Department of AERONAUTICS and ASTRONAUTICS
STANFORD UNIVERSITY

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STANFORD TRANSPORTATION RESEARCH PROGRAM

Studies in Short Haul Air Transportation in the California Corridor: Effects of Design Runway Length; Community Acceptance; Impact of Return on Investment and Fuel Cost Increases

Volume I

Richard S. Shevell, Principal Investigator
assisted by
David W. Jones, Jr.

July 1973

Submitted to
NASA-Ames Research Center
Contract No. NAS 2-7199

SUDAAR No. 460

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PREFACE

This study of Alternative Short Haul Aircraft Systems has been conducted by Stanford University graduate students in a course on Short Haul Transportation, AA 420, directed by Professor Richard S. Shevell. Many of the travel demand, vehicle cost, and systems analysis methods were formulated by the 1972 class. These methods were modified, improved and expanded, and applied to the current study by the class of 1973.

Special acknowledgement is due to Dr. David Jones, Research Associate, from the Department of Communications, for his work in creating and guiding the community acceptance and community impact work in this study. We believe the methodology and the results are of unusual interest.

Members of the research team were as follows:

1972

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INTRODUCTION, SUMMARY AND CONCLUSIONS

Introduction

Much of the mythology of the use of Short Take-off and Landing (STOL) aircraft in short haul transportation is based on the creation of an air transportation system utilizing new terminals or STOLports, located close to the sources of demand. "Tiny airports shoe-horned into the city-center" and STOLports close to suburban residential areas are typical phrases. The rise of citizen concern with ecological and environmental quality has made the realization of these new close-in terminals very difficult, at best, and impossible, at the worst. It seems much more likely that community approval can be obtained to convert existing general aviation airports to at least partial commercial short haul use since the surrounding communities are accustomed to some aircraft operations.

In either case, a need is implied for runway length requirements below those required by current short haul aircraft, such as the B-727, B-737 and DC-9. Certainly it is desirable that new airports require as small an area as possible since land is at a premium near population centers. On the other hand, existing general aviation airport runways are seldom shorter than 2500 feet and often much longer. A longer runway raises airport costs if runway lengthening or strengthening is required. But a shorter runway raises airplane investment and operating costs, an additional expense which must be borne for the life of the aircraft.

If the shorter runway requirement permits the airport to be located closer to the origin and/or destination of the traveller, the traveller saves access time and cost. And, of course, the time has a monetary value thereby increasing the total access cost.

Major air terminals sometimes suffer from significant runway and air traffic congestion. When STOL systems are compared to conventional take-off and landing (CTOL) aircraft operations, the reductions in passenger processing time, runway delays, and air traffic delays are usually assumed as important factors contributing to the relative worth of STOL. By far the largest portion of these time savings has nothing to do with runway length but is associated with removal of short haul traffic to separate airports. This could be done using any separate airport with conventional aircraft. However, STOL systems economics generally are studied as a trade-off between the higher operating and investment costs of STOL aircraft, the lower infrastructure costs, primarily airports, and the savings in traffic delay costs and access costs.

In many of these studies, large inconsistencies are introduced -- usually to maximize the relative value of STOL aircraft. Air traffic delays are often based on the most congested route in the country, STOLports are visualized as small fields with easy access and no delays -- although large passenger volumes may be assumed in the next chapter -- indirect costs are miraculously reduced by the use of propulsive lift, and STOL all coach interiors replace conventional mixed class interiors for little purpose except to lower comparative STOL costs.

Study Purpose

The primary purpose of this study is to analyze the impact of design runway length on the economics and traffic demand of a 1985 short haul air transportation system. The second major objective is to study community acceptance of new commercial airports for short haul service. The California corridor, or more specifically the route from the San Francisco Bay Area to the Greater Los Angeles area, is chosen as the study locale. The systems studied are a 2000-ft runway system, usually designated as a STOL system and a 3000-ft runway system, designated as a reduced runway length or RTOL system. The STOL/RTOL differentiation is a rather arbitrary convenience only since neither has a clear universally accepted definition and, in this case, both use similar propulsive lift concepts.

The two systems are alternative short haul commuter systems, separate as much as possible from the remainder of the air transport system but using existing major terminals if no other reasonable choice exists. Terminals are chosen to cover the demand area as uniformly as possible. The 2000-ft system utilizes a Central Business District (CBD) STOLport. It is assumed that a CBD STOLport could not accomodate a 3000-ft runway. This assumption is the major impetus for studying the 2000-ft case since all other STOLports or RTOLports are placed on existing airport sites with runways greater than 2000 feet in length. The major question is whether the access advantages of a CBD STOLport outweighs the higher cost of a 2000-ft runway aircraft. In truth, the likelihood of any CBD terminals, capable of handling 100 to 150 passenger aircraft, ever existing is small. The likelihood of enough of them existing to justify the expensive shorter field length aircraft is close to zero. Nevertheless, a 2000-ft CBD was assumed at both ends of the route studied here to evaluate the relative worth of 2000-ft and 3000-ft runway length aircraft assuming that the former has the advantage of a CBD STOLport.

Since both systems are to a large extent separate from the basic air transport system, no significant traffic delays are anticipated. When the major terminals are used, a longer processing time, from arrival at the parking lot to aircraft departure is assumed. In all assumptions, care has been exercised to select reasonable and consistent values. Since the main purpose is a comparison, consistency is paramount.

Several interesting secondary results evolved during the study, namely the effect on demand, fares and total perceived travel costs of rate of return on investment (ROI) and fuel cost increases.

Study Organization

The study is divided into 5 major sections: Travel Demand, Vehicle Technology, which includes vehicle costs, Infrastructure, Systems Analysis and Community Acceptance. Some subjects such as travel demand and infrastructure costs developed a large amount of data and arithmetic manipulation of that data. In such cases, the essential method and results are in the main body of the report while detailed calculations, discussions and data are given for reference in appropriate appendices.

Summary of Results

Travel Demand

The results of the travel demand study are shown in Tables 1 and 2. Table 1 shows the 1970 origin-destination travel demand in one-way trips between the San Francisco Bay Area and the Greater Los Angeles Area by mode. The data are also given for other major city-pairs involving the Bay Area. Total 1970 demand for the Bay Area-Los Angeles area segment, all modes, was 14,166,680 while air demand was 5,126,000. The projected annual demand, all modes, in 1985 is shown in Table 2. The 1985 value for the Bay Area-Los Angeles total demand is 40,567,600. The portion of this 1985 demand that travels by air is shown in the systems analysis to vary, for an ROI of 12%, from 12,226,400 to 15,900,000 depending upon the air system configuration.

Travel demand is distributed into 98 geographic zones in the Bay Area and 19 zones in the Los Angeles area. Each zone was then assigned to the appropriate air terminal on the basis of minimum access time. Access cost and time was calculated for each zone and then averaged on a weighted basis, for each airport. The total demand, all modes, that provide an air traffic potential for each airport is summarized in Tables 3 and 4. The average weighted total access cost per passenger, including the value of access time at $6 per hour, for the 2000-ft and 3000-ft runway systems is summarized in the following table.

System	2000-ft STOL	3000-ft RTOL
Bay Area Access Cost	$5.29	$5.90
Los Angeles Area Access Cost	$4.76	$4.96
Total Trip Access Cost	$10.05	$10.86

Thus the difference in total access cost, per passenger, averaged over all travellers, between a 2000-ft STOL system with a CBD and a 3000-ft system without a CBD is $0.81.

Vehicle Technology

The aircraft characteristics were taken from a Douglas Aircraft Co. study performed for NASA-Ames. This study represents a major and consistent effort to derive future quiet turbofan aircraft with 50 to 200 passenger capacity and a basic sound level at 500 feet sideline of 95 to 97 EPNdB. Externally blown flap configurations were selected as representative of the most efficient lift systems. The direct operating cost curves used are shown in Figures 1, 2, and 3. Figure 1 shows the data for 150 passenger aircraft with 2000-ft and 3000-ft runway lengths and a production quantity of 400. Figure 2 shows a correlation developed in Section II from Douglas and Lockheed data to correct to any other passenger capacity while Figure 3 corrects to any desired production quantity. The correlations are shown to apply to any design runway length and any type of lift system. Similar data are developed in Section II for acquisition cost of the aircraft.

