach, The M.I.T. Press, Cambridge, Mass. (1968) pp. 84-121.

E. 2 Code of Federal Regulations, Title 14, Chapter V, National Aeronautics and Space Administration, (January 1, 1970).

E. 3 Code of Federal Regulations, Title 14, Chapter I, Federal Aviation Administration, Department of Transportation, (January 1, 1970).

E. 4 Code of Federal Regulations, Title 14, Chapter II, Civil Aeronautics Board, (January 1, 1970).

E. 5 California Legislature, Analysis of the Budget Bill of the State of California for Fiscal Year 1970-1971, pp. 878-884.

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APPENDIX F

COST AND FUNDING REQUIREMENTS

CONTENTS

FIGURES

FIGURES (Continued)

TABLES

TABLES (Continued)

APPENDIX F

COST AND FUNDING REQUIREMENTS

F.1 SUMMARY OF 1980 AND 1990 V/STOL SYSTEMS

A time-phased implementation schedule and funding analysis for the forced scenario 1980 STOL and fostered scenario 1990 VTOL system has been developed based on the technology, performance and costs of developing, acquiring, and introducing STOL service in 1980 and VTOL service in 1990.

The implementation schedules for the 1980 and 1990 scenarios are shown in Figure F-1 and indicate the key milestones associated with aircraft development, airline introduction, V/STOL port development and availability of the necessary air traffic control facilities and equipment.

A summary of implementation costs for the 1980 STOL and 1990 VTOL systems is shown in Figure F-2. The aircraft cost which consists of flyaway costs and spares for the specified fleet sizes required is seen to be the largest system cost element. VTOLport development costs are significantly higher than STOLport costs because of the costs of land acquisition and new facility construction. Similarly, VTOLports require new air traffic control facilities instead of additional facilities as for the STOL system.

A time-phased summary of these implementation costs is shown in Figure F-3 for both the 1980 STOL and 1990 VTOL systems. Peak implementation costs are shown for both systems during the initial year of service which is also the peak in aircraft production, V/STOL port development, and installation of air traffic facilities and equipment.

Fare levels for these aircraft are shown in Figure F-4 with the 1990 VTOL requiring the highest fare level because of the characteristics of its lift and cruise engine system. These fare levels are determined from an analysis of direct and indirect operating costs, return on investment, and load factor.

Sources of funding for development of the 1980 STOL and 1990 VTOL systems are shown in Figure F-5. Commercial banks are shown to provide the largest funds for aircraft development, airline acquisition, and STOL and VTOL port development.

A summary of STOL and VTOL port development costs by region is shown in Table F-1. The Northeast Region is seen to require the largest investment compared to other regions for both STOL and VTOL ports.

F. 2 1980 STOL SYSTEM

The implementation schedule for the 1980 STOL system is shown in Figure F-6 which illustrates the key milestones associated with aircraft development, airline acquisition and introduction, airport development, and the supporting air traffic control facilities and equipment.

The pacing item in aircraft development is the availability of a quiet, lightweight, and efficient engine. Go-ahead of aircraft manufacture requires that airlines receive appropriate route certification. STOLport development follows go-ahead of aircraft manufacture and airline route certification. Availability of air traffic control facilities and equipment is shown required during the aircraft certification phase.

A summary of the implementation costs for the 150-passenger aircraft is shown in Figure F-2. A cost breakdown by major system element is contained in Table F-2.

Commercial banks will finance 70% of aircraft and engine development and manufacture. Airlines will finance 30% of the flyaway price, spares, and GSE and 100% of introduction costs.

For the 1980 STOL system, airport authorities and the FAA will share airfield development costs on a 50-50 basis. Support facility costs covering passenger terminal and airport parking will be provided by airport authorities. Airport authorities will obtain 30% of all required implementation costs from available funds and 70% from sale of revenue bonds. Airlines will finance aircraft maintenance facilities, 30% from available funds and 70% from commercial banks. Air traffic control facilities will be provided by the FAA.

a. Aircraft Development and Production Costs

(1) Aircraft Development Costs

Airframe. Airframe development costs for the 1980 EBF STOL, 1990 AW STOL, and 1990 Lift Fan VTOL are illustrated according to aircraft size in Figure F-8. These costs represent an Aerospace estimate and are based on analysis of available data.

Engine. A recently completed engine technology and assessment cost study by the Rand Corporation[F-1] was utilized to estimate engine development and production costs. The Rand study is based on performance and cost data of 29 turbojet and 9 turbofan engines and utilizes engine thrust, weight, temperature, total pressure and SFC to develop a technology/time assessment and cost estimate. Based on the STOL and VTOL performance parameters, developed engine technology appears available to meet the developmental schedules. Table F-3 provides a summary of engine performance, technology assessment, and engine costs and quantities.

This method, although extremely sensitive to engine weight, temperature, and SFC, does not consider the impact of noise reduction which is a large uncertainty. Cost experience in developing and producing a quiet engine is at best limited. Current indications are that engines meeting the noise goals forecast for 1980 and 1990 will be more than double the cost of current equivalent thrust engines.

NASA STOL Development. The STOL airframe and engine development schedules and costs assume that NASA funded STOL development activities will accelerate in areas of quiet engine and QUESTOL aircraft development. Projected NASA funding in support of 1980 STOL development is shown in Table F-4. These development activities are essential to the necessary technology, operational hardware, and system planning being available to meet the system implementation schedule for the 1980 STOL system. The results of these activities must provide aircraft and engine manufacturers with design and test criteria and specifications for the development and manufacture of production aircraft.

(2) Production Costs

Airframe. Cost estimating relationships covering aluminum and composite structures and other equipment and controls were developed from analysis of available industry data. A large cost reduction in the cost of composite structures was forecast for 1990. Cost estimating relationships for composite structures are illustrated in Figure F-9, while Figure F-10 illustrates the cost relationships for aluminum structures and other equipment and controls.

To determine unit cost as a function of quantity, the above costs, which are based on quantity, were multiplied by 2.644 to obtain a first unit cost. Average cost was then obtained by: Average cost = 1st airframe unit cost (quantity of airframes)$^{.497}$.

Engine. Engine production costs for the cruise engine were obtained from the engine technology and cost method and were shown in Table F-3.

(3) Flyaway Costs

Flyaway costs for the airframe and engine for the 50, 100, 150, and 200 passenger aircraft are illustrated in Figure F-11.

b. Airline Acquisition and Introduction Costs

Time phased airline acquisition and introduction costs are shown in Figure F-12 and cover flyaway costs of the aircraft and spares and GSE and introduction costs. Airline investment cost factors related to payment schedules for the aircraft and allowances for various categories of introduction costs are shown in Table F-5.

c. STOLport Development Costs

A time phased summary of STOLport development costs is shown in Figure F-13 and covers costs of improving or adding runways, taxiways, taxiway access, aprons, and passenger terminals, airport parking, and aircraft maintenance facilities.

A summary of these costs by state for both minimum and maximum demand levels is shown in Table F-6. A time phased summary for each STOLport in each state is contained in Table F-7. A cost breakdown of airfield and support facilities for each STOLport is shown in Tables F-8 and F-9. STOLport cost factors for the landing area, terminal building, and parking area are listed in Table F-10. Aircraft maintenance facility costs for centralized and regional bases are contained in Table F-11. Maintenance facility locations are shown in Table F-12.

d. Air Traffic Control System Costs

A summary of air traffic control facility costs is shown in Figure F-14 and covers additional control towers, microwave ILS, and approach lighting systems required at various STOLports. Time phased costs for these facilities are shown in Figure F-15. A cost breakdown of each category of facilities necessary for each STOLport is shown in Table F-13.

F.3 1990 VTOL SYSTEM

The implementation schedule for the 1990 VTOL system is shown in Figure F-16 which illustrates the key milestones associated with aircraft development, airline acquisition and introduction, VTOLport development, and the supporting air traffic control facilities and equipment.

As in the STOL system, the pacing item in aircraft development is the availability of quiet, lightweight, and efficient cruise and lift engines. Go-ahead of aircraft manufacture and VTOLport development requires that airlines receive appropriate route certification.

A time phased summary of implementation costs for the 100-passenger aircraft is shown in Table F-14. A cost breakdown into major system elements is contained in Table F-15. System financing similar to the STOL system has been assumed. It is recognized that current FAA funding criteria excludes the costs of terminal and parking facilities; however, since these facilities are integral to the VTOLport, a change in funding criteria has therefore been made. This funding appears to be essential to VTOLport development if airport authorities are to be able to finance their share.

The flyaway cost estimate for the 100-passenger lift fan VTOL was derived using the same costing estimation techniques used for the 1980 STOL which are:

	(000)
Airframe	$5,764
Engine	$3,187
Total	$8,951

a. Aircraft Development and Production Costs

(1) Aircraft Development Costs

Airframe development costs for VTOL aircraft as a function of size were illustrated in Figure F-8. Cruise engine development costs were shown in Table F-3 and were based on the Rand Corporation engine technology and assessment cost study. Lift engine development costs represent Aerospace estimates and are based on analysis of available data. Development costs as a function of engine thrust are illustrated in Figure F-17.

(2) NASA VTOL Development Costs

The VTOL airframe and engine development schedules and costs assume that NASA funded VTOL development activities are required in areas of quiet lift fan engine and quiet VTOL aircraft. Projected NASA funding in support of 1990 VTOL development is shown in Table F-16. These development activities are essential to the necessary technology, operational hardware, and system planning being available to meet the system implementation schedule for the 1990 VTOL system. The results of these activities must provide aircraft and engine manufacturers with design and test criteria and specifications for the development and manufacture of production aircraft.

(3) Production Costs

For the airframe, cost estimating relationships covering aluminum and composite structures and other equipment and controls as shown in Figures F-9 and F-10 were used to develop aircraft production costs. A reduced cost for composite materials was forecast in 1990. Cruise engine costs were obtained from the engine technology and cost method. Lift engine costs as a function of thrust are illustrated in Figure F-18. These costs are Aerospace estimates based on available industry data.

b. Airline Acquisition and Introduction Costs

Time phased airline acquisition and introduction costs were shown in Figure F-12 and cover flyaway costs of the aircraft and spares and GSE and introduction costs.

c. VTOLport Development Costs

A summary of VTOLport development costs by type of facility for each hub city is shown in Table F-17. These costs consist of land and construction costs of ground level, small elevated and large elevated ports. Costs of centralized and regional aircraft maintenance facilities are also included. Land and construction cost factors for each of the VTOLports are listed in Table F-18.

d. Air Traffic Control

For the 1990 VTOL system new terminal air control, communications, data acquisition, and navigation landing aids will be required and are listed for a typical VTOLport in Table F-19.

F. 4 OPERATING COST ANALYSIS

a. Direct Operating Costs (DOC)

DOC for STOL aircraft were based on the utilization of a modified Boeing 1971 DOC method[F-2] which updates cost factors to 1970 levels and reflects airline experience. The following modifications were made to the Boeing 1971 method to bring the costs to 1972 levels and reflect the impact of a new STOL aircraft design in initial airline service.

Flight Crew	-	Increase 15%
Fuel & Oil	-	\$. 115/Gal vs \$. 095/Gal
Insurance	-	2% vs 1%
Maintenance	-	2,000' STOL Increase 30%
	-	3,000' STOL Increase 20%
Depreciation	-	14 Years, 2% Residual vs 12 Years, 0% Residual

The resulting DOC per available seat mile as a function of distance is illustrated in Figure F-19.

The DOC for VTOL aircraft utilized the above modified Boeing 1971 method with the exception of an increase in the insurance rate to 2.5% and the addition of lift engine maintenance equations obtained from an Eastern Airline Guideline for V/STOL systems.[F-3] The DOC per block hour based on 500 statute miles are shown in Table F-20.

b. Indirect Operating Costs (IOC)

The IOC were based on the operational characteristics of a V/STOL system limited to high density short haul markets. The IOC formulas were developed on the basis of (1) intrastate carrier cost of operation in the California Corridor, and (2) typical domestic trunk carriers experience, adjusted for STOL service.[F-4]

The resulting IOC formulas are as follows:

California Corridor = \$21.71 + (0.3249 X CAP) + (0.67161 X NO PAX) + (0.004061 X ASM) + (0.002318 X RPM)

Domestic Trunk = \$47.30 + (0.6438 X CAP) + (1.972 X NO PAX) + (.004383 X ASM) + (0.001307 X RPM)

CAP = Airport Size (No. of Seats)

NO PAX = Number of Passengers

ASM = Available Seat Miles

RPM = Revenue Passenger Miles

The IOC vary widely depending upon the service characteristics of airlines such as fleet size, airports served, and average stage length. Table F-21 illustrates the different IOC obtained from various industry methods. The level of California Corridor IOC can be seen to be far lower than any method based on domestic trunk IOC. This comparison indicates that more research is required to determine the level of IOC that can be achieved by domestic trunk airlines in performing high density STOL service.

c. Return on Investment (ROI)

A return on investment analysis was incorporated into the system economics to provide a means to evaluate the economic viability of various aircraft designs and operational concepts.

The ROI developed represents a rate averaged over a number of years. The rate of return on investment utilized is based on current practices of regulatory agencies. For the California Corridor, the rate of return used is 10.5% which is established by the California Public Utilities Commission.[F-5] A 10% ROI on the total investment base is equivalent to an ROI of 13.8% per year based only on the aircraft investment.

For domestic trunk carriers, the rate of return used is 12% which is established by the Civil Aeronautics Board.[F-6] A 12% ROI on the total investment is equivalent to an ROI of 19.7% per year based exclusively on the aircraft investment.