TABLE 1

1970 Annual Intermetropolitan Travel by Modes To and From Bay Area
Number of One-Way Trips

Metropolitan Area	r (st. mi.)	Air Travel[a]	% Air	Rail Travel	Bus Travel	% Rail and Bus	Auto Travel	% Auto	Total
Bakersfield	247	30,700	10.6	0	21,048	7.3	237,773	82.1	289,521
Eugene	441	50,200	27.5	0	4,752	2.6	127,872	70.0	182,824
Fresno	164	98,000	12.2	0	77,280	9.6	630,720	78.3	806,000
Las Vegas	419	149,540	15.6	0	4,872	0.5	802,066	83.8	956,478
Los Angeles	354	5,126,000	36.2	45,480	124,800	1.2	8,870,400	62.6	14,166,680
Monterey	87	44,700	0.6	0	0	0.0	6,989,069	99.4	7,033,769
Portland	541	208,890	22.3	4,680	17,616	2.4	707,414	75.4	938,600
Reno	187	142,690	4.8	0	126,240	4.2	2,712,499	91.0	2,981,429
Sacramento	79	112,370	0.9	0	283,440	2.2	12,700,087	97.0	13,095,897
San Diego	456	594,000	42.4	6,696	19,152	1.8	780,840	55.7	1,400,688
Santa Barbara	271	75,250	25.9	0	7,200	2.5	208,591	71.7	291,041
Stockton	65	9,230	0.1	0	67,152	0.7	9,013,777	99.2	9,090,159
Lake Tahoe	154	4,920	0.1	0	192,600	3.7	5,033,700	96.2	5,231,220

a - Ref.: Ltr.; Douglas Aircraft Company, Long Beach, California, C1-25-1274, 22 Feb. 73
Data Source: Civil Aeronautics Board; 10% Origin-Destination Survey, 12 months ending Dec. 31; California PUC Transportation Division

TABLE 2

1985 Total Projected Travel between the Bay Area and Various Cities

Metropolitan Area	Projected Travel 1985
Bakersfield	582,126
Eugene	573,667
Fresno	1,789,934
Las Vegas	1,922,998
Los Angeles	40,567,600
Monterey	12,778,276
Portland	2,247,125
Reno	6,777,859
Sacramento	29,810,780
San Diego	4,336,954
Santa Barbara	796,727
Stockton	19,829,046
Lake Tahoe	12,444,061
Total Bay Area Travel	134,457,153

Table 3

1985 Los Angeles Area Total Demand Associated with Each Airport

(Demand is Total Los Angeles-San Francisco corridor traffic, all modes)
Total Los Angeles Area Demand with Respect to Bay Area = 40,567,000

System 2000-ft (CBD) →

Airport	CBD		Long Beach	Santa Monica	Van Nuys
% of Los Angeles Area Demand	41.26		25.84	16.25	16.65
Annual Demand (1-way trips)	16,738,000		10,482,500	6,592,100	6,679,500

System 3000-ft (No CBD) →

Airport	Burbank	El Monte	Long Beach	Santa Monica	Van Nuys
% of Los Angeles Area Demand	11.24	12.68	25.84	38.11	12.13
Annual Demand (1-way trips)	4,509,200	5,086,900	10,482,500	15,460,100	4,866,200

Los Angeles Area 4 and 5 Air Terminal Systems

Table 4

1985 Bay Area Total Demand Associated with Each Airport

(Demand is total San Francisco-Los Angeles corridor traffic, all modes)
Total Bay Area Demand with Respect to Los Angeles = 40,567,000

System	2000-ft (CBD)				
Airport	CBD	San Carlos	San Jose	Hayward	Buchanan
% of Bay Area Demand	35.90	15.12	18.85	12.39	16.60
Annual Demand (1-way trips)	14,564,000	6,133,500	7,646,600	5,026,300	6,734,122

System	3000-ft (No CBD)				
Airport	San Francisco	Palo Alto	San Jose	Hayward	Buchanan
% of Bay Area Demand	30.58	10.53	18.18	19.44	20.16
Annual Demand (1-way trips)	12,405,400	4,271,700	7,375,200	7,886,300	8,178,307

Bay Area 5 Air Terminal Systems

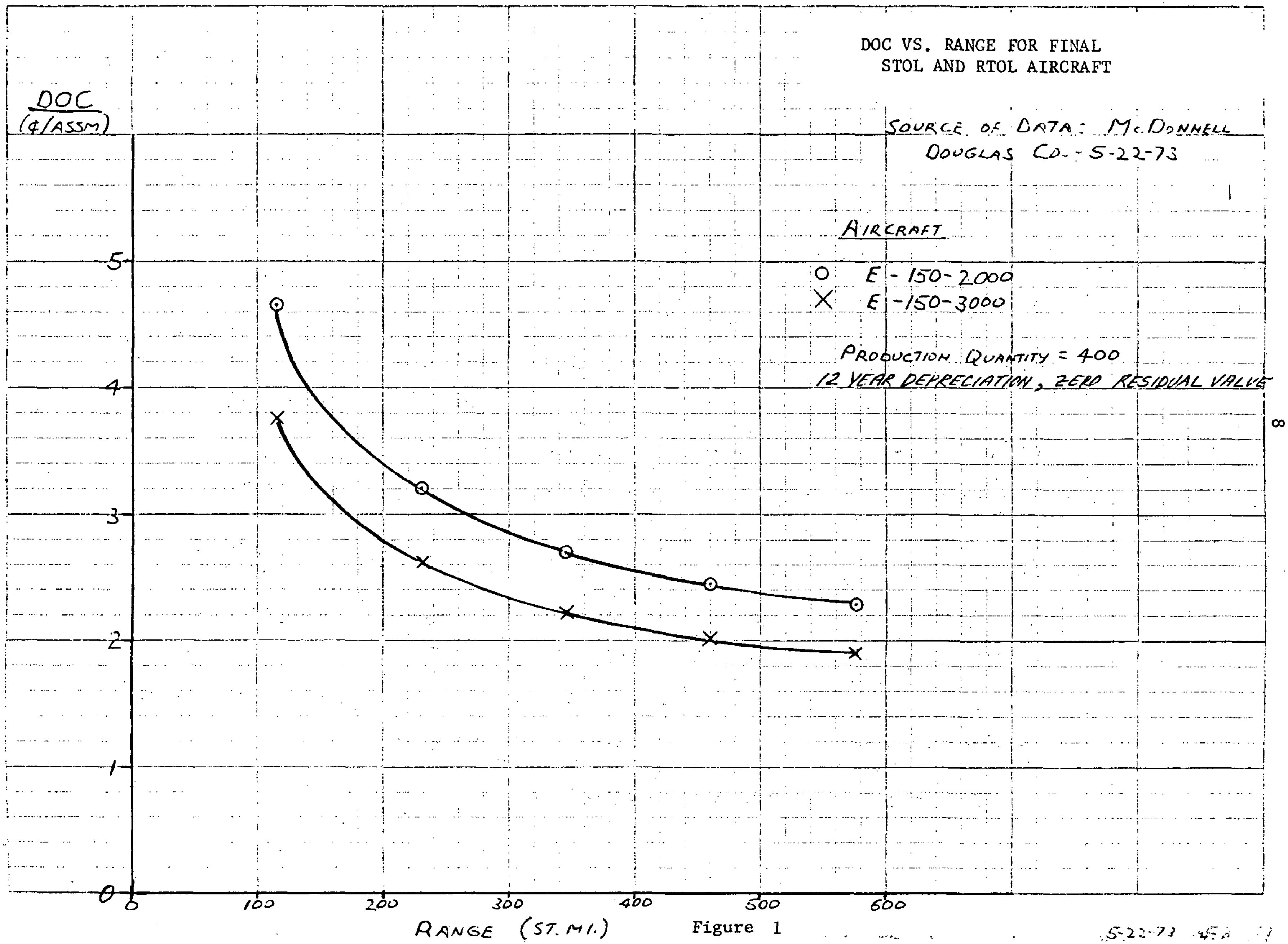
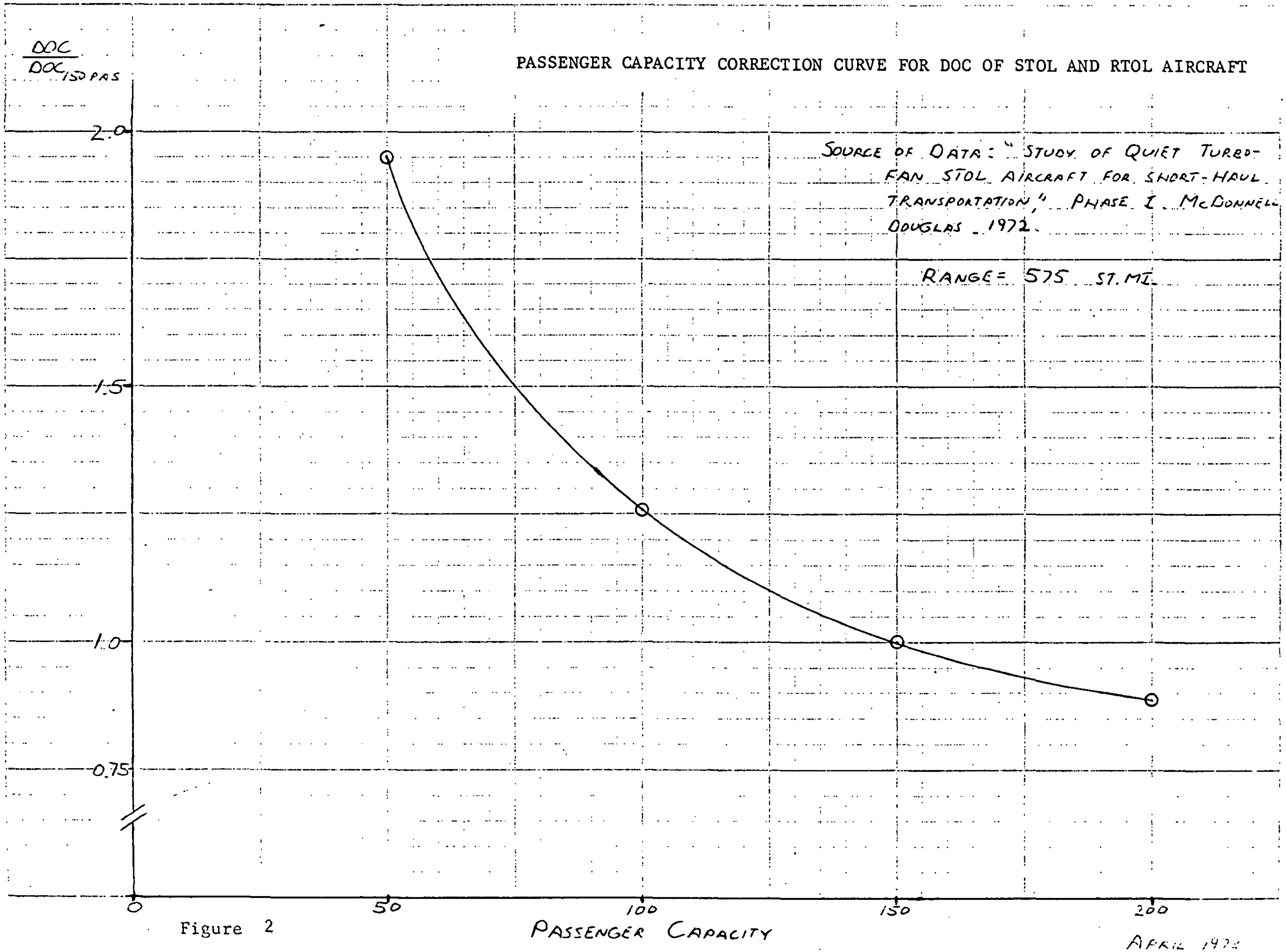

DOC VS. RANGE FOR FINAL
STOL AND RTOL AIRCRAFT

Figure 1



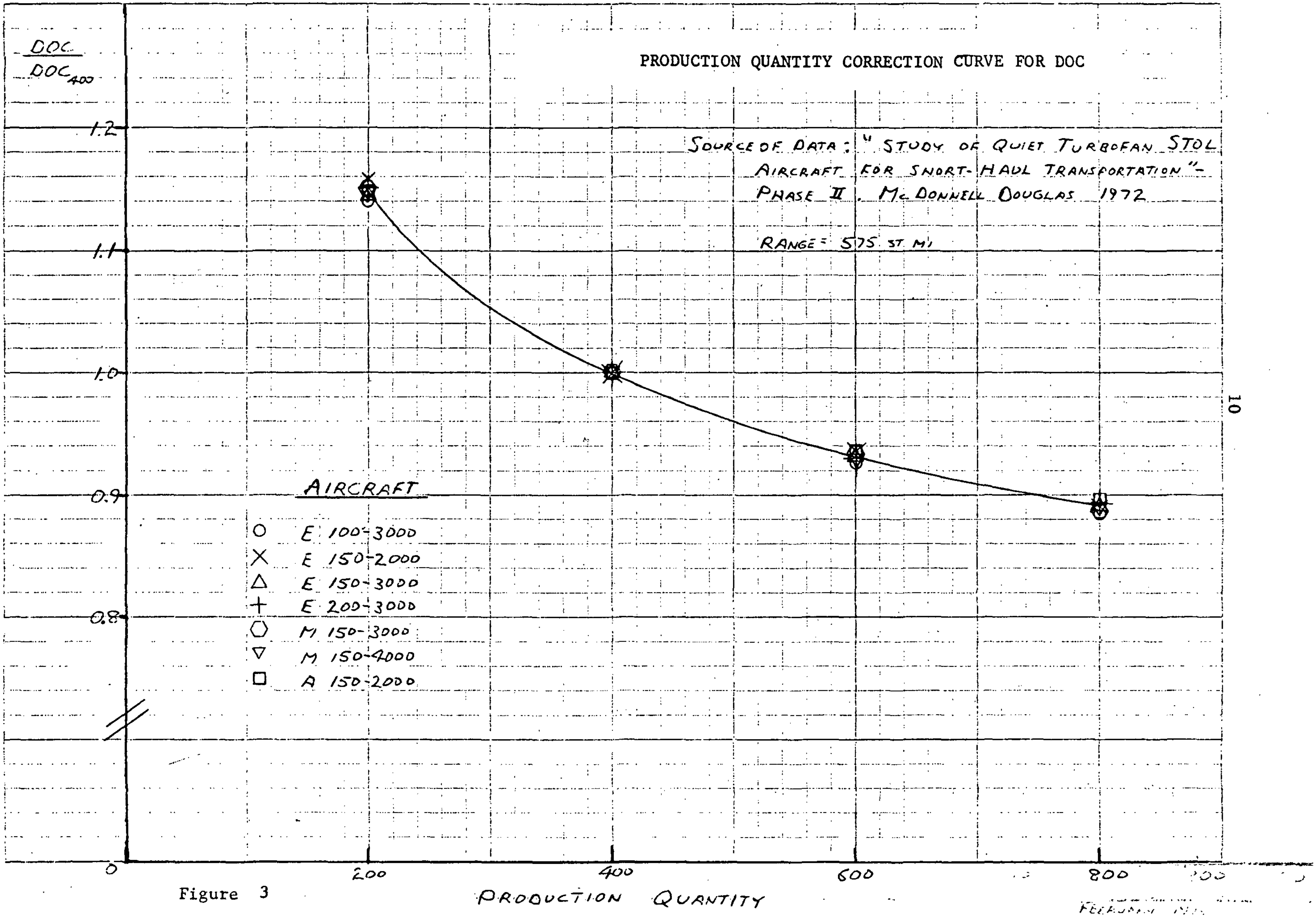
PASSENGER CAPACITY CORRECTION CURVE FOR DOC OF STOL AND RTOL AIRCRAFT

SOURCE OF DATA: "STUDY OF QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION," PHASE I. McDONNELL DOUGLAS. 1972.

RANGE = 575 ST. MI.

Figure 2

APRIL 1973



PRODUCTION QUANTITY CORRECTION CURVE FOR DOC

SOURCE OF DATA: "STUDY OF QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION" - PHASE II, McDONNELL DOUGLAS 1972

RANGE = 575 ST MI

Figure 3

Cost data for the competing mode, the automobile, were derived from several sources. The perceived cost per mile of an automobile was estimated to be $0.05.

With the current emphasis on efficient use of energy resources, the comparative fuel consumption of the 2000-ft runway and the 3000-ft runway designs are of great interest. The fuel required per passenger mile is 35% greater for the 2000-ft case.

Infrastructure

Selected airports are illustrated in Figures 4 and 5.