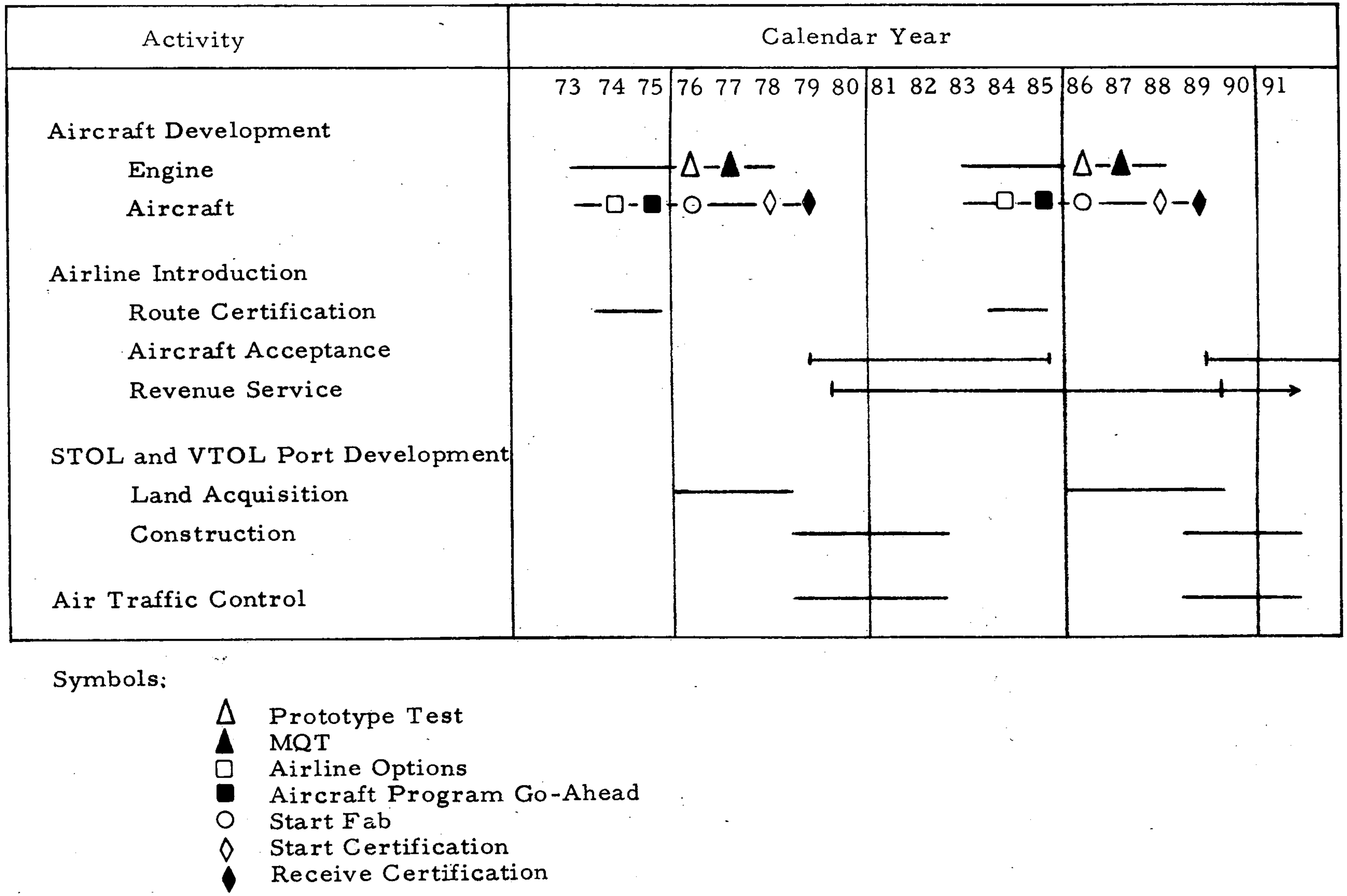

Figure F-1. 1980 STOL and 1990 VTOL Implementation Schedule

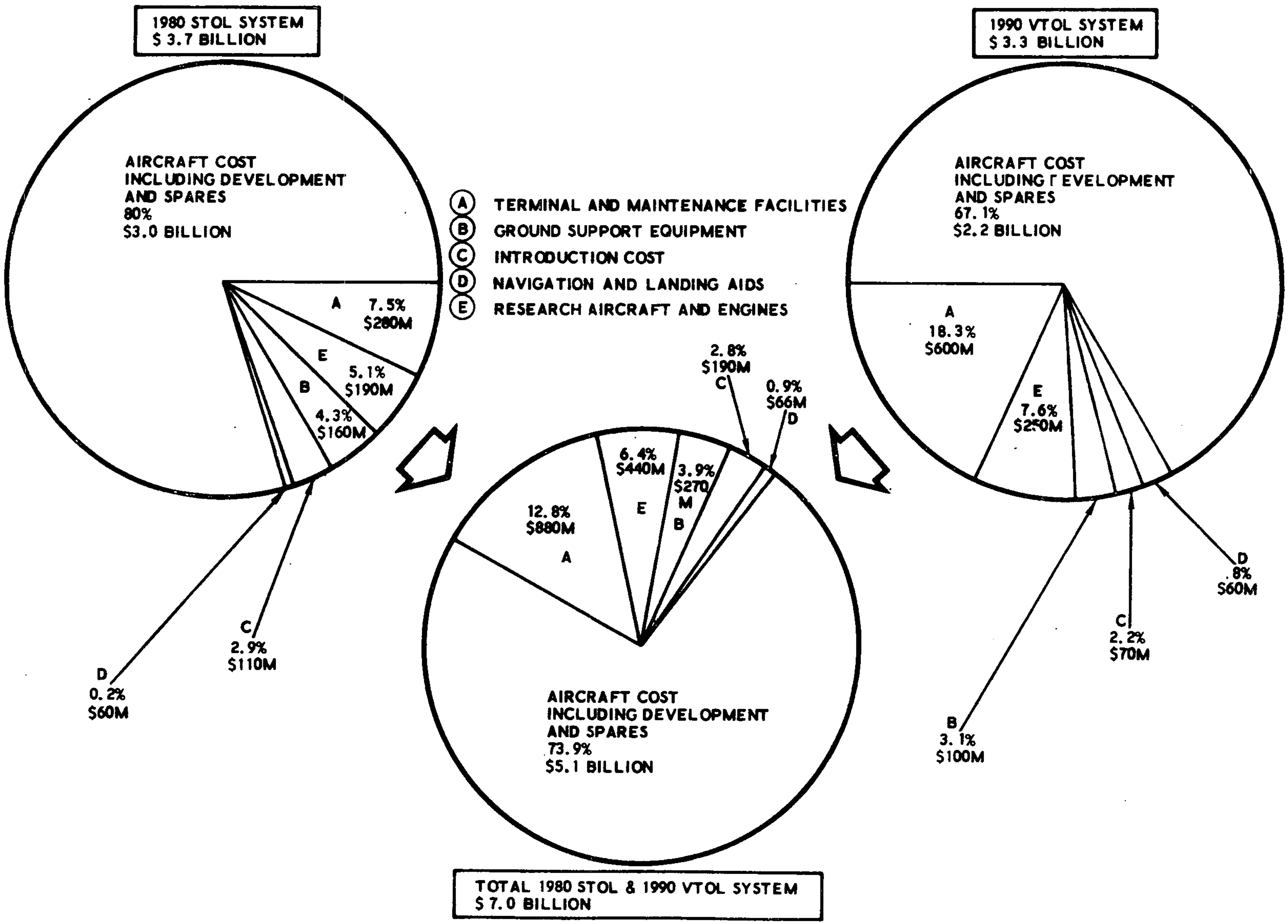

Figure F-2. 1980 STOL and 1990 VTOL Systems Costs

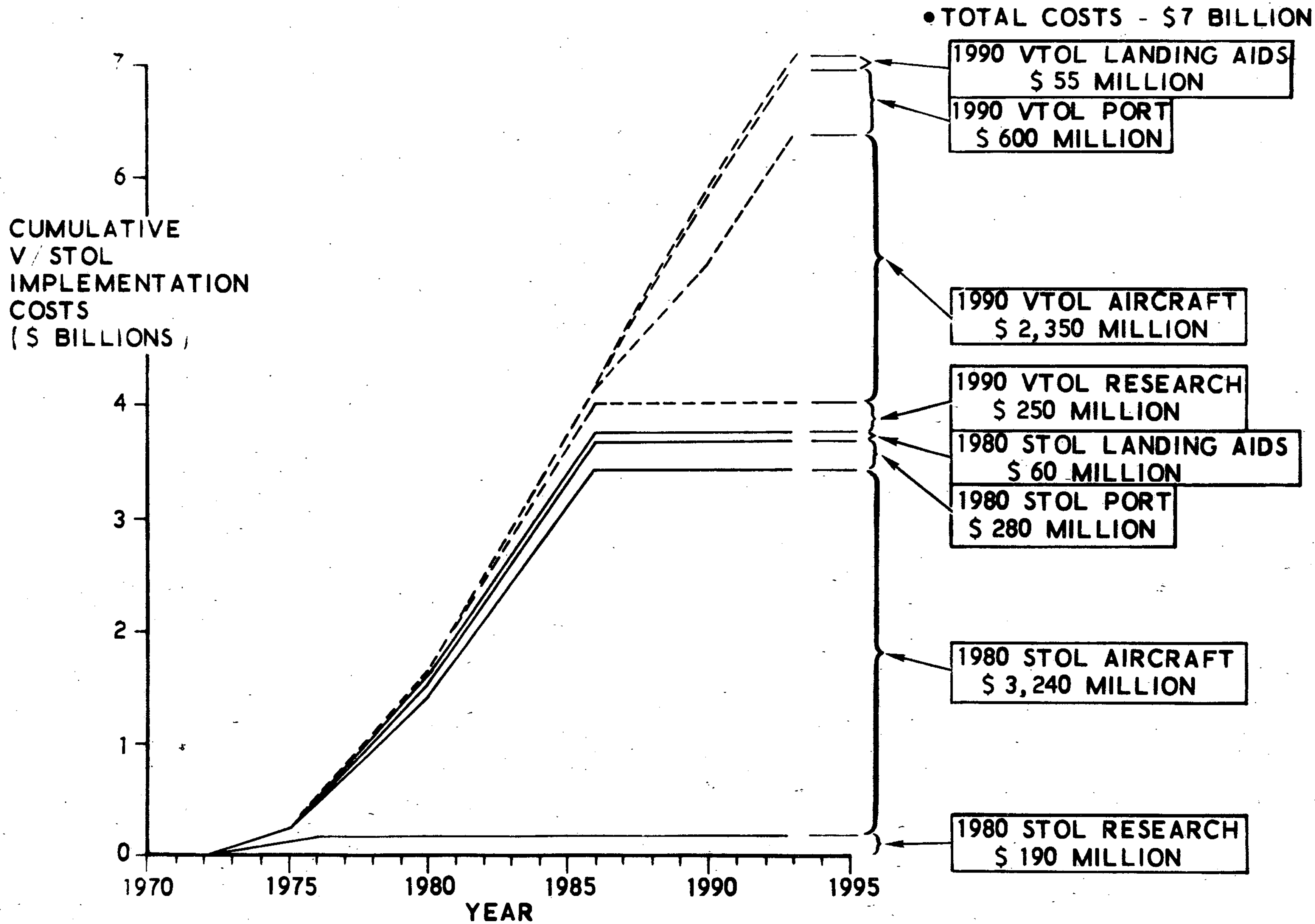

Figure F-3. Cumulative 1980 STOL and 1990 VTOL System Implementation Costs

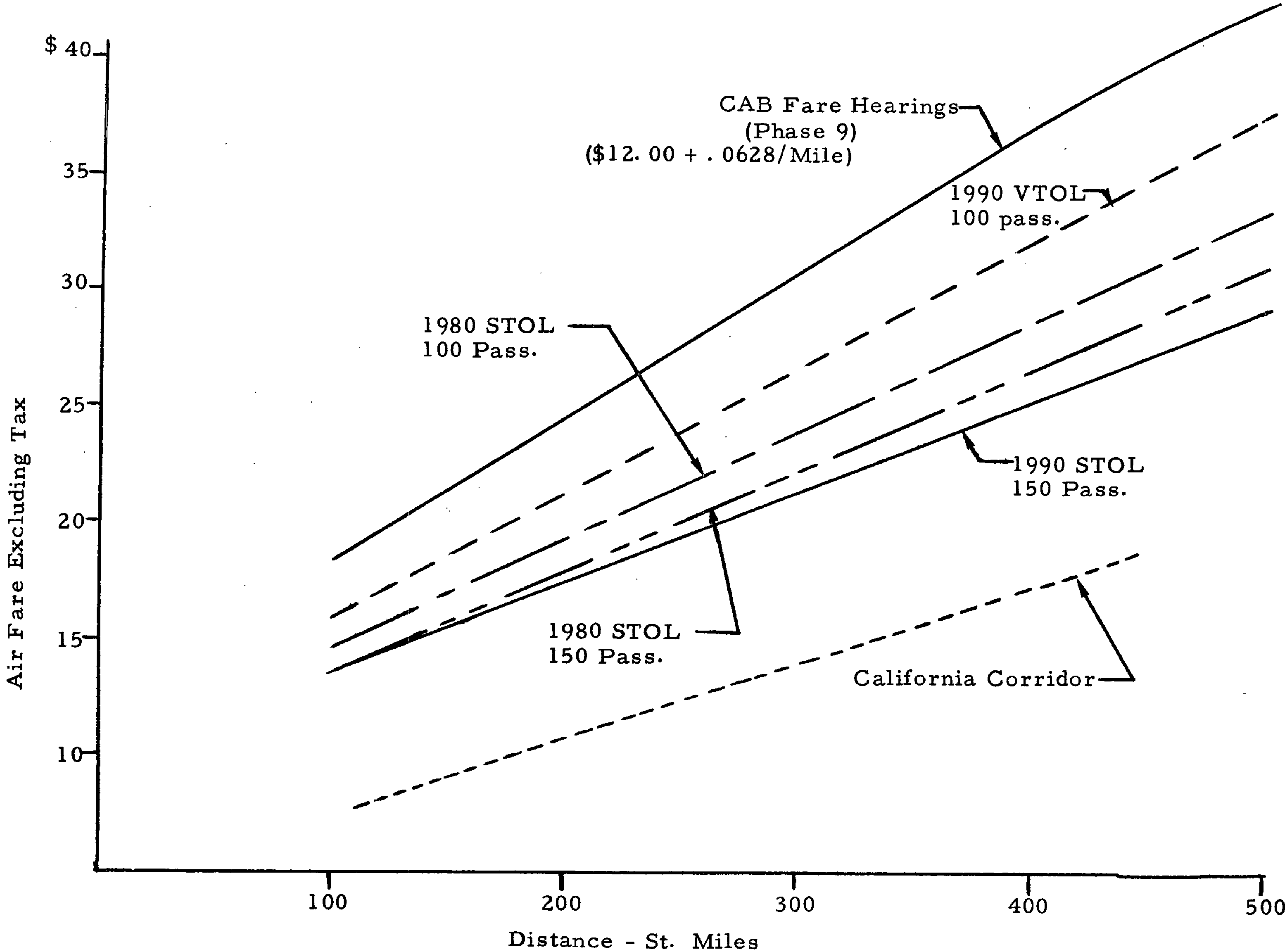

Figure F-4. Comparison of Fare Levels
1980 STOL & VTOL Systems
(Adjusted Domestic Trunk IOC)

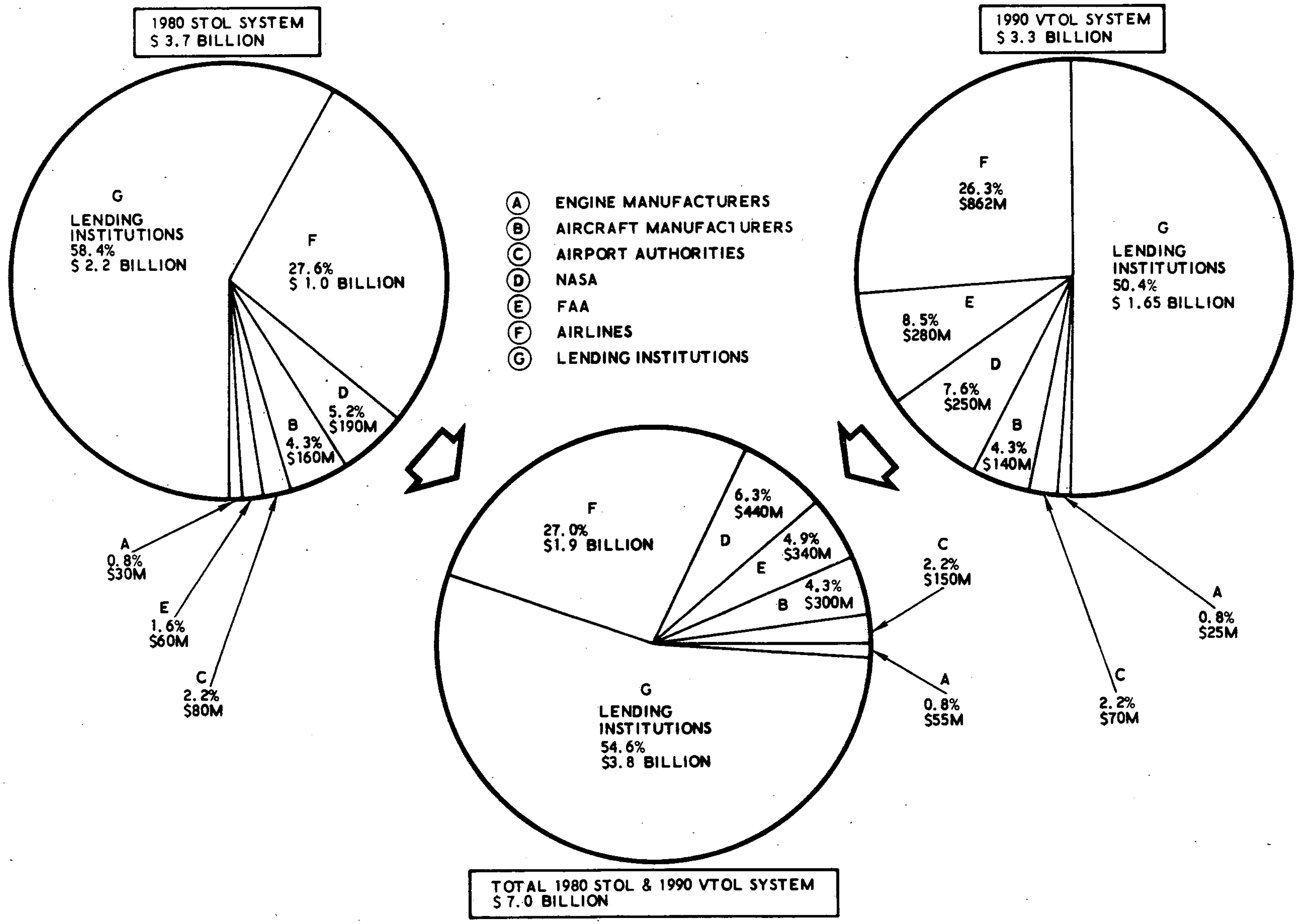

Figure F-5. 1980 STOL and 1990 VTOL System Cumulative Funding

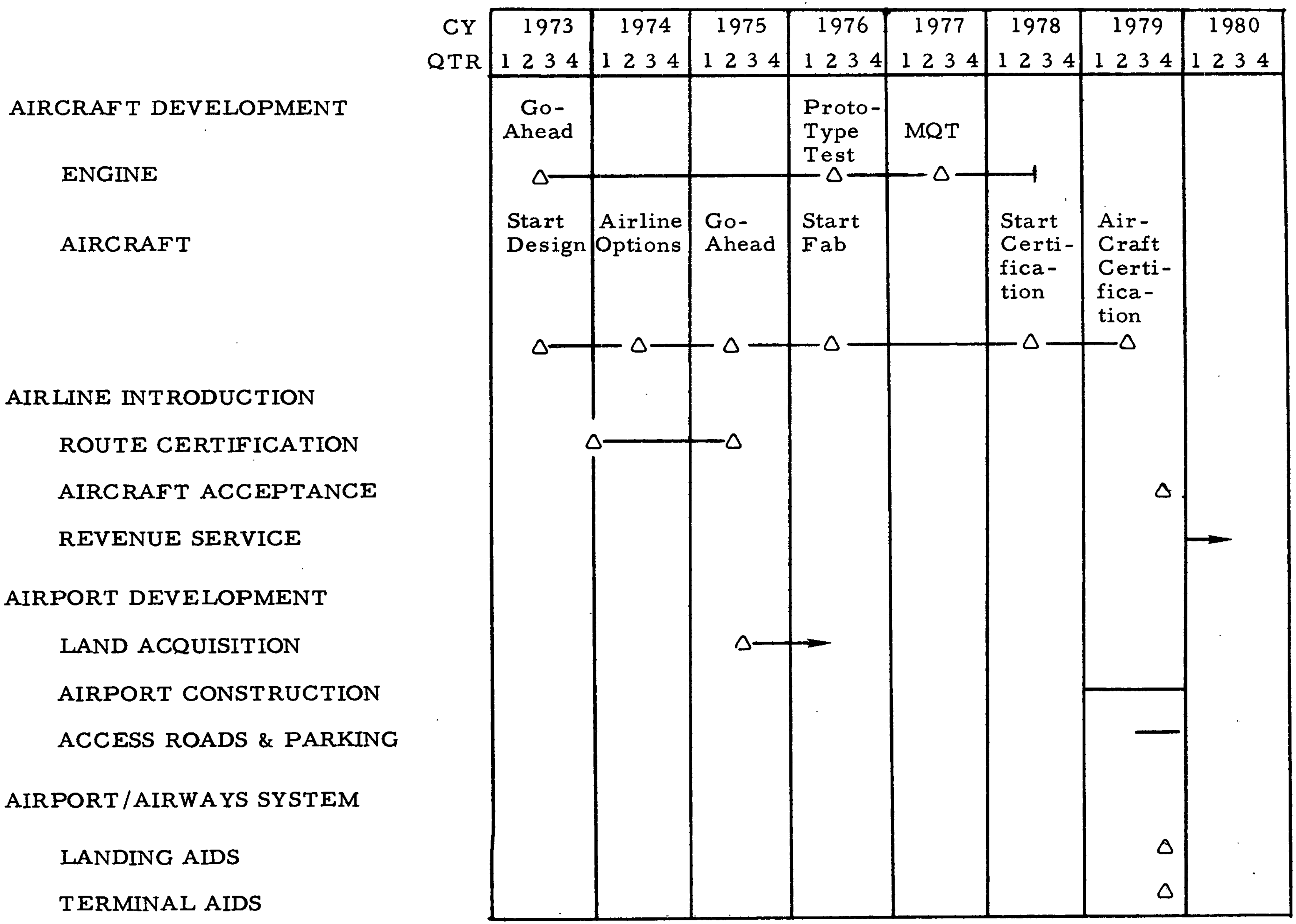

Figure F-6. 1980 STOL Implementation Schedule

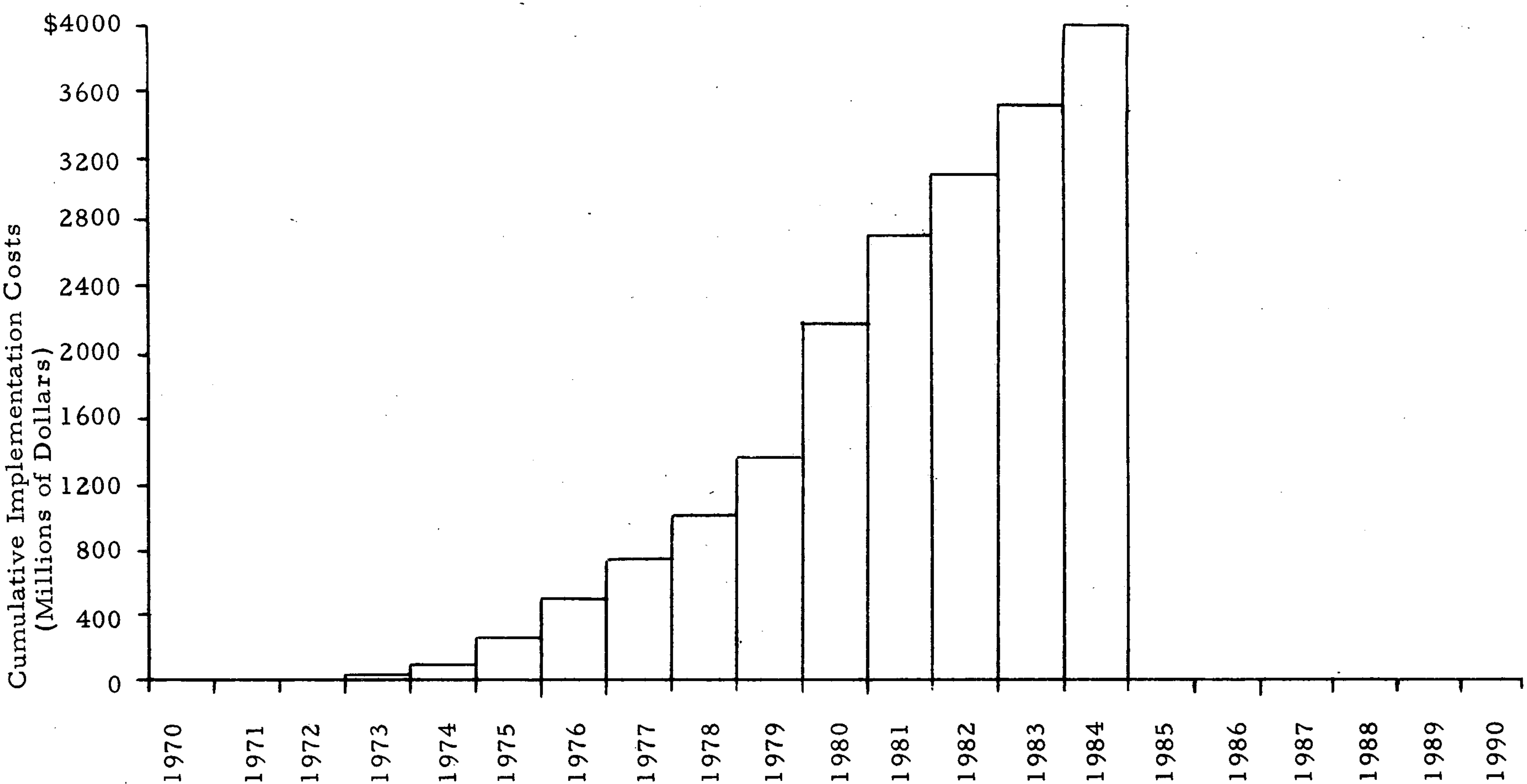

Figure F-7. Cumulative Time Phased Summary of Implementation Costs (1980 STOL System - 150 Passenger Aircraft)