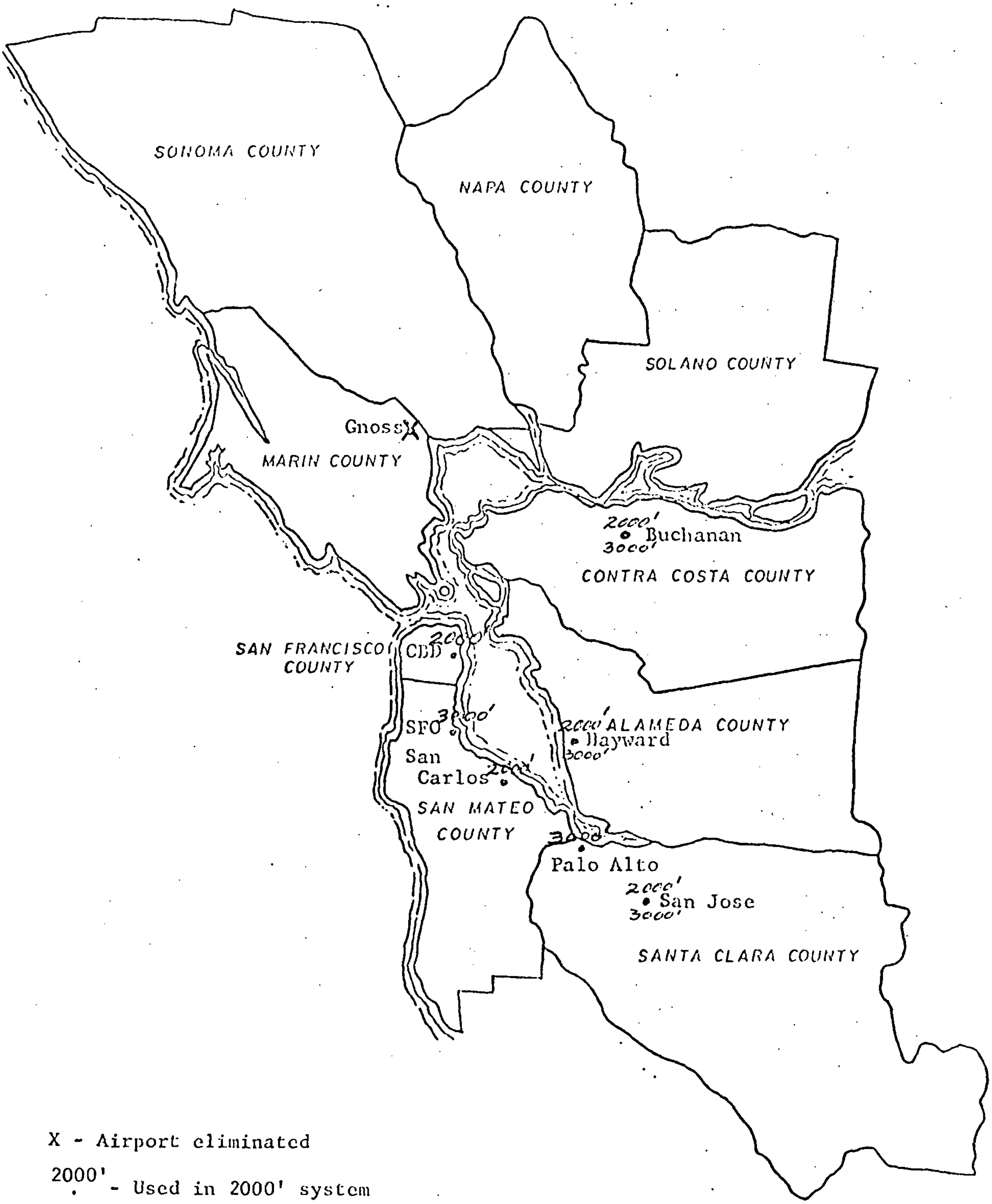
Airport suitability and costs for commercial service was carefully studied at all Bay Area terminals selected for conversion to airline use. Los Angeles STOL/RTOL terminal costs were estimated by comparison with the Bay Area results. The conversion cost for each Bay Area airport is shown in Table 5. The total conversion costs are shown below along with the estimated costs that would have to be amortized by the users after the federal Department of Transportation contribution to airport development is subtracted.

	Total Airport Costs	Approximate Airport Costs After DOT Aid
3000-ft RTOL System	$22,570,000	$13,542,000
2000-ft STOL System	$58,292,000	$34,975,000

It was assumed that the less expensive infrastructure was paid for from normal indirect costs included in the fare. The additional cost of the more expensive infrastructure was amortized over 30 years at 6% interest and charged to the passengers. This additional airport cost for the 2000-ft STOL system is $21,433,200 and requires an annual payment of $1,543,190. Distributing this amount to the 12,226,400 annual passengers on the 2000-ft system, with 12% ROI, requires a fare increase of only $0.13. Since the fare is about $32.00, this cost is trivial.

If the CBD STOLport were not included in the 2000-ft system, the 2000-ft system would have a lower cost but by only about $2,000,000. The annual incremental amortization cost for the 3000-ft system would be of the order of $150,000 per year. This higher cost per passenger would be defrayed by a fare increase for the 3000-ft system of about 1 cent.

The study of airport physical suitability revealed large differences between sites. For example, Palo Alto airport with almost ideal approach and departure paths, mostly over the bay, is built on very poor fill and would need a complete reconstruction of the soil to a considerable depth. San Carlos has similar troubles plus inadequate width between existing buildings for runway and taxiway. Complete reconstruction would be required. Hayward and Buchanan airports, on the other hand, need relatively little strengthening. Each airport needs a careful individual examination.



X - Airport eliminated

2000' • - Used in 2000' system

3000' • - Used in 3000' system

Figure 4

GREATER LOS ANGELES

Travel Zones

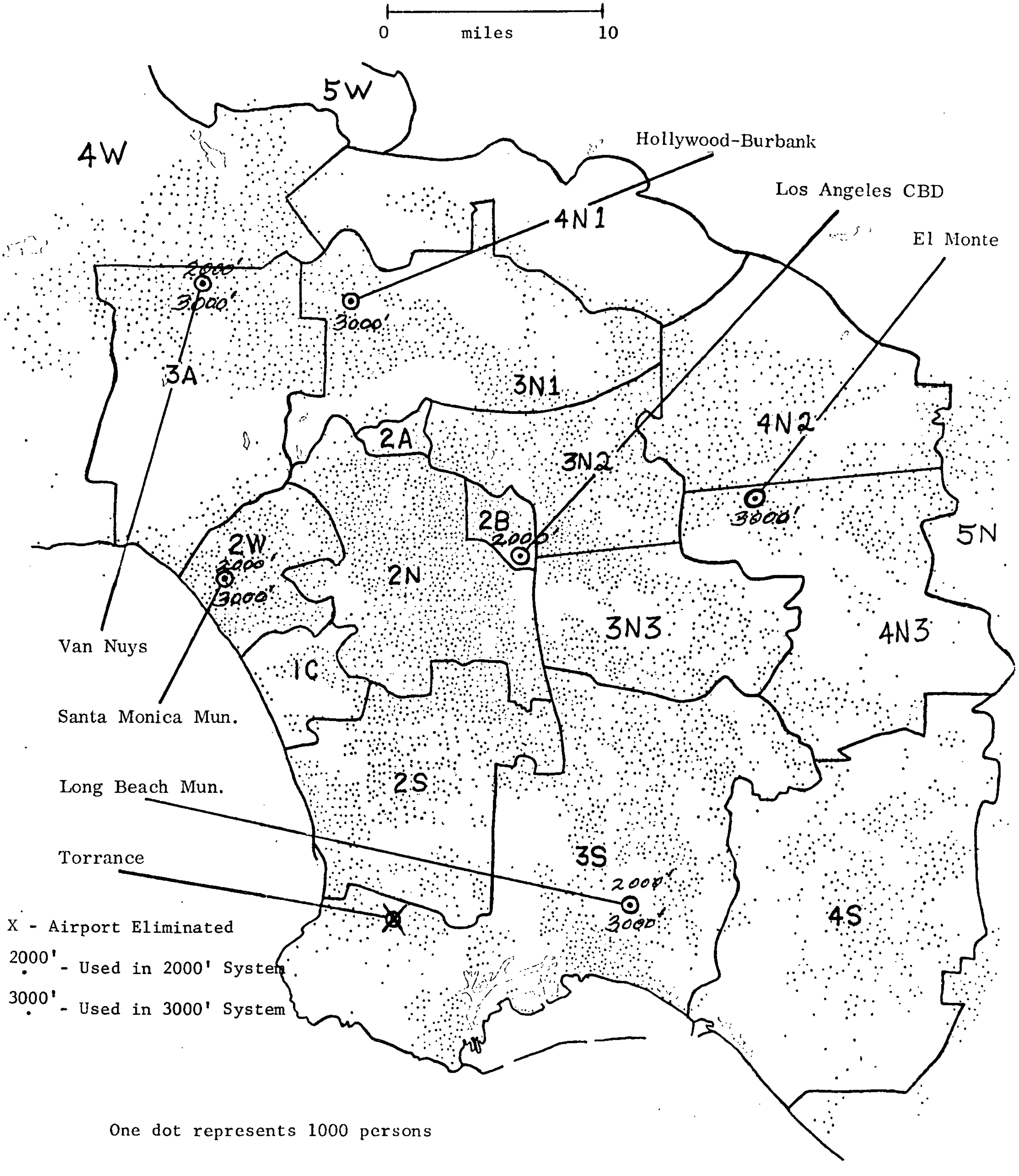


Figure 5

Table 5

AIRPORT CONSTRUCTION COSTS (Millions of Dollars)