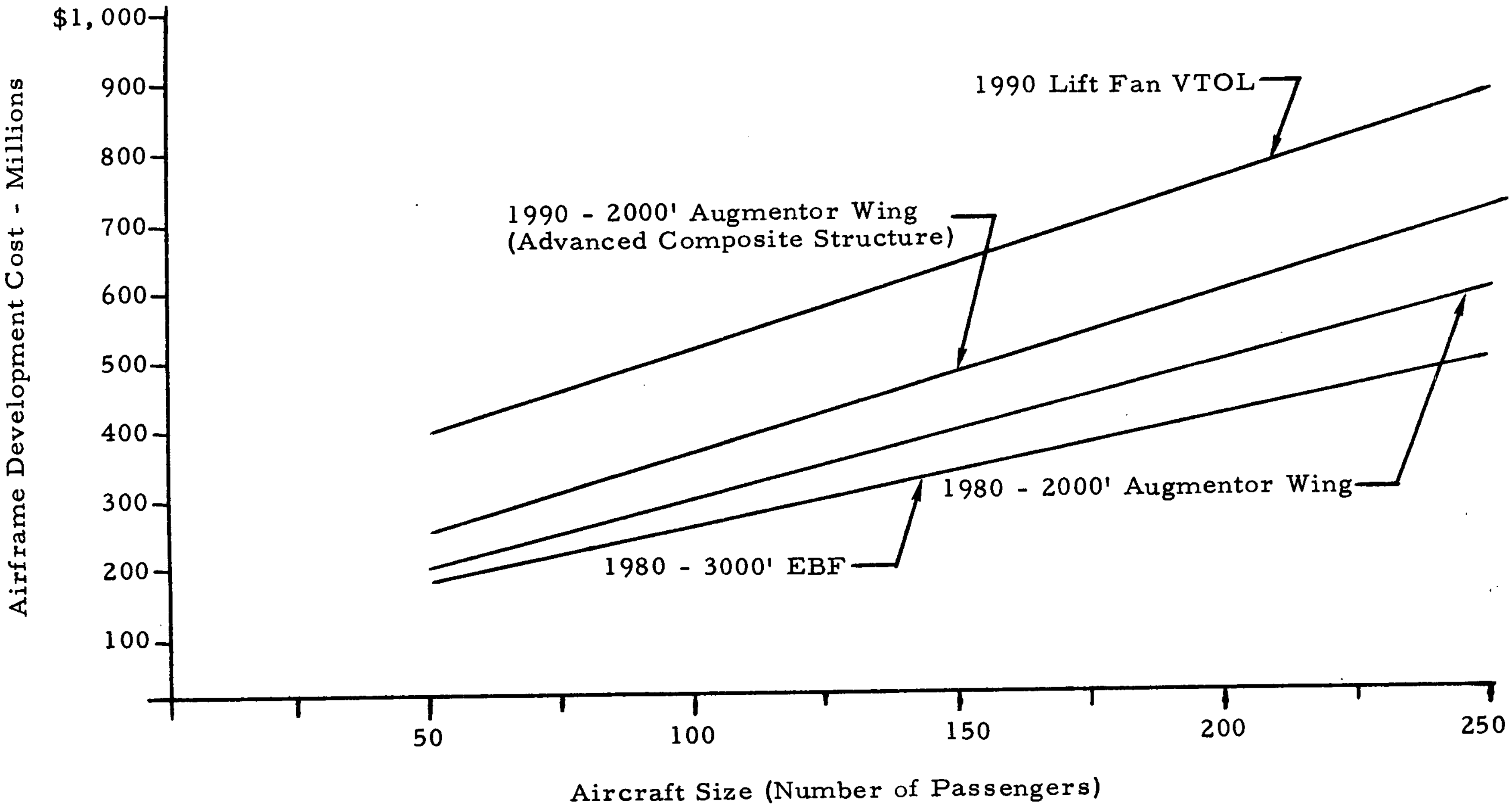

Figure F-8. Airframe Development Cost

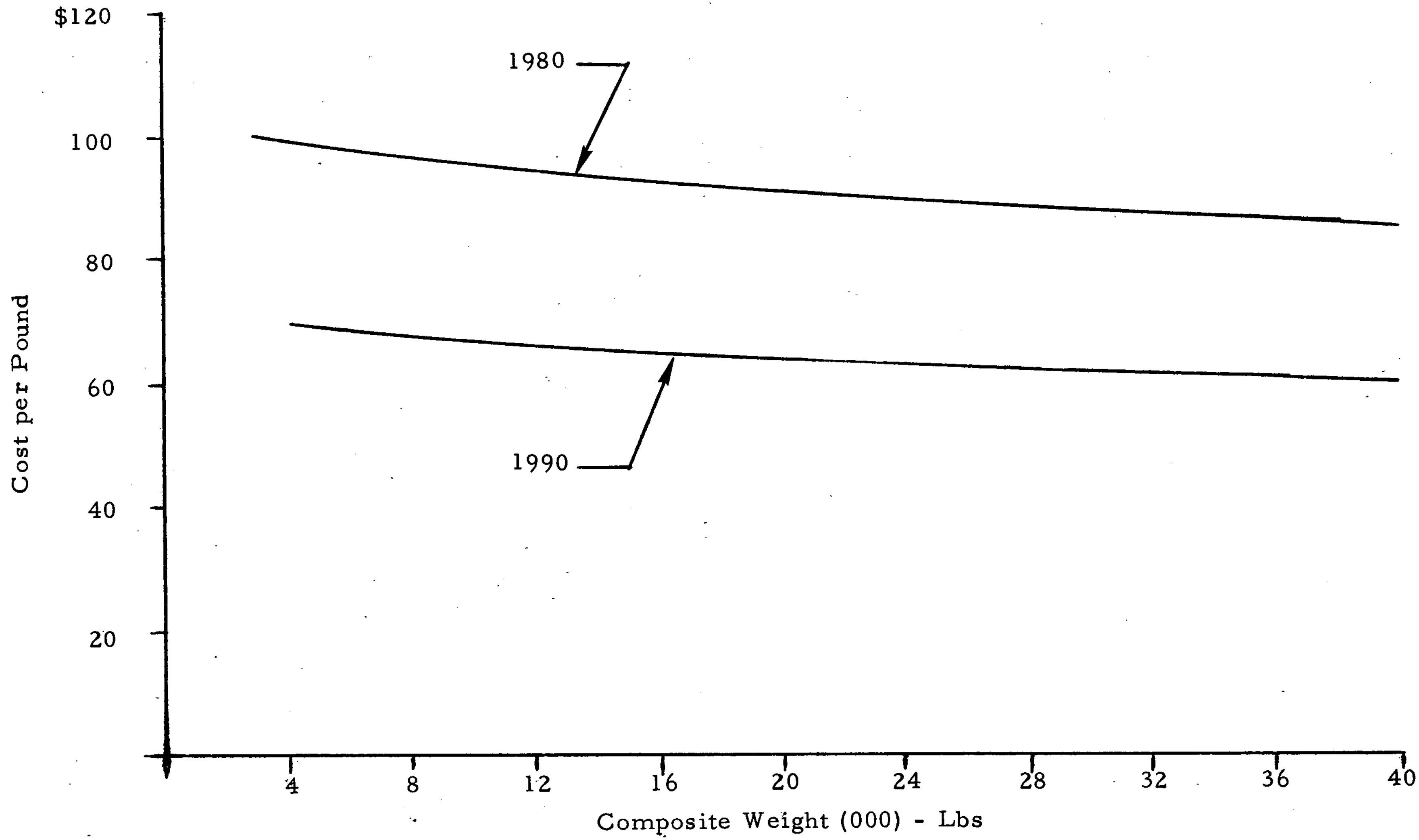

Figure F-9. Composite Structures, Cost Estimating Relationships

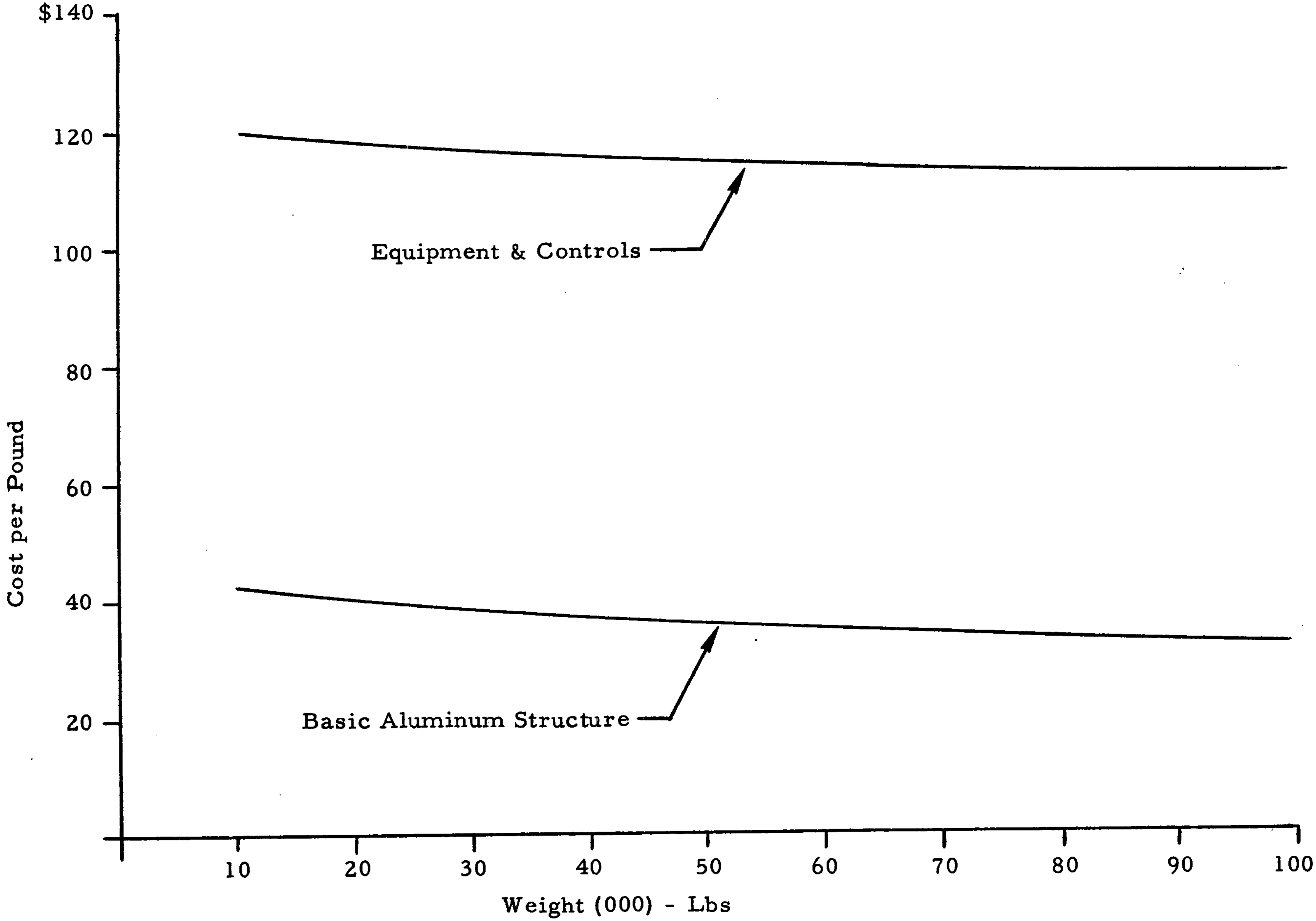

Figure F-10. Airframe Cost Estimating Relationships

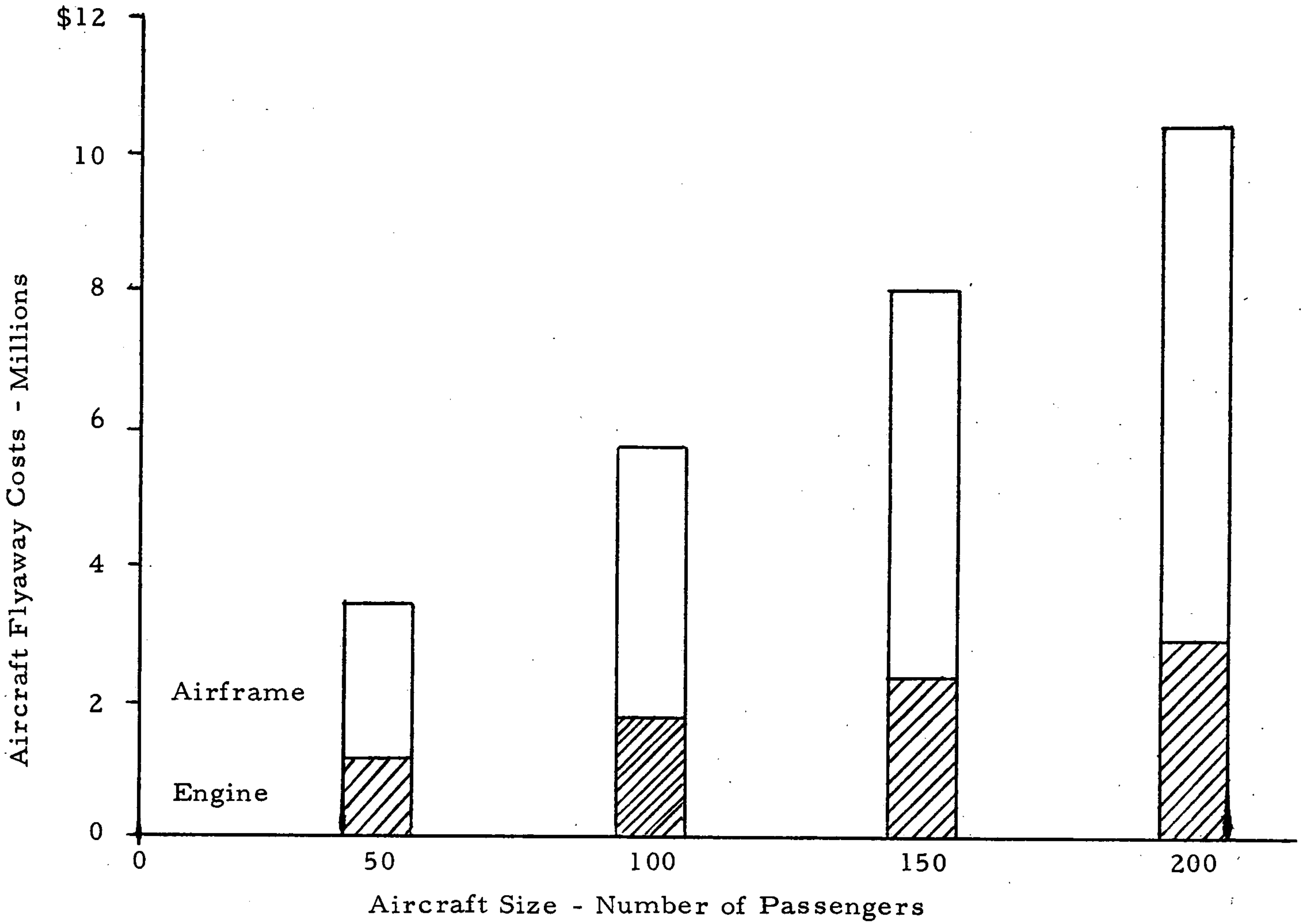

Figure F-11. 1980 STOL System Aircraft Flyaway Costs

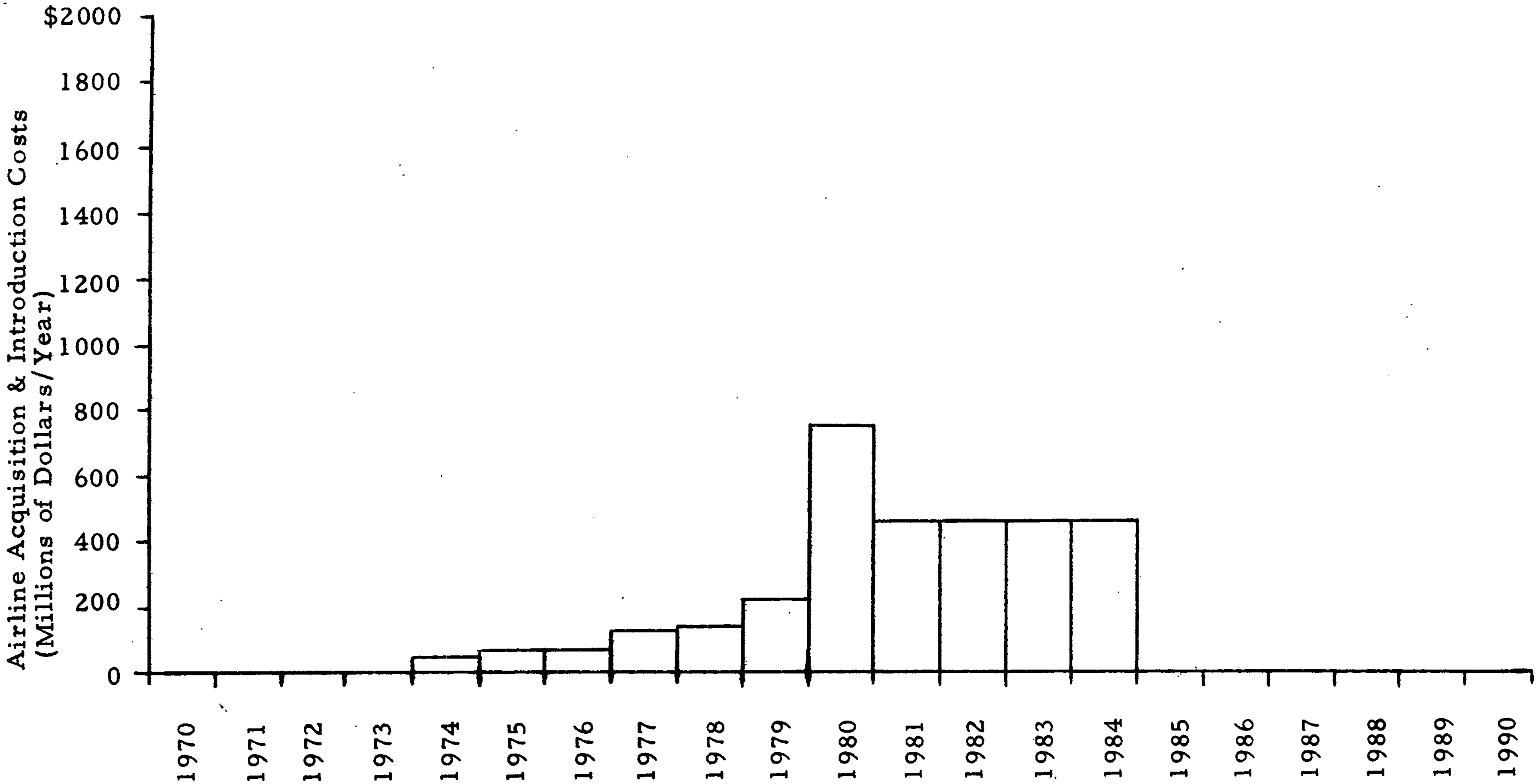

Figure F-12. Implementation Costs by Year for 1980 STOL System - Airline Acquisition & Introduction