	PALO ALTO		SAN CARLOS		HAYWARD		BUCHANAN		CBD
	2000'	3000'	2000'	3000'	2000'	3000'	2000'	3000'	2000'
Land Acquisition	1.470	1.470	.490		0	0	0	0	15.602
Site Preparation	.005	.056	.206		.0002	.0001	.001	.001	*
Paving - Runway	.119	.176	.119		0	0	.020	.042	.133
Paving - Taxiway	.080	.117	.080		.039 ≠	.026 ≠	.041	.048	.242
Paving - Apron	.313	.317	.470		0	0	.022	.022	**
Terminal Construction	1.040	1.040	1.444		1.225	1.790	1.570	1.694	3.387
Maintenance Facilities	.030	.030	.030		0	0	0	0	
ILS	.370	.370	.370		.370	.370	.370	.370	.370
Communication Equipment	.160	.160	.160		.160	.160	.160	.160	.160
Emergency Equipment	.091	.091	.091		0	0	.091	.091	.091
Runway, Taxiway Approach Lighting	.398	.398	.398		.398	.398	.398	.398	.398
Control Tower	.228	.228	.228		.228	.228	.228	.228	.228
Parking Area Grading and Paving	.192	.192	.252		.202	.304	.283	.311	.552
TOTAL	4.496	4.644	4.338		2.622	3.276	3.192	3.365	21.163

* included in runway paving cost

** included in taxiway paving cost

≠ New taxiways at Hayward would be constructed from the turnoff points of the 2000-ft or 3000-ft runway to the existing apron. Due to the shape of the apron, the taxiway constructed to connect the apron and 3000-ft runway would be shorter than that required to connect a 2000-ft runway and the closest apron point.

Studies of noise and air quality impacts were carried out in detail for the Bay Area locations.

The air quality studies were based on the assumption that progress in engine design would reduce STOL/RTOL pollutants per cycle to a level of 1/2 the emissions produced by the current DC-10 airplane. Based on a preliminary estimate of flight frequencies, it was determined that the contribution to local air pollution levels was relatively small and would not cause pollutant concentrations to exceed state or federal standards except for the nitrogen oxides. The final analysis showed lower flight frequencies than the preliminary estimates. This correction would further lower the emissions. The nitrogen oxide standards are now the subject of considerable debate since it is widely believed that they are too stringent. Nevertheless, since nitrogen oxides are associated with the production of photochemical smog, it is clear that every effort to minimize this contaminant should be made.

The noise footprint contours for both the STOL and RTOL aircraft were superimposed on each Bay Area STOL/RTOLport. San Francisco and San Jose airports were not studied because it is obvious that the noise impact of STOL/RTOL aircraft at these airports is much less than that of longer range aircraft and is almost entirely contained within the airport. The contours were identified in terms of both effective perceived noise level (EPNL) and noise exposure forecast (NEF), a measure which includes the flight frequency. The EPNL contours were obtained from Douglas Aircraft Co. and apply to the same aircraft used for the economic characteristics of this study.

Residential population affected by various noise levels, e.g., NEF from 15 to 20 or EPNdB from 80 to 85, were identified from census tract data. Using a method developed by TRACOR, Inc. for NASA, the number of people who would be highly annoyed and the number of complaints were estimated for each airport. The results are summarized in Table 6.

A method of compensating residents disbenefited by an air transportation system was evolved. Obviously subject to much debate, the system was based on compensating property owners for depreciation in the value of real property due to noise impact. This compensation was expressed as an equivalent monthly cost to the airport. The compensation scale used was the following:

Range of Noise NEF*	Range of Noise EPNL	$/month/residential dwelling
25-30	90-95 dB	$100
20-25	85-90 dB	$ 50
15-20	80-85 dB	$ 25
10-15	75-80 dB	-0-

*NEF is based on assumed frequencies of general aviation and STOL/RTOL aircraft

Table 6

NOISE IMPACT: POPULATION AFFECTED AND PROJECTED ANNOYANCE

	PALO ALTO		SAN CARLOS		HAYWARD		BUCHANAN	
	2000'	3000'	2000'	3000'	2000'	3000'	2000'	3000'
Population Affected NEF Zones 15-30	432	1420	4800	6430	9600	15,560	7820	8200
Number Predicted to be Highly Annoyed	26	86	420	540	765	1194	728	815
Predicted Number of Complaints	5	15	18	22	30	45	33	40

The resulting costs for the Bay Area are illustrated in Tables 6 and 7. Doubling the Bay Area costs so determined to estimate the total system costs gives

3000-ft System	$3,585,000/year
2000-ft System	$3,890,400/year

The difference of $305,400 amounts to a 2 cents per passenger higher fare for the 2000-ft system.

As seen from Tables 7 and 8, the 3000-ft aircraft always impacts more people with any given noise level at a particular airport than does the 2000-ft aircraft. The reason the 2000-ft system shows a higher cost is that it contains San Carlos airport rather than Palo Alto. The departure end of San Carlos is blessed with major housing tracts built on filled land. Palo Alto is largely free of this. San Carlos airport is used with the 2000-ft system because the distance from the 2000-ft CBD airport to Palo Alto is about 40 miles, too large a separation from a demand point of view.

If the differences between the noise compensation costs for the two runway lengths at given airports are averaged, the added cost of the 3000-ft system is about $110,000 per year per airport. Taking 6 airports affected, 3 at each end of the system, yields $660,000 as the difference. Spread over the 15,900,000 passengers in the 3000-ft system, the cost is 4 cents per passenger.

The conclusion is that the added costs of noise compensation at the levels assumed is of the order of 25 to 30 cents per passenger and the difference between the two systems is completely trivial.

System Analysis Method

The systems analysis method required the development of a computer program which combined the demand, vehicle and infrastructure information to produce a comparative form of total system cost to the user. Essential elements of this procedure were (1) computations of fare (based on desired return on investment) and other perceived costs associated with the value of time and out-of-pocket expenses and (2) a modal split defining the percentage of total travelers choosing air and auto modes based on the perceived costs. Outputs of the program yielded optimum aircraft size, required fleet size, fares, and system cost for each system.

Figure 6 shows an extremely simplified schematic of the system analysis method. Using initial assumptions on maximum load factor (65%), return on investment for the airline (12%, 8% and 0), value of time ($6/hour) and aircraft size (passenger capacity), the first block performed those computations specific to each route (20 or 25 routes depending upon the system). Inputs to the first block included total travel demand for that airport pair, block time, access time and cost, and operating costs based on an initial assumption of aircraft buy quantity. This block contained an iterative loop between total traveler cost computations and the modal split, and produced, for each aircraft size, the number of air travelers on that route, flight frequency, the final fare and other costs associated with access and waiting time, and number of aircraft required to serve the route. The second block summed these outputs

Table 7

<u>Community Noise Compensation Summary</u>

2000-ft Case

			(PALO ALTO)[1]		SAN CARLOS		HAYWARD		BUCHANAN	
Range of Noise NEF	Range of Noise EPNL	Monthly Compensation per unit ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)
30 & higher	95 dB & higher		0	0	0	0	0	0	0	0
25 to 30	90-95 dB	100	0	0	120	12000	77	7700	46	4600
20 to 25	85-90 dB	50	0	0	150	7500	387	19350	500	25000
15 to 20	80-85 dB	25	350	8750	850	21250	1608	40200	980	24500
10 to 15	75-80 dB	0	740	0	-	0	-	0	-	0
Total Monthly Compensation per Airport				(8750)[1]		40750		67250		54100
Total Annual Compensation per Airport				(105000)[1]		489000		807000		649200

Total Bay Area 2000-ft System Annual Compensation = $1,945,200

---

[1] This airport not used in 2000-ft system. Shown for information only.

Table 8

Community Noise Compensation Summary

3000-ft Case

			PALO ALTO		(SAN CARLOS)[1]		HAYWARD		BUCHANAN	
Range of Noise NEF	Range of Noise EPNL	Monthly Compensation per unit ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)
30 & higher	95 dB & higher		0	-	0	-	10	12600*	0	-
25 to 30	90-95 dB	100	0	0	120	12000	59	5900	105	10500
20 to 25	85-90 dB	50	0	0	225	11250	607	30350	540	27000
15 to 20	80-85 dB	25	100	2500	920	23000	1975	49375	950	23750
10 to 15	75-80 dB	0	1830	-			-		-	
Total Monthly Compensation per Airport				2500		(46250)[1]		85625		61250
Total Annual Compensation per Airport				30000		(555000)[1]		1027500		735000

Total Bay Area 3000-ft System Annual Compensation = $1,792,500

[1] This airport not used in 3000-ft system. Shown for information only.

* Noise levels above 95 EPNdB are assumed to be unsuitable for residential use. Therefore the airport must buy the property. 20% is added to the price for relocation. 1/3 of the cost is assumed recovered by conversion to compatible land use. Remaining cost is amortized over 30 years at 6%.