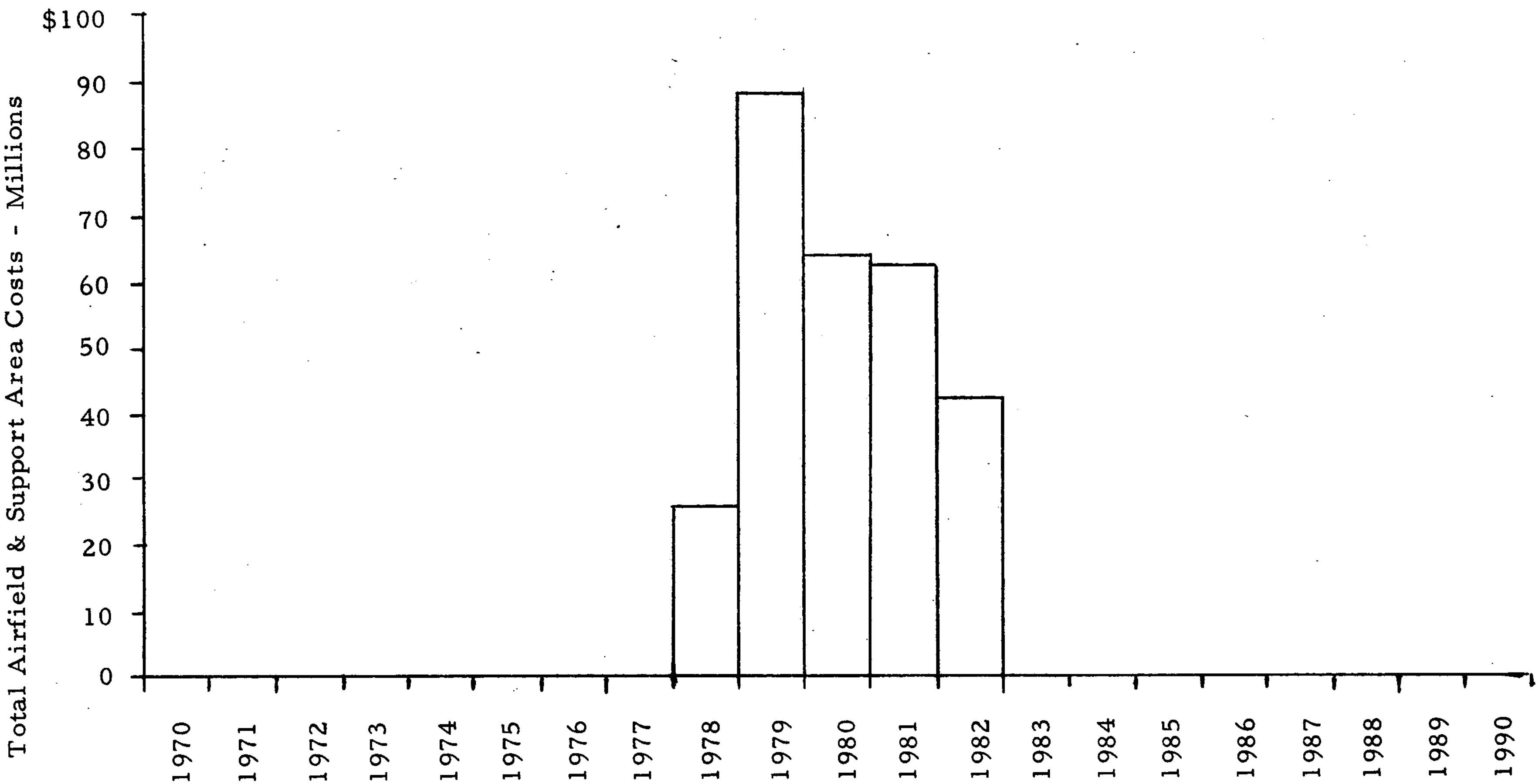

Figure F-13. 1980 STOL System Time Phased STOLport Development Costs
Airfield & Support Area

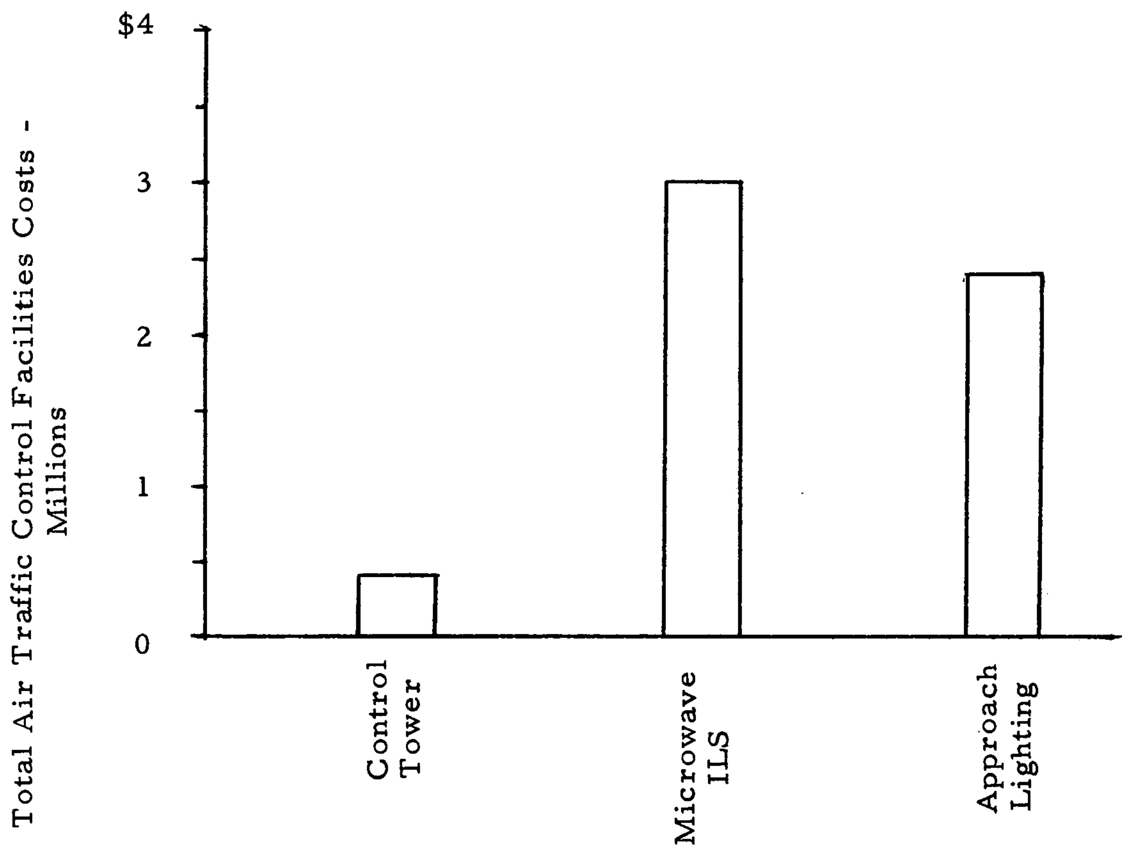

Figure F-14. 1980 STOL System
Air Traffic Control Facilities Cost

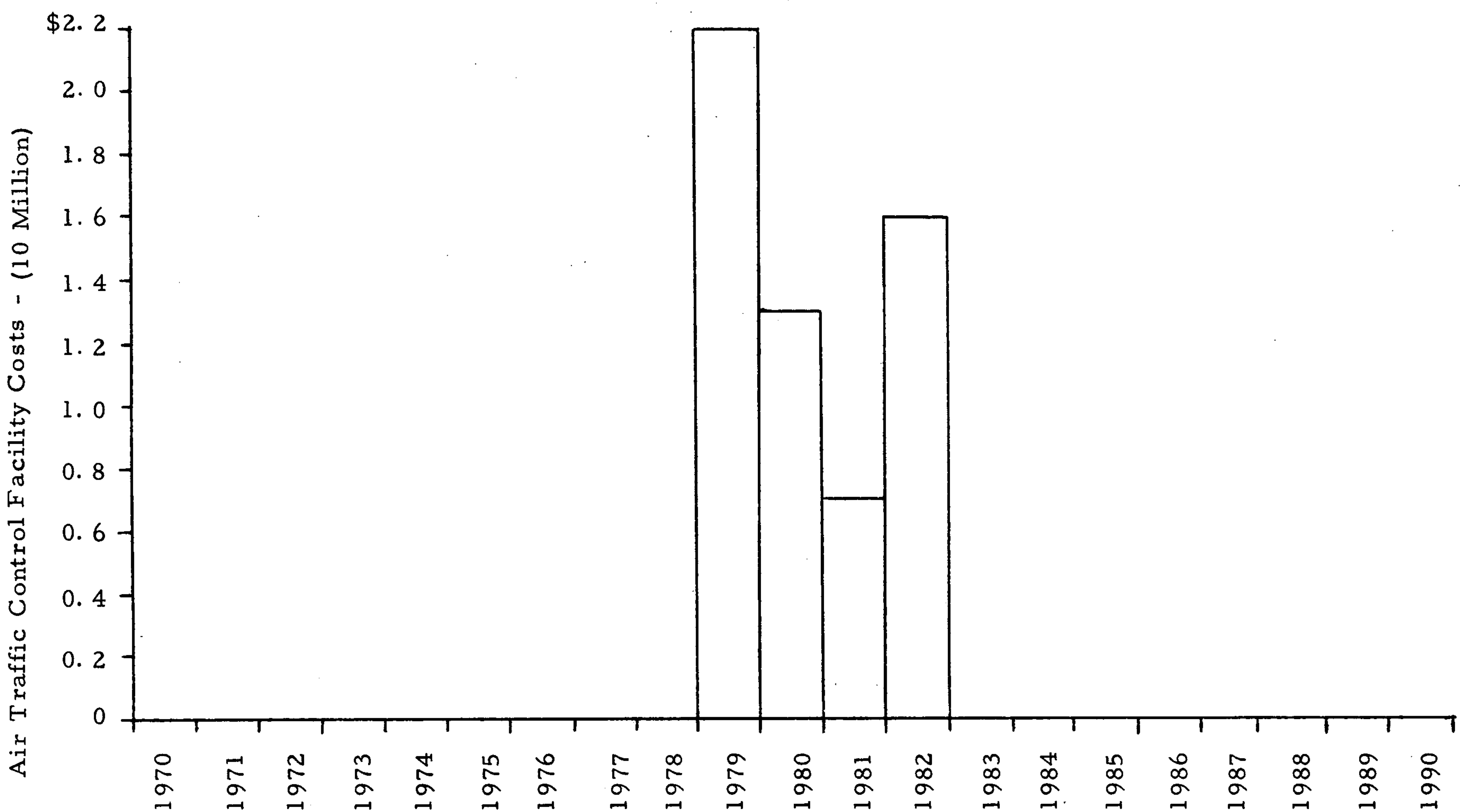

Figure F-15. 1980 STOL System
Time Phased Air Traffic Control Facilities Cost

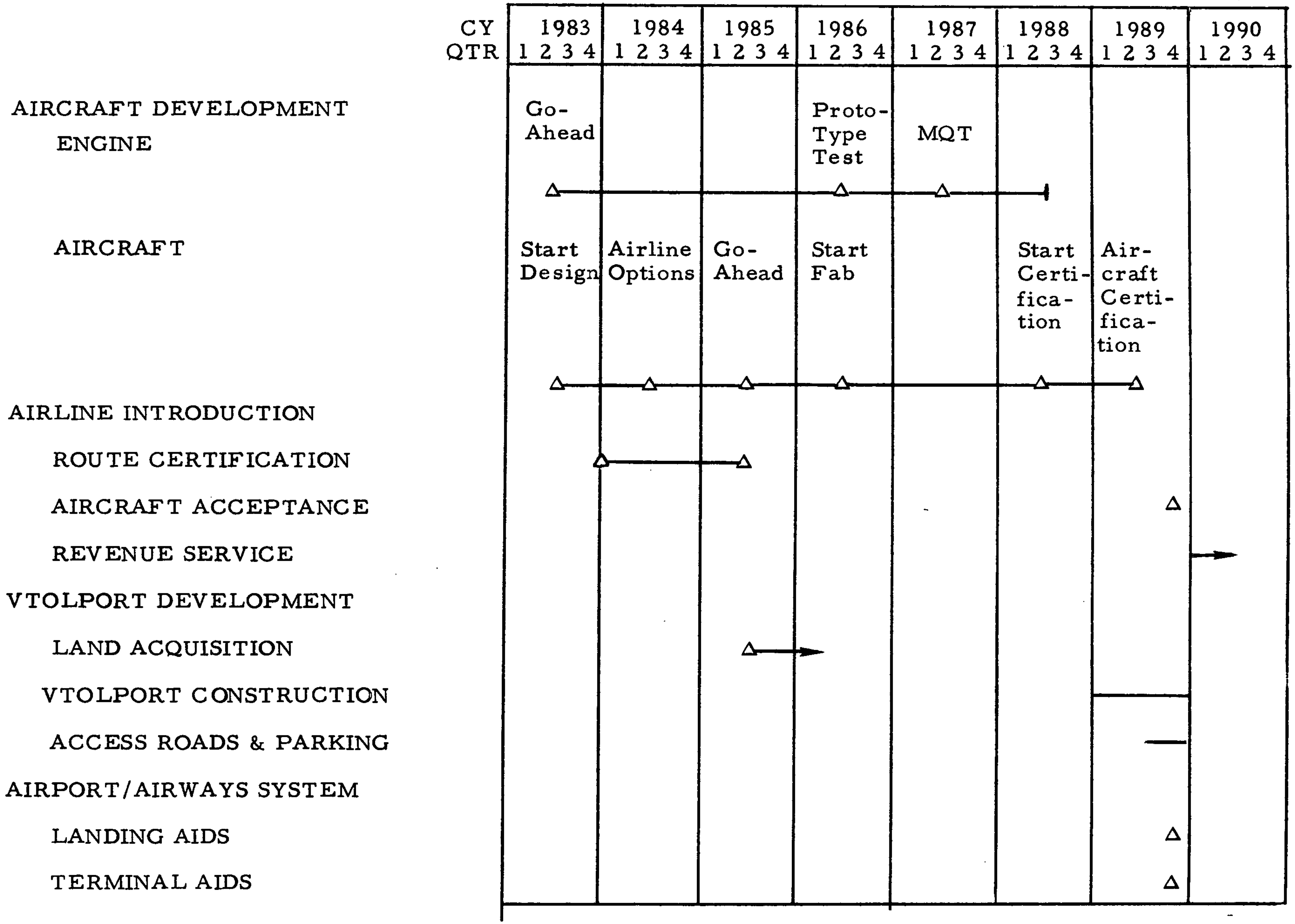

Figure F-16. 1990 VTOL Implementation Schedule

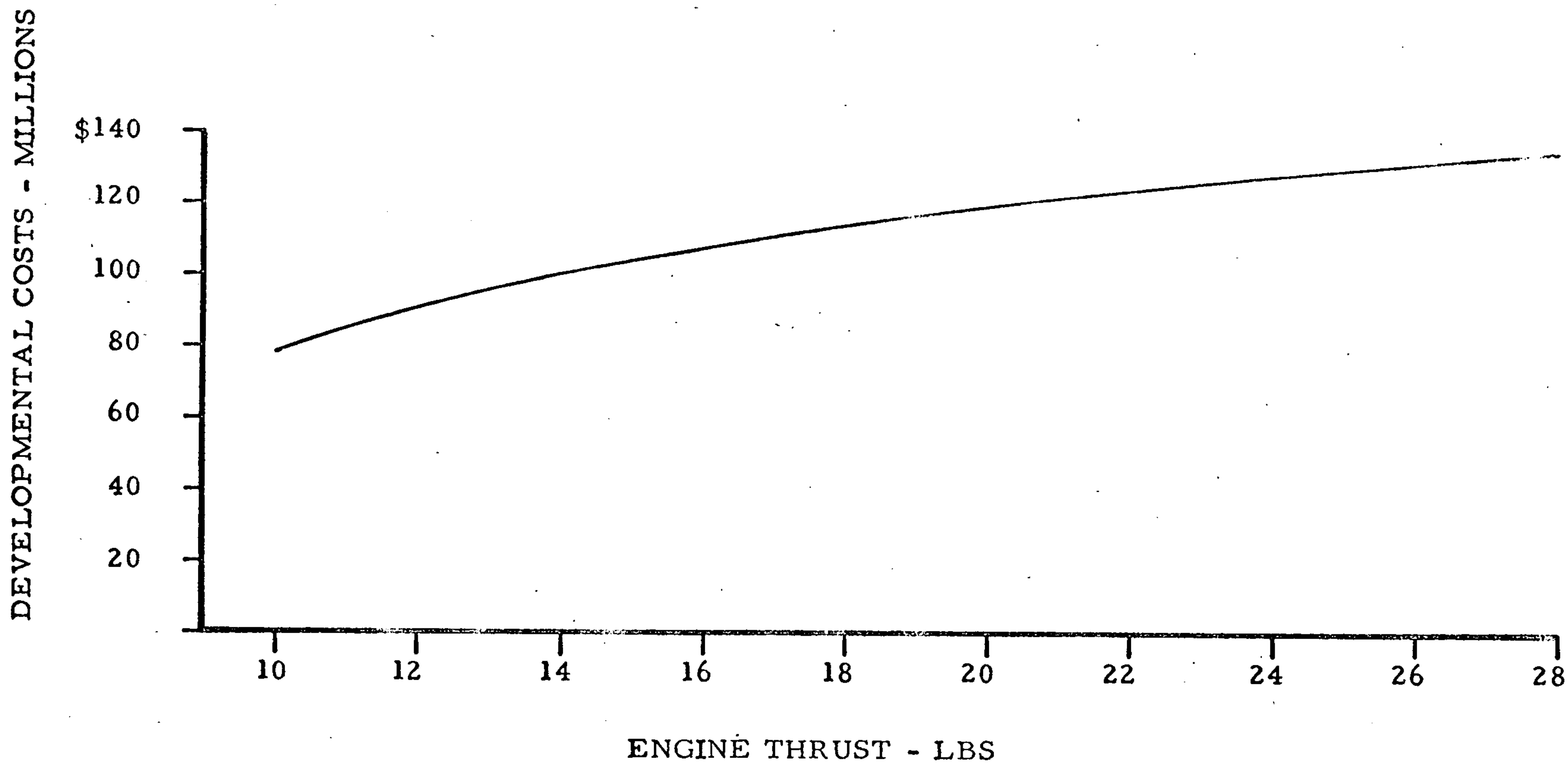

Figure F-17. 1990 VTOL Aircraft
Lift Turbofan Engines Developmental Costs

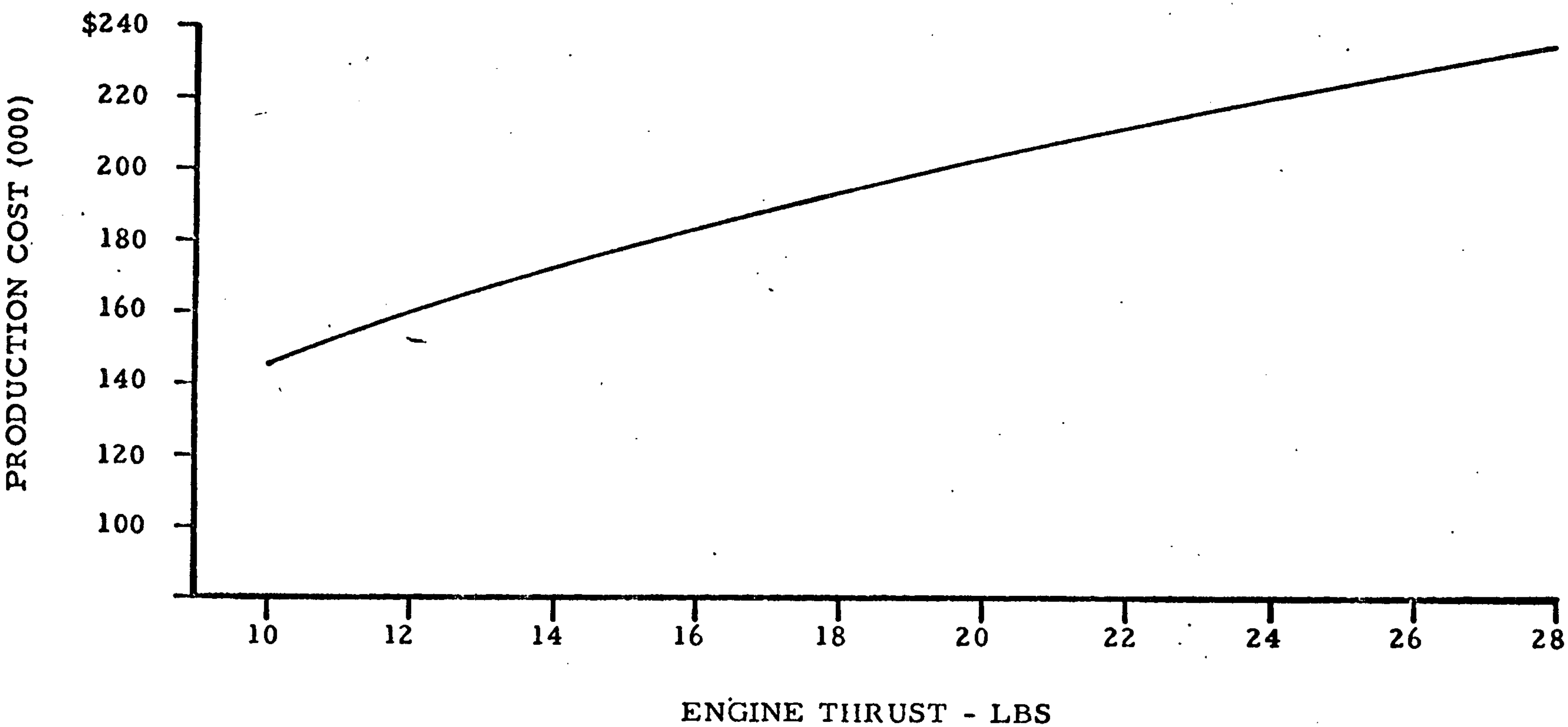

Figure F-18. 1990 VTOL Aircraft, Lift Turbofan Engines Production Cost

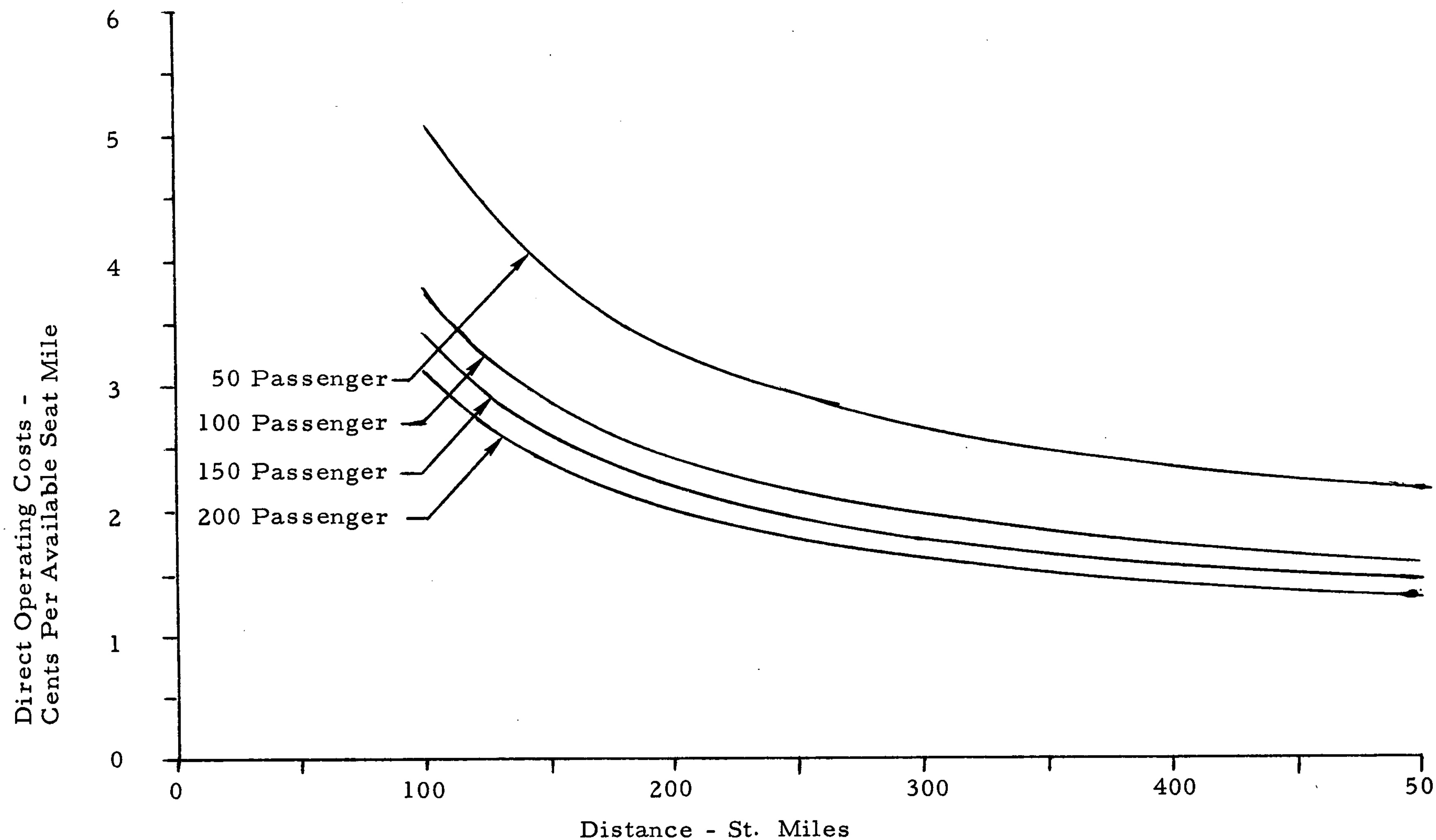

Figure F-19. 1980 STOL System - EBF 3000 Ft.
Direct Operating Costs

Table F-1. STOL and VTOL Port Development Costs by Region
Cost in Thousands (000)

Region	1980 STOL System	1990 VTOL System	Total 1980 & 1990 System
Northeast	$ 79,301	$282,950	$362,251
Pacific Southwest	67,492	113,350	180,842
North Central	60,256	154,700	214,956
South Central	16,354	12,850	29,204
Hawaiian	24,326	24,900	49,226
Southeast	20,180	12,850	33,030
Pacific Northwest	7,460		7,460
Rocky Mountain	6,851		6,851
Total STOL & VTOLport Development	$282,220	$601,600	$883,820

Table F-2. Summary of Implementation Costs - 1980 STOL System 150-Passenger Aircraft (Cost in Millions)

Aircraft Development	$ 603
Airline Acquisition & Introduction	
Aircraft	
Flyaway Cost	$2,623
Spares	342
	$2,965
GSE	163
Introduction Cost	114
	$3,242
STOLport Development	
Airfield Area	$ 27
Support Facilities	255
	$ 282
Air Traffic Control	$ 6
Total Implementation Cost	
Including Development	$4,133
Excluding Development	$3,530

Table F-3. Engine Technology Assessment & Costs

	1980 STOL		1990 STOL	1990 VTOL
	100 Passenger	150 Passenger	150 Passenger	100 Passenger
				Cruise Engine
Performance				
Weight (lbs)	1,990	2,800	2,037	1,067
Thrust (lbs)	11,850	16,600	14,363	10,170
Temperature (°R)	2,860	2,860	2,860	2,900
Max Q x Pressure Ratio	13,043	13,043	16,508	16,508
SFC (lbs/hr)	.303	.303	.452	.330
Engine T/W	5.95	5.93	7.04	9.53
Technology Assessment				
Technology Required	Jul 1977	Jul 1977	Jul 1987	Jul 1987
Technology Available	Jan 1973	Jan 1975	Jan 1975	Oct 1977
Engine Cost				
Development Cost (MQT)-Millions	$ 100	$ 117	$ 109	$ 93
Production Unit Cost (000)	410	534	494	431
Flyaway Cost (000)	445	591	588	519
Production Quantity	2,440	1,630	1,155	1,060

Table F-4. NASA Funded STOL Developments
(In Millions of Dollars)

Calendar Year	72	73	74	75	76	77	Total
System Studies	2.0	2.0	2.0	2.0	2.0	2.0	12.0
Quiet Engine Development	1.2	2.0	6.0	18.0	30.0	4.0	61.2
QUESTOL Aircraft	15.0	28.0	42.0	18.0	6.0	2.0	111.0
C-8 Buffalo AW Aircraft	2.2	1.5					3.7
Total Yearly Cost	20.4	33.5	52.0	38.0	38.0	8.0	189.9
Cumulative Cost	20.4	53.9	105.9	143.9	181.9	189.9	

Table F-5. Airline Investment Cost Factors Per Aircraft

Aircraft

5%	Purchase Contract
25%	Progress Payments
70%	Delivery (Financed)

Spares

Engine	30%
Airframe	6%

	Aircraft Size		
	50 - 100	101 - 150	151 - 200
GSE (000)	$400	$500	$600
Introduction Costs (000)			
Training			
Flight Crew	$120	$150	$180
Maintenance & Other Ground Support	30	40	50
Simulator & Other Training Aids	110	140	170
	$260	$330	$440
Other			
Advertising, Facilities, Administrative, Legal	$ 10	$ 20	$ 30
Total Introduction Cost	$270	$350	$430

Table F-6. STOLport Improvement Costs (000)
Airfield & Support Facilities 1980-1984

State	Minimum Demand			Maximum Demand		
	Airfield	Support Facilities	Total	Airfield	Support Facilities	Total
Arizona	$ 332	$ 3,081	$ 3,413	$ 382	$ 3,741	$ 4,123
California	6,011	52,381	58,392	6,160	59,632	65,792
Colorado	1,273	4,231	5,504	1,273	4,617	5,890
Connecticut	166	1,644	1,810	216	2,938	3,154
District of Columbia	315	5,725	6,040	365	7,746	8,111
Florida	498	8,769	9,267	648	11,158	11,806
Georgia	216	2,313	2,529	516	3,131	3,347
Hawaii	880	23,446	24,326	880	23,446	24,326
Illinois	1,638	24,305	25,943	1,787	25,775	27,562
Indiana	166	1,545	1,711	216	2,601	2,817
Iowa	166	826	992	166	1,069	1,235
Kansas	216	5,565	5,781	216	6,168	6,384
Kentucky	166	929	1,095	166	1,293	1,459
Louisiana	498	2,111	2,609	548	2,772	3,320
Maryland	216	3,525	3,741	315	4,635	4,950
Massachusetts	1,638	10,099	11,737	1,688	11,842	13,530
Michigan	1,422	5,755	7,177	1,472	6,789	8,261
Minnesota	216	2,677	2,893	216	3,531	3,747
Missouri	1,273	2,780	4,053	1,323	3,868	5,191
Nebraska	166	930	1,096	166	1,105	1,271
Nevada	382	5,305	5,687	531	8,343	8,874
New Jersey	2,745	22,895	25,640	2,894	25,691	28,585
New York	2,352	14,361	16,713	2,551	19,332	21,883

Table F-6. STOLport Improvement Costs (000)
Airfield & Support Facilities 1980-1984 (Continued)