SCHEMATIC OF SYSTEMS ANALYSIS METHOD

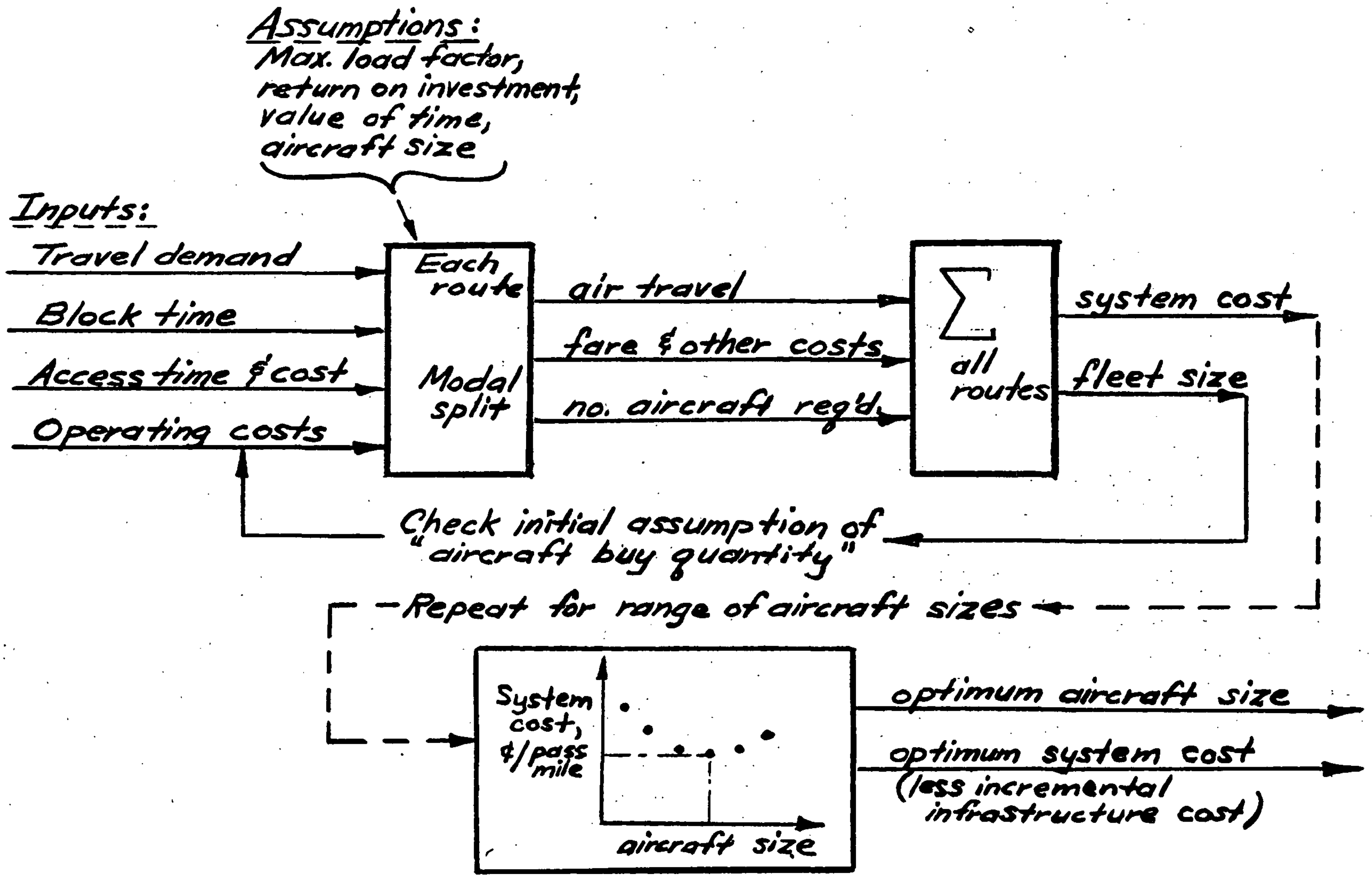


Figure 6

for all routes in the system to provide total system cost, including the value of time, in terms of average cents per passenger mile and fleet size. At this point, the fleet size value was used to check the initial assumption on aircraft buy quantity, and if significantly different, the entire process was repeated using DOC's and acquisition costs based on the new buy quantity. The buy quantity or manufacturer's predicted production quantity, was assumed to be 6 times the California fleet requirement.

Once system cost and fleet size was defined for the assumed aircraft size, a new size was assumed and the process repeated over a desired range of sizes. These results were then plotted as system cost (cents/passenger mile) versus aircraft size for each system. The minimum cost value defined the optimum aircraft size for each system. Finally the incremental infrastructure costs (difference between the infrastructure costs defined for the 2000-ft and 3000-ft systems) were amortized over a 30 year period at 6% interest rate allocated on a cents/revenue passenger mile basis and were to be added to the optimum system cost of the appropriate system. In fact, these incremental infrastructure costs turned out to be negligibly small, as noted above.

The system costs for the two systems were then directly compared. Sensitivity studies were conducted to investigate the effect on the results of varying the assumed return on investment (ROI) value and the cost of fuel.

Fare Determination

The fare equation for constant discounted-cash-flow rate of return on investment (ROI), and zero residual value at the end of the depreciation period, was derived as:

$$\text{Fare/passenger/trip} = \frac{T_B\,(A)\,IC}{U \bullet lf \bullet N} + \frac{TOC \bullet d}{lf}$$

where:

IC = total initial cost of the aircraft, $ per unit (1.3 times the individual aircraft cost to account for equipment and spares)

T_B = flight block time (hours)

U = aircraft annual utilization (hours per year) = 3000

lf = load factor, the ratio of passengers to available seats

N = number of available seats per aircraft

TOC = total operating cost ($/statute mile) = DOC + IOC

DOC = direct operating cost

IOC = indirect operating cost

d = air distance, statute miles

This method assumes that each segment has a fare that provides the desired return on investment. For a 12 year depreciation period, the value of A is 0.1503 for a rate of return of 12%, and 0.0948 for an ROI of 8%.

Modal Split

The modal split equation, explained in detail in Section I, defines the fraction of total travelers anticipated to travel by air, % AIR, as:

$$\%\,\text{AIR} = \frac{1}{1 + \left(\frac{\$\text{AIR}}{K\ \$\text{AUTO}}\right)^{\gamma}} = \frac{1}{1 + \left(\frac{\$\text{AIR}}{.82\ \$\text{AUTO}}\right)^{3.5}}$$

where \$AIR is the total cost to the air passenger for a trip including access cost and the value of time, and \$AUTO is the corresponding perceived cost per person travelling by automobile. The K and γ terms were defined by a fairing through the distribution of data points representing a modal split analysis of recent short haul traffic originating in the San Francisco Bay Area.

System Configuration Analyzed

Computer analyses were performed for ten differing systems. The two basic systems were the 2000-ft and 3000-ft systems based on 12% return on investment (ROI). Eight other systems were included to investigate the effects of varying ROI and the effect of increased fuel costs. The ten systems studied were:

Runway Length (feet)	ROI (percent)	Fuel Cost Factor (ratio of fuel cost to present fuel cost)
2000	12	1
2000	8	1
2000	0	1
3000	12	1, 2 and 3
3000	8	1, 2 and 3
3000	0	1

System Analysis Results

The results of this California corridor study are summarized in Figures 7 8 and 9. Figure 7 shows the variation of total perceived air travel cost, including the value of time, the fare, the daily travel demand and the optimum aircraft size with return on investment, ROI. The results are shown for both the 2000-ft and the 3000-ft runway systems.

With 12% ROI, the 2000-ft system requires an average fare 28% higher than the 3000-ft system. With 8% ROI the increase in fare is 23%. The total cost is higher by 13% for the 2000-ft case with 12% ROI and by 8.4% with 8% ROI. Air travel demand is greater for the 3000-ft system, because of its lower costs, by 31% with 12% ROI and by 17% with 8% ROI.

The effect of airplane passenger capacity is extremely small over a wide range of sizes as shown in Figure 8. With a 12% ROI, the optimum size range is 125 to 155 passengers for the 3000-ft runway case and 130 to 148 passengers for the 2000-ft runway aircraft.