State	Minimum Demand			Maximum Demand		
	Airfield	Support Facilities	Total	Airfield	Support Facilities	Total
North Carolina	$ 332	$ 2,169	$ 2,501	$ 332	$ 2,502	$ 2,834
Ohio	1,035	8,030	9,065	1,085	10,081	11,166
Oklahoma	166	916	1,082	166	1,302	1,468
Oregon	166	1,127	1,293	166	1,689	1,855
Pennsylvania	630	9,052	9,682	680	12,678	13,358
Rhode Island	166	1,271	1,437	166	2,066	2,232
Tennessee	166	1,509	1,675	166	1,940	2,106
Texas	764	11,899	12,663	863	15,740	16,603
Utah	166	1,181	1,347	166	1,567	1,733
Virginia	332	5,282	5,614	332	6,072	6,404
Washington	332	5,835	6,167	382	7,115	7,497
Wisconsin	166	1,379	1,545	166	1,819	1,985
	$27,372	$254,848	$282,220	$29,065	$305,794	$334,859

Figure F-7. Time Phased STOLport Development Costs (000)
Airfield and Support Facilities

Hub City	STOLport	1978	1979	1980	1981	1982	Total
<u>Arizona</u>							
Phoenix	Skyharbor	$	$	$ 600	$ 1,556	$	$ 2,156
Tucson	Tucson International				327	930	1,257
				$ 600	$ 1,883	$ 930	$ 3,413
<u>California</u>							
Fresno					$ 388	$ 1,071	$ 1,459
Los Angeles	Hawthorne		$ 800	$ 3,186			3,986
	Hollywood-Burbank		800	2,079			2,879
	Long Beach		800	2,079			2,879
	Ontario		5,330	12,649			17,979
	Orange County		800	2,079			2,879
Monterey	Monterey Peninsula				320	915	1,235
Sacramento	Sacramento Executive			992	2,530		3,522
San Diego	Lindberg Field			1,174	2,955		4,129
San Francisco	Oakland International			1,292	3,330		4,622
	San Francisco Int'l.		850	3,307			4,157
	San Jose		2,173	6,493			8,666
			$11,553	$35,330	$ 9,523	$ 1,986	$ 58,392
<u>Colorado</u>							
Denver	Stapleton				$ 1,269	$ 4,235	$ 5,504

Table F-7. Time Phased STOLport Development Costs (000)
Airfield and Support Facilities (Continued)

Hub City	STOLport	1978	1979	1980	1981	1982	Total
Connecticut							
Hartford	Bradley Field				$ 493	$ 1,317	$ 1,810
D. C.							
Washington	Washington Nat'l	$ 1,718	$ 4,322				$ 6,040
Florida							
Jacksonville	Jacksonville Int'l				$ 526	$ 1,392	$ 1,918
Miami	Opa-Locka				580	1,518	2,098
Tampa	Tampa Int'l.				1,526	3,725	5,251
					$ 2,632	$ 6,635	$ 9,267
Georgia							
Atlanta	Fulton County				$ 694	$ 1,835	$ 2,529
Hawaii							
Honolulu	Honolulu			$ 5,617	$13,323		$ 18,940
	Lihue			406	1,112		1,518
	Hilo			389	1,073		1,462
	Maui			374	1,040		1,414
	Kailua, Kona				248	744	992
				$ 6,786	$16,796	$ 744	$ 24,326

Table F-7. Time Phased STOLport Development Costs (000)
Airfield and Support Facilities (Continued)

Hub City	STOLport	1978	1979	1980	1981	1982	Total
Illinois							
Chicago	Midway	$ 6,132	$14,622				$ 20,754
	Meigs Field	1,160	4,029				5,189
		$ 7,292	$18,651				$ 25,943
Indiana							
Indianapolis	Weir Cook		$ 464	$ 1,247			$ 1,711
Iowa							
Des Moines	Des Moines				$ 248	$ 744	$ 992
Kansas							
Kansas City	K. C. Municipal		$ 1,670	$ 4,111			$ 5,781
Kentucky							
Louisville	Standiford Field			$ 279	$ 816		$ 1,095
Louisiana							
New Orleans	New Orleans Lakefront			$ 633	$ 1,976		$ 2,609
Maryland							
Baltimore	Friendship			$ 1,058	$ 2,683		$ 3,741

Table F-7. Time Phased STOLport Development Costs (000)
Airfield and Support Facilities (Continued)

Hub City	STOLport	1978	1979	1980	1981	1982	Total
Massachusetts							
Boston	Logan	$ 2,395	$ 7,011				$ 9,406
	Hanscom Field	635	1,696				2,331
		$ 3,030	$ 8,707				$ 11,737
Michigan							
Detroit	Detroit City	$ 1,727	$ 5,450				$ 7,177
Minnesota							
Minneapolis	Minn-St. Paul	$ 803	$ 2,090				$ 2,893
Missouri							
St. Louis	Weiss	$ 834	$ 3,219				$ 4,053
Nebraska							
Omaha	Omaha			$ 279	$ 817		$ 1,096
Nevada							
Las Vegas	McCarren			$ 1,136	$ 2,867		$ 4,003
Reno	Reno Int'l.				455	1,229	1,684
				$ 1,136	$ 3,322	$ 1,229	$ 5,687
North Carolina							
Greensboro	Greensboro				$ 308	$ 886	$ 1,194
Raleigh	Raleigh-Durham				342	965	1,307
					$ 650	$ 1,851	$ 2,501

Table F-7. Time Phased STOLport Development Costs (000)
Airfield and Support Facilities (Continued)

Hub City	STOLport	1978	1979	1980	1981	1982	Total
New Jersey							
Newark	Newark	$ 935	$ 3,505				$ 4,440
Teterboro	Teterboro	5,933	15,267				21,200
		$ 6,868	$18,772				$25,640
New York							
Albany	Albany				$ 282	$ 823	$ 1,105
Buffalo	Buffalo		$ 756	$ 1,980			$ 2,736
New York	Republic Aviation	$ 1,403	4,697				6,100
	Westchester County	935	2,398				3,333
Rochester	Rochester-Monroe		494	1,320			1,814
Syracuse	C. E. Hancock			438	1,187		1,625
		$ 2,338	$ 8,345	$ 3,738	$ 1,469	$ 823	$16,713
Ohio							
Cincinnati	Lunken Field		$ 314	$ 898			$ 1,212
Cleveland	Burke Lakefront		1,296	3,562			4,858
Columbus	Columbus			551	1,452		2,003
Dayton	Dayton			248	744		992
			$ 1,610	$ 5,259	$ 2,196		$ 9,065
Oklahoma							
Oklahoma City	Oklahoma City				$ 275	$ 807	$ 1,082
Oregon							
Portland	Portland Int'l				$ 338	$ 955	$ 1,293

Table F-7. Time Phased STOLport Development Costs (000) Airfield and Support Facilities (Continued)

Hub City	STOLport	1978	1979	1980	1981	1982	Total
Pennsylvania							
Philadelphia	North Philadelphia				$ 1,380	$ 3,535	$ 4,915
Pittsburgh	Allegheny County	$ 1,336	$ 3,431				4,767
		$ 1,336	$ 3,431		$ 1,380	$ 3,535	$ 9,682
Rhode Island							
Providence	T. F. Green				$ 381	$ 1,056	$ 1,437
Tennessee							
Memphis	Memphis				$ 453	$ 1,222	$ 1,675
Texas							
Austin	R. E. Mueller				$ 278	$ 813	$ 1,091
Dallas	Love Field			$ 2,168	5,276		7,444
Houston	Hobby			778	2,030		2,808
San Antonio	San Antonio				346	974	1,320
				$ 2,946	$ 7,930	$ 1,787	$12,663
Utah							
Salt Lake City	Salt Lake City				$ 354	$ 993	$ 1,347
Virginia							
Norfolk	Norfolk				$ 1,329	$ 3,266	$ 4,595
Richmond	R. E. Byrd				256	763	1,019
					$ 1,585	$ 4,029	$ 5,614

Table F-7. Time Phased STOLport Development Costs (000)
Airfield and Support Facilities (Continued)

Hub City	STOLport	1978	1979	1980	1981	1982	Total
Washington							
Seattle	Boeing Field				$ 1,432	$ 3,509	$ 4,941
Spokane	Spokane Int'l				318	908	1,226
					$ 1,750	$ 4,417	$ 6,167
Wisconsin							
Milwaukee	Mitchell Field				$ 414	$ 1,131	$ 1,545
Total Airfield & Support Area		$25,946	$88,284	$63,402	$62,327	$42,261	$282,220

Table F-8. STOLport Improvement Costs (000)
Airfield Area
Minimum Demand 1980 Initial Service

Hub City	STOLport	Runway	Taxiway	Taxiway Access	Apron	Total Airfield
Arizona						
Phoenix	Skyharbor				$ 166	$ 166
Tucson	Tucson International				166	166
					$ 332	$ 332
California						
Fresno	Fresno				$ 166	$ 166
Los Angeles	Hawthorne	$ 855	$ 218	$ 34	216	1,323
	Hollywood-Burbank				216	216
	Long Beach				216	216
	Ontario				216	216
	Orange County				216	216
Monterey	Monterey Peninsula				166	166
Sacramento	Sacramento Executive				216	216
San Diego	Lindberg Field				216	216
San Francisco	Oakland International				315	315
	San Francisco International	855	218	34	216	1,323
	San Jose	855	218	34	315	1,422
		$2,565	$ 654	$102	$2,690	$6,011
Colorado						
Denver	Stapleton	$ 855	$ 218	$ 34	$ 166	$1,273

Table F-8. STOLport Improvement Costs (000)
Airfield Area
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Runway	Taxiway	Taxiway Access	Apron	Total Airfield
Connecticut						
Hartford	Bradley Field				$ 166	$ 166
D. C.						
Washington	Washington National				$ 315	$ 315
Florida						
Jacksonville	Jacksonville International				$ 166	$ 166
Miami	OPA-Locke				166	166
Tampa	Tampa International				166	166
					$ 498	$ 498
Georgia						
Atlanta	Fulton County				$ 216	$ 216
Hawaii						
	Honolulu				$ 216	$ 216
	Lihue, Kauai				166	166
	Hilo				166	166
	Maui				166	166
	Kailua, Kona				166	166
					$ 880	$ 880
Illinois						
Chicago	Midway				$ 315	$ 315
	Meigs Field	$ 855	$ 218	$ 34	216	1,323
		$ 855	$ 218	$ 34	$ 531	$1,638
Indiana						
Indianapolis	Weir Cook				$ 166	$ 166

Table F-8. STOLport Improvement Costs (000)
Airfield Area
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Runway	Taxiway	Taxiway Access	Apron	Total Airfield
Iowa						
Des Moines	Des Moines				$ 166	$ 166
Kansas						
Kansas City	Kansas City Municipal				$ 216	$ 216
Kentucky						
Louisville	Standiford Field				$ 166	$ 166
Louisiana						
New Orleans	New Orleans Lakefront	$ 257	$ 65	$ 10	$ 166	$ 498
Maryland						
Baltimore	Friendship				$ 216	$ 216
Massachusetts						
Boston	Logan	$ 855	$ 218	$ 34	$ 315	$1,422
	Hanscom Field				216	216
		$ 855	$ 218	$ 34	$ 531	$1,638
Michigan						
Detroit	Detroit City	$ 855	$ 218	$ 34	$ 315	$1,422
Minnesota						
Minneapolis	Minneapolis-St. Paul				$ 216	$ 216
Missouri						
St. Louis	Weiss	$ 855	$ 218	$ 34	$ 166	$1,273

Table F-8. STOLport Improvement Costs (000)
Airfield Area
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Runway	Taxiway	Taxiway Access	Apron	Total Airfield
Nebraska						
Omaha	Omaha				$ 166	$ 166
Nevada						
Las Vegas	McCarren				$ 216	$ 216
Reno	Reno International				166	166
					$ 382	$ 382
North Carolina						
Greensboro	Greensboro				$ 166	$ 166
Raleigh	Raleigh-Durham				166	166
					$ 332	$ 332
New Jersey						
Newark	Newark	$ 855	$ 218	$ 34	$ 216	$1,323
Teterboro	Teterboro	855	218	34	315	1,422
		$1,710	$ 436	$ 68	$ 531	$2,745
New York						
Albany	Albany				$ 166	$ 166
Buffalo	Buffalo				216	216
New York	La Guardia	$ 855	$ 218	$ 34	315	1,422
	Westchester County				216	216
Rochester	Rochester-Monroe				166	166
Syracuse	C. E. Hancock				166	166
		$ 835	$ 218	$ 34	$1,245	$2,352

Table F-8. STOLport Improvement Costs (000)
Airfield Area
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Runway	Taxiway	Taxiway Access	Apron	Total Airfield
Ohio						
Cincinnati	Lunken Field				$ 166	$ 166
Cleveland	Burke Lakefront	$ 171	$ 44	$ 7	315	537
Columbus	Columbus				166	166
Dayton	Dayton				166	166
		$ 171	$ 44	$ 7	$ 813	$1,035
Oklahoma						
Oklahoma City	Oklahoma City				$ 166	$ 166
Oregon						
Portland	Portland International				$ 166	$ 166
Pennsylvania						
Philadelphia	North Philadelphia				$ 315	$ 315
Pittsburgh	Allegheny County				315	315
					$ 630	$ 630
Rhode Island						
Providence	T. F. Green				$ 166	$ 166
Tennessee						
Memphis	Memphis				$ 166	$ 166
Texas						
Austin	R. E. Muellen				$ 166	$ 166
Dallas	Love Field				216	216
Houston	Hobby				216	216
San Antonio	San Antonio				166	166
					$ 764	$ 764

Table F-8. STOLport Improvement Costs (000)
Airfield Area
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Runway	Taxiway	Taxiway Access	Apron	Total Airfield
Utah						
Salt Lake City	Salt Lake City				$ 166	$ 166
Virginia						
Norfolk	Norfolk				$ 166	$ 166
Richmond	R. E. Byan				166	166
					$ 332	$ 332
Washington						
Seattle	Boeing Field				$ 166	$ 166
Spokane	Spokane International				166	166
					$ 332	$ 332
Wisconsin						
Milwaukee	Mitchell Field				$ 166	$ 166
TOTAL AIRFIELD AREA		$9,833	$2,507	$391	$14,641	$27,372

Table F-9. STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
Arizona					
Phoenix	Skyharbor	$ 1,776	$ 214		$ 1,990
Tucson	Tucson Int'l	976	115		1,091
		$ 2,752	$ 329		$ 3,081
California					
Fresno	Fresno	$ 1,156	$ 137		$ 1,293
Los Angeles	Hawthorne	2,372	291		2,663
	Hollywood-Burbank	2,372	291		2,663
	Long Beach	2,372	291		2,663
	Ontario	2,372	291	$15,100	17,763
	Orange County	2,372	291		2,663
Monterey	Monterey Peninsula	956	113		1,069
Sacramento	Sacramento Executive	2,948	358		3,306
San Diego	Lindberg Field	3,488	425		3,913
San Francisco	Oakland Int'l	3,836	471		4,307
	San Francisco Int'l	2,524	310		2,834
	San Jose	3,736	458	3,050	7,244
		$30,504	$3,727	$18,150	$52,381
Colorado					
Denver	Stapleton	$ 1,056	$ 125	$ 3,050	$ 4,231
Connecticut					
Hartford	Bradley Field	$ 1,468	$ 176		$ 1,644
D. C.					
Washington	Washington Nat'l	$ 5,100	$ 625		$ 5,725