The impacts of large fuel cost increases on fare and demand are surprisingly small as shown in Figure 9. Doubling the fuel cost increases fares by 6% and total perceived air travel cost by 4.3%. This results from the small portion of

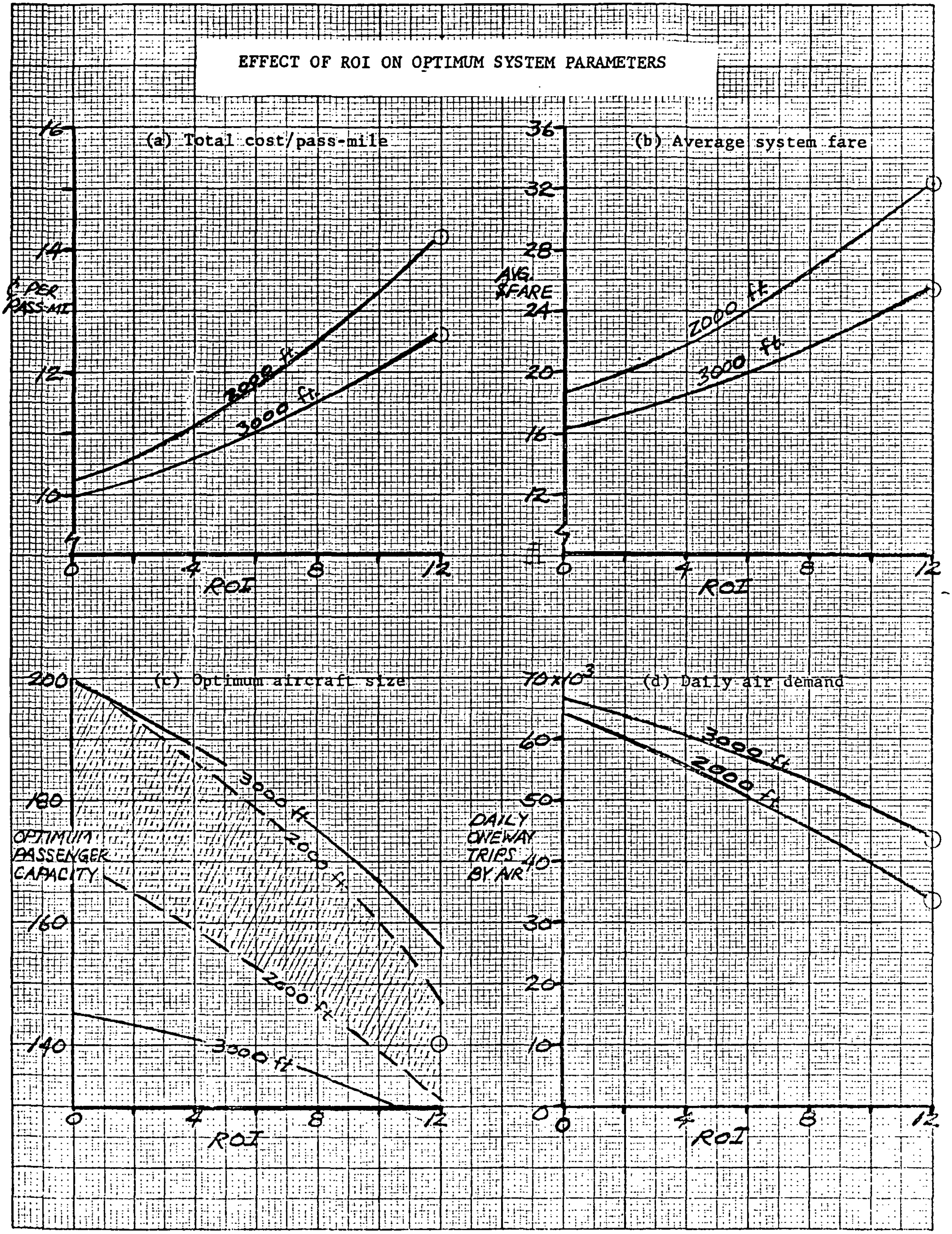

EFFECT OF ROI ON OPTIMUM SYSTEM PARAMETERS
(a) Total cost/pass-mile
¢ PER PASS-MI
16
14
12
10
2000 ft.
3000 ft.
0
4
8
12
ROI
(b) Average system fare
AVG. $FARE
36
32
28
24
20
16
12
2000 ft.
3000 ft.
0
4
8
12
ROI
(c) Optimum aircraft size
OPTIMUM PASSENGER CAPACITY
200
180
160
140
3000 ft
2000 ft
2000 ft
3300 ft
0
4
8
12
ROI
(d) Daily air demand
DAILY ONEWAY TRIPS BY AIR
70x10³
60
50
40
30
20
10
0
3000 ft
2000 ft
0
4
8
12
ROI

Figure 7

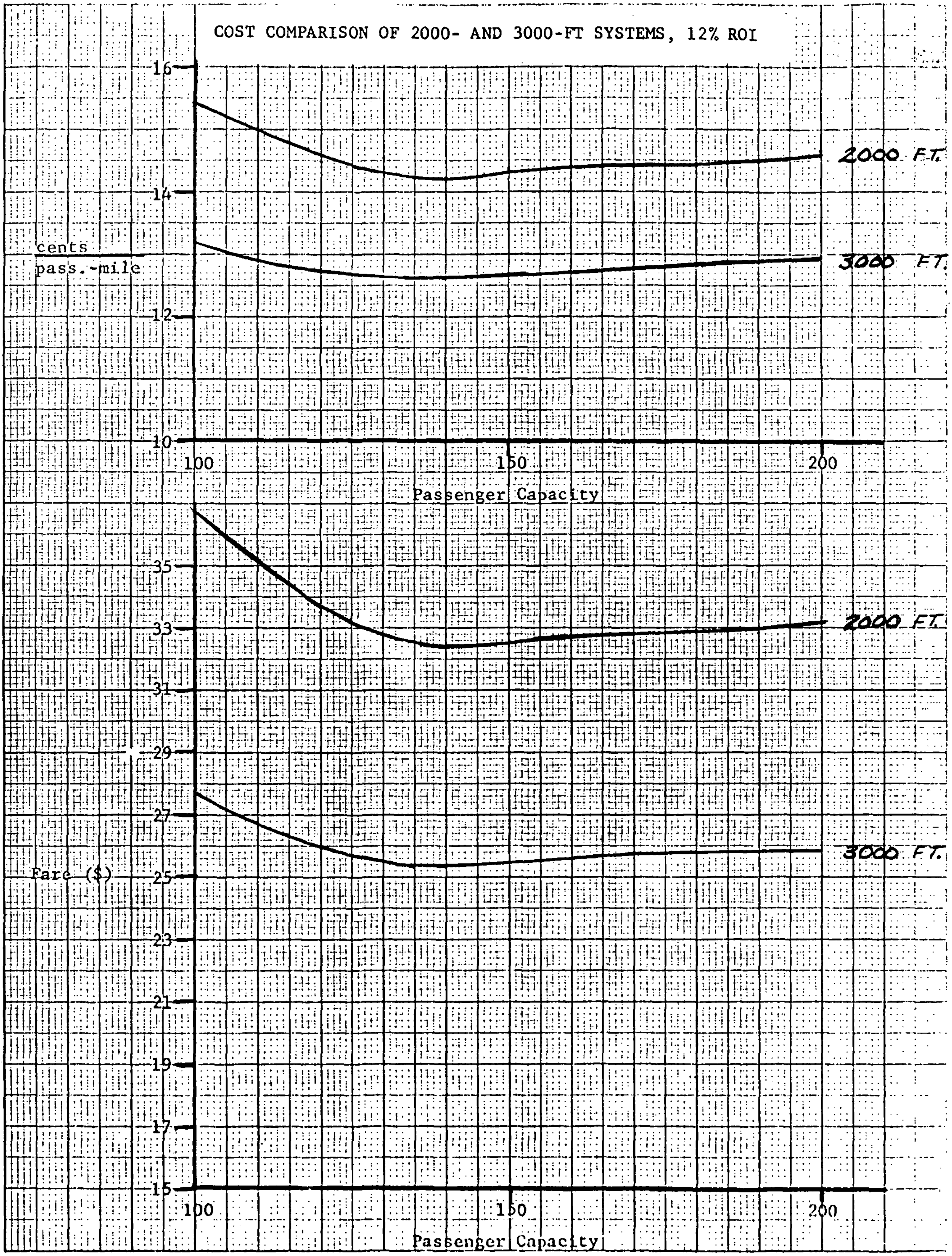
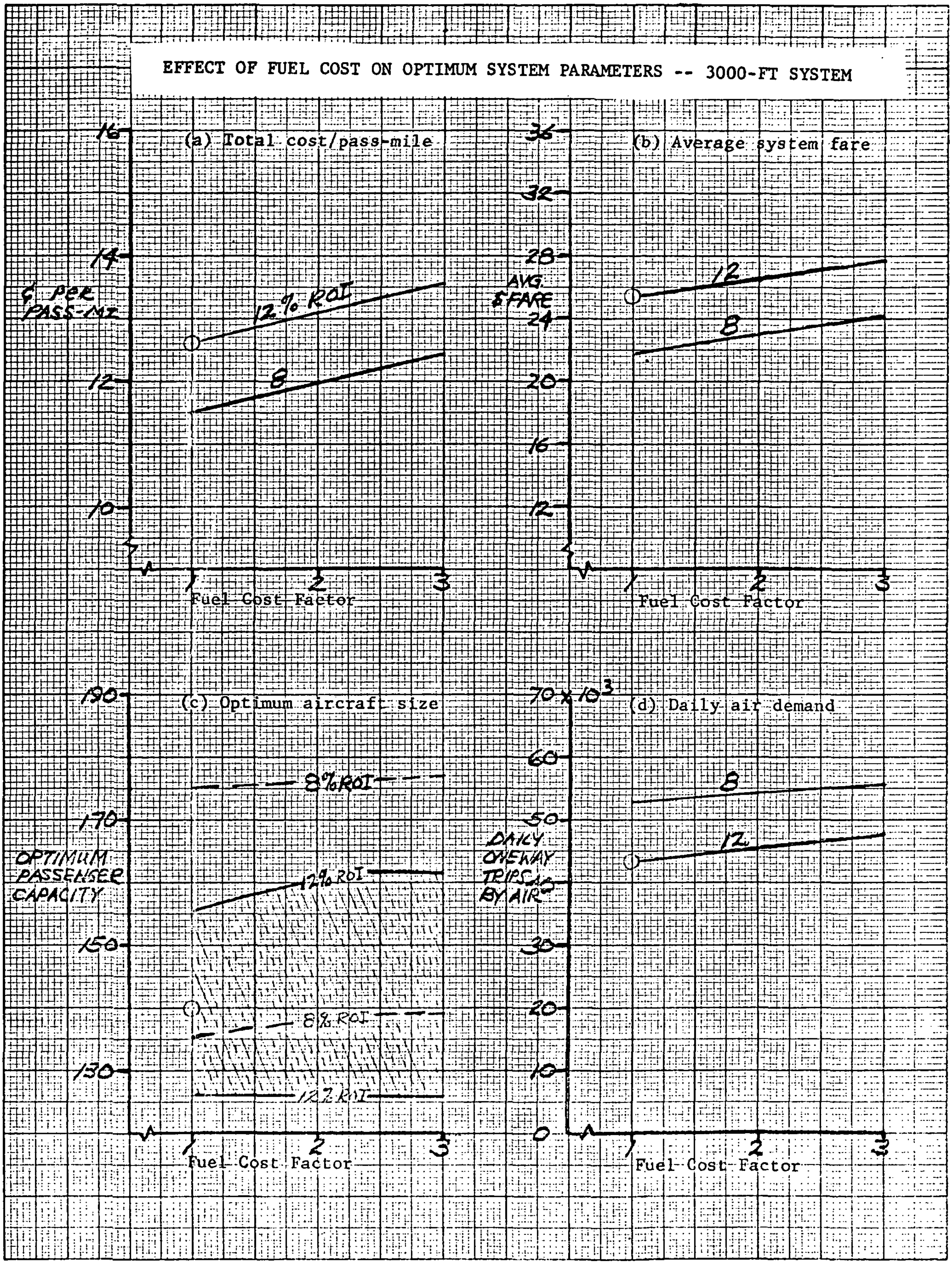