Table F-9. STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
Florida					
Jacksonville	Jacksonville Int'l	$ 1,564	$ 188		$ 1,752
Miami	Opa-Locke	1,724	208		1,932
Tampa	Tampa Int'l	1,816	219	$ 3,050	5,085
		$ 5,104	$ 615	$ 3,050	$ 8,769
Georgia					
Atlanta	Fulton County	$ 2,064	$ 249		$ 2,313
Hawaii					
	Honolulu	$ 3,280	$ 344	$15,100	$ 18,724
	Lihue, Kauai	1,200	152		1,352
	Hilo	1,160	136		1,296
	Maui	1,120	128		1,248
	Kailua, Kona	740	86		826
		$ 7,500	$ 846	$15,100	$ 23,446
Illinois					
Chicago	Midway	$ 4,756	$ 583	$15,100	$ 20,439
	Meigs Field	3,444	422		3,866
		$ 8,200	$ 1,005	$15,100	$ 24,305
Indiana					
Indianapolis	Weir Cook	$ 1,380	$ 165		$ 1,545

Table F-9 . STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
Iowa					
Des Moines	Des Moines	$ 740	$ 86	$	$ 826
Kansas					
Kansas City	Kansas City Muni.	$ 2,244	$ 271	$ 3,050	$ 5,565
Kentucky					
Louisville	Standiford Field	$ 832	$ 97		$ 929
Louisiana					
New Orleans	New Orleans Lakefront	$ 1,884	$ 227		$ 2,111
Maryland					
Baltimore	Friendship	$ 3,144	$ 381		$ 3,525
Massachusetts					
Boston	Logan	$ 4,396	$ 538	$ 3,050	$ 7,984
	Hanscom Field	1,884	231		2,115
		$ 6,280	$ 769	$ 3,050	$10,099
Michigan					
Detroit	Detroit City	$ 5,128	$ 627		$ 5,755

Table F-9. STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
Minnesota					
Minneapolis	Minneapolis-St. Paul	$ 2,388	$ 289		$ 2,677
Missouri					
St. Louis	Weiss	$ 2,480	$ 300		$ 2,780
Nebraska					
Omaha	Omaha	$ 832	$ 98		$ 930
Nevada					
Las Vegas	McCarren	$ 3,376	$ 411		$ 3,787
Reno	Reno Int'l	1,356	162		1,518
		$ 4,732	$ 573		$ 5,305
North Carolina					
Greensboro	Greensboro	$ 920	$ 108		$ 1,028
Raleigh	Raleigh-Durham	1,020	121		1,141
		$ 1,940	$ 229		$ 2,169
New Jersey					
Newark	Newark	$ 2,776	$ 341		$ 3,117
Teterboro	Teterboro	4,166	512	$15,100	19,778
		$ 6,942	$ 853	$15,100	$22,895

Table F-9 . STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
New York					
Albany	Albany	$ 840	$ 99		$ 939
Buffalo	Buffalo	2,248	272		2,520
New York	La Guardia	4,166	512		4,678
	Westchester County	2,776	341		3,117
Rochester	Rochester-Monroe	1,468	180		1,648
Syracuse	C. E. Hancock	1,304	155		1,459
		$12,802	$ 1,559		$14,361
Ohio					
Cincinnati	Lunken Field	$ 936	$ 110		$ 1,046
Cleveland	Burke Lakefront	3,852	469		4,321
Columbus	Columbus	1,640	197		1,837
Dayton	Dayton	740	86		826
		$ 7,168	$ 862		$ 8,030
Oklahoma					
Oklahoma City	Oklanhoma City	$ 820	$ 96		$ 916
Oregon					
Portland	Portland Int'l	$ 1,008	$ 119		$ 1,127
Pennsylvania					
Philadelphia	North Philadelphia	$ 4,100	$ 500		$ 4,600
Pittsburg	Allegheny County	3,968	484		4,452
		$ 8,068	$ 984		$ 9,052

Table F-9. STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
Rhode Island					
Providence	T. F. Green	$ 1,136	$ 135		$ 1,271
Tennessee					
Memphis	Memphis	$ 1,348	$ 161		$ 1,509
Texas					
Austin	R. E. Mueller	$ 828	$ 97		$ 925
Dallas	Love Field	3,724	454	$ 3,050	7,228
Houston	Hobby	2,312	280		2,592
San Antonio	San Antonio	1,032	122		1,154
		$ 7,896	$ 953	$ 3,050	$11,899
Utah					
Salt Lake City	Salt Lake City	$ 1,056	$ 125		$ 1,181
Virginia					
Norfolk	Norfolk	$ 1,232	$ 147	$ 3,050	$ 4,429
Richmond	R. E. Byrd	764	89		853
		$ 1,996	$ 236	$ 3,050	$ 5,282
Washington					
Seattle	Boeing Field	$ 1,540	$ 185	$ 3,050	$ 4,775
Spokane	Spokane Int'l	948	112		1,060
		$ 2,488	$ 297	$ 3,050	$ 5,835

Table F-9 . STOLport Improvement Costs (000)
Support Facilities
Minimum Demand 1980 Initial Service (Continued)

Hub City	STOLport	Passenger Terminal	Airport Parking	Aircraft Maintenance	Total Support Facilities
Wisconsin					
Milwaukee	Mitchell Field	$ 1,232	$ 147		$ 1,379
Total Support Facilities		$151,712	$18,336	$84,800	$254,848

Table F-10. STOLport Improvement Costs

	Unit Cost (Per Sq. Ft.)
Landing Area	
Runway (18" Thickness)	$ 1.90
Taxiway	1.10
Taxiway Access	1.10
Apron	1.70
Terminal Building	$ 40.00
Parking Area	$ .80

Table F-11. Aircraft Maintenance Facility Costs

	Area (Sq Ft)	Cost Per Sq Ft	Total Cost (000)
Centralized Maintenance Base			
Shop Area	350,000	$ 20	$ 7,000
Hangar Area	60,000	25	1,500
Engine Test Cell			430
Overhaul Equipment			5,570
Tools & Stands			600
			$15,100
Regional Maintenance Base			
Shop Area	55,000	$ 20	$ 1,100
Hangar Area	60,000	25	1,500
Tools & Stands			450
			$ 3,050

Total Maintenance Facility Costs (000)

(4) Centralized Maintenance Bases	$60,400
(8) Regional Maintenance Bases	24,400
	$84,800

Source: Study of Aircraft in Intraurban Transportation Systems, San Francisco Area, The Boeing Company, September 1971.

Table F-12. Maintenance Facility Locations

Centralized Maintenance Bases		Shops
California	Ontario	Instrument
Hawaii	Honolulu	Avionic & Electrical
Illinois	Midway	Hydraulic
New Jersey	Teterboro	Engine Overhaul - Major
		Wheels, Tires, Brakes
		Sheet Metal & Seat Repair
		Engine Replacement
		Pneumatics
		Standard & Special Tool Rooms
		Engine Test Cell
Regional Maintenance Bases		**Shops**
California	San Jose	Wheels, Tires & Brakes
Colorado	Denver	Sheet Metal & Seat Repair
Florida	Tampa	Engine Replacement
Massachusetts	Logan	Standard & Special Tool Rooms
Missouri	Kansas City	
Texas	Dallas	
Virginia	Norfolk	
Washington	Seattle	

Table F-13. Air Traffic Control Facilities

Hub City	STOLport	Control Tower	Microwave ILS	Approach Lighting	Total ATC Facilities
California					
Los Angeles	Hawthorne		$ 500	$ 200	$ 700
	Long Beach			200	200
Monterey	Monterey Peninsula		500		500
Sacramento	Sacramento Executive			200	200
			$1,000	$ 600	$1,600
Florida					
Miami	Opa-Locka		$ 500	$ 200	$ 700
Georgia					
Atlanta	Fulton County			$ 200	$ 200
Illinois					
Chicago	Meigs Field		$ 500	$ 200	$ 700
Kansas					
Kansas City	Kansas City Municipal			$ 200	$ 200
Louisiana					
New Orleans	New Orleans Lakefront		$ 500		$ 500
Michigan					
Detroit	Detroit City			$ 200	$ 200

Table F-13. Air Traffic Control Facilities (Continued)

Hub City	STOLport	Control Tower	Microwave ILS	Approach Lighting	Total ATC Facilities
Missouri					
St. Louis	Weiss	$ 400	$ 500	$ 200	$1,100
New Jersey					
Teterboro	Teterboro			$ 200	$ 200
Ohio					
Cleveland	Burke Lakefront			$ 200	$ 200
Washington					
Seattle	Boeing Field			$ 200	$ 200
Total Air Traffic Control Facilities		$ 400	$3,000	$2,400	$5,800

Table F-14. Time Phased Implementation Costs - 1990 VTOL System
Airline Acquisition & Introduction
100-Passenger Aircraft

Aircraft	1984	1985	1986	1987	1988	1989	1990	1991	1992-94	Total 1983-1994
Flyaway Cost	$ 29	$ 43	$ 43	$ 80	$ 87	$135	$437	$407	$637	$1,898
Spares	4	6	6	12	13	20	63	59	93	276
	$ 33	$ 49	$ 49	$ 92	$100	$155	$500	$466	$730	$2,174
GSE						$ 3	$ 27	$ 28	$ 48	$ 106
Introduction Costs						3	18	19	34	74
Total Airline Acquisition Introduction	$ 33	$ 49	$ 49	$ 92	$100	$161	$545	$513	$812	$2,354

Table F-15. Summary of Implementation Costs 1990 VTOL System (Cost in Millions)

	100 Pass.
Aircraft Development	
Airframe	$ 530
Engine	199
	$ 729
Airline Acquisition & Introduction	
Aircraft	
Flyaway Cost	$1,898
Spares	276
	$2,174
GSE	106
Introduction Costs	74
	$2,354
VTOLport Development	
Ground Level	$ 88
Elevated	441
Aircraft Maintenance	73
	$ 602
Air Traffic Control	$ 55
Total Implementation Cost	
Including Development	$3,740
Excluding Development	$3,011

Table F-16. Estimated NASA VTOL Funding Requirements
(In Millions of Dollars)

Year	79	80	81	82	83	84	Total
VTOL Systems Studies	4. 0	3. 0	2. 0	2. 0	2. 0	2. 0	15. 0
Quiet Lift Fan Development	2. 0	4. 0	15. 0	20. 0	30. 0	4. 0	75. 0
Ducted Lift Fan Quiet VTOL Aircraft	15. 0	35. 0	55. 0	30. 0	20. 0	5. 0	160. 0
Total Yearly Cost	21. 0	42. 0	72. 0	52. 0	52. 0	11. 0	250. 0
Cumulative Cost	21. 0	63. 0	135. 0	187. 0	239. 0	250. 0	

Table F-17. VTOLport Development Costs
Cost in Thousands (000)

Hub City	Average Ground Level	Average Small Elevated	Average Large Elevated	Total VTOLport Cost
Chicago			$ 67,500	$ 67,500
New York			(2)135,000	135,000
Washington			67,500	67,500
Boston		$ 42,700		42,700
San Francisco		42,700		42,700
Los Angeles		42,700		42,700
Detroit		42,700		42,700
San Diego	$ 9,800			9,800
Minneapolis	9,800			9,800
St. Louis	9,800			9,800
Cleveland	9,800			9,800
Pittsburg	9,800			9,800
Atlanta	9,800			9,800
Honolulu	9,800			9,800
Dallas	9,800			9,800
Philadelphia	9,800			9,800
	$88,200	$170,800	$270,000	$529,000
Aircraft Maintenance				
Centralized (4)				$ 60,400
Regional (4)				12,200
				$ 72,600
Total VTOLport				$601,600

Table F-18. VTOLport Development Costs (000)
Construction Cost Factor

	Typical Ground Level	Typical Small Elevated	Typical Large Elevated
Land Costs			
Ground $25/sq ft	$ 4,200	$ 6,200	$15,000
Over Water $5/sq ft	1,200	1,200	3,000
Over RR Tracks $8/sq ft	2,000	2,000	4,800
Construction Costs			
Land Clearing		1,400	1,800
Over Water Foundations	700	1,200	1,600
Over RR Tracks	400	600	800
Basic Structure	7,000	38,500	58,500
Total VTOLport Cost			
Land	$11,200	$46,100	$75,300
Over Water	8,900	40,900	63,100
Over RR Tracks	9,400	41,100	64,100
Average VTOLport Cost	$ 9,800	$42,700	$67,500

Table F-19. Air Traffic Control Facilities & Equipment
Cost in Thousands (000)

	Typical VTOLport
Terminal Air Traffic Control	
Control Tower	$ 400
Terminal Radar Approach Control	670
Radar Beacon Display Equipment	100
	$1,170
Communications	
Remote Transmitter Receiver	$ 100
Automatic Terminal Information System	5
Voice Recorder	15
FDEP	20
	$ 140
Data Acquisition	
Airport Surveillance Radar	$ 600
Airport Surface Detection Equipment	600
	$1,200
Navigation Landing Aids	
ILS Cat III	$ 630
Outer, Middle & Inner Marker	30
LOM/LMM	20
Runway Visual Range	30
Approach Lighting System with Sequenced Flashers	240
	$ 950
Total Air Traffic Control	$3,460

Table F-20. Direct Operating Costs, 1990 VTOL Lift Fan 100-Passenger Aircraft

	Per Block Hour (500 st. miles)
Flying Operations	
Flight Crew	$ 94.04
Fuel & Oil	166.76
Insurance	78.39
	$ 339.19
Maintenance	
Labor - Airframe	$ 25.23
Material - Airframe	56.16
Labor - Cruise Engine	14.30
Material - Cruise Engine	85.55
Labor - Lift Engine	3.70
Material - Lift Engine	11.30
Maintenance Burden	86.45
	$ 282.69
Depreciation	$ 287.09
Total DOC Per Block Hour	$ 908.97
Per Aircraft Mile	$ 1.79
Per Available Seat Mile	$ 1.79

Table F-21. Comparison of Indirect Operating Costs 1970 Cost Levels

	IOC Item	Boeing 1971 Method	Ames Lockheed-Douglas Modified Method	Aerospace Modified Boeing 1971 Method	Aerospace California Corridor
I	System Expense	$ 41.93	$ 24.05	$ 41.93	$ 22.83
II	Local Expense	132.42	181.91	132.42	40.50
III	Aircraft Control	19.84	14.71	19.84	4.55
IV	Cabin Attendant Expense	68.84	88.17	68.84	79.20
V	Passenger Food	168.65	16.72	16.86	4.86
VI	Passenger Handling & Reservations	305.10	292.50	305.10	80.88
VII	Baggage Handling	216.54	19.91	38.22	11.12
VIII	Other Passenger Expense	121.50	198.00	121.50	160.68
IX	Other Cargo Expense	--	--	--	--
X	General & Admin. Expense	74.96	98.15	61.85	119.80
	Total IOC	$1149.78	$ 933.62	$ 806.56	$ 524.42

150 Passenger Capacity, 500 St. Mi. Trip, 60% L. F., No Cargo Onboard

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