COST COMPARISON OF 2000- AND 3000-FT SYSTEMS, 12% ROI
16
14
12
10
cents / pass.-mile
100
150
200
Passenger Capacity
2000 FT.
3000 FT.
35
33
31
29
27
25
23
21
19
17
15
Fare ($)
100
150
200
Passenger Capacity
2000 FT.
3000 FT.

Figure 8



EFFECT OF FUEL COST ON OPTIMUM SYSTEM PARAMETERS -- 3000-FT SYSTEM

Figure 9

the fare attributable to fuel. Air travel demand is increased slightly by fuel cost increases because the impact on auto costs is greater. The auto is not abandoned as rapidly as one might guess because the fuel portion of the perceived automobile operating cost is only 36% of the total. Furthermore, the value of time is about 5.5 times as large as the operating cost per person (an average of about 2.8 persons per car is assumed). Thus the fuel cost is about 5.5% of the total perceived auto cost including value of time. Note that fuel tax is assumed constant. The fuel cost increase is applied only to the fuel itself.

One interesting result is the large effect of ROI on fare. The portion of the fare attributable to profit is 29.3% for the 3000-ft aircraft with 12% ROI. This amounts to a markup on total operating cost of 41.4%. The large markup is due to the high initial cost per seat of the short field aircraft. High initial cost requires a large profit to maintain a given ROI.

Community Acceptance

Intensive interviews with civic leaders in three Bay Area communities -- Concord, Hayward and Palo Alto -- indicate that community reaction to the STOL concept is sufficiently negative to make the development of a full system of suburban STOLports extremely unlikely.

The controversiality of the STOL concept indicates that it is highly unlikely that STOLports could be developed in a rational regionwide configuration which minimizes airport access time -- the primary economic incentive for introducing STOL or RTOL aircraft in the Bay Area. The most important element determining community reaction was the current travel times from each community to hub airports in the Bay Area. The community most distant from existing metropolitan airports was <u>most</u> favorable to the STOL/RTOL concept -- this in spite of the fact that the site is <u>least</u> advantageous in terms of adverse environmental impact. Even in this case -- Concord -- the likelihood of community acceptance must be rated "marginal."

Although the intensity of reaction varied from community to community, a number of consistent themes did emerge from the interviews with community leaders:

1. The introduction of commercial STOL service would be extremely controversial; the chances of approval by local leaders are sufficiently slim that potential STOL proponents would prefer to avoid the long and bitter controversy they are certain would ensue.

2. Communities in the Bay Area are reluctant to compound environmental problems unless there is an over-riding social need; incremental gains in passenger convenience and the economic benefits of STOLport development are not viewed as "over-riding social needs."

3. General aviation airports provide a valuable service; the scale of STOL/RTOL operations using 100 to 150 passenger aircraft is out of keeping with the level of general aviation activity projected for 1985.

4. The STOL concept is too much too late; street capacities, clear zones and airspace capacities have been designed with general aviation aircraft in mind; it is too late to unravel the patterns of urban development that surround suburban airports.

5. STOL does not have a readily identifiable political constituency. The number of people who would benefit from shorter airport commutes is not sufficiently large or concentrated to overcome the predicted vehement opposition of organized environmental groups and ad hoc groups of adversely affected homeowners.

6. The number of potential STOL supporters is reduced by the availability of inexpensive and frequent air service at San Jose, Oakland and San Francisco airports.

The reaction to the STOL/RTOL concept in each community focused on different factors with the common thread of reaction reported above. Thus, these reactions cannot be reported as a general indictment of the STOL concept although it suggests that a multi-site suburban STOLport system is, at this time, nothing less than a political albatross.

The controversiality of the STOL proposal in each of the three suburban communities and intense negative reaction from two communities do not negate the acceptance potential of STOL/RTOL aircraft in other settings:

1. STOL would significantly reduce noise levels at San Jose Municipal Airport; the environmental organizations that have brought San Jose airport expansion to a standstill indicate strong support for the STOL/RTOL concept.

2. Hamilton Air Force Base and other large military airfields can be explored as potential STOL sites.

3. Rapidly urbanizing areas on the metropolitan periphery such as Santa Rosa can be explored as potential STOL markets.

The intensely negative reaction from two out of three communities, does however, suggest the wisdom of caution in projecting the market for STOL/RTOL aircraft. This conclusion is buttressed by the characteristics of the communities which reacted negatively to the STOL concept: they are, in effect, a cross section of the metropolitan subcenters in the Bay Area.

Extension of these community acceptance results to the entire country is fraught with perils but it seems likely that the acceptance difficulties encountered in the Bay Area would appear in substantial areas throughout the United States. The development of a sufficiently large market to stimulate the production of a large specialized short field transport aircraft seems extremely doubtful.

Conclusions

This study has clearly shown the substantial economic superiority -- including all system costs -- of a 3000-ft runway quiet short haul aircraft over a 2000-ft aircraft in the California corridor. The difference in fare is 23% with an ROI of 8% and 28% with an ROI of 12%. The 3000-ft aircraft attracts a 31% larger air travel market. There are no redeeming features to the 2000-ft system since the average system access cost savings with a CBD STOLport credited to the 2000-ft aircraft is small compared to the fare increments. Differences in noise and infrastructure costs are negligible compared to the fare differences. In addition the fuel consumption is 35% higher for the 2000-ft case.

Unique cases may exist elsewhere in the country where a 2000-ft airport can be built but a 3000-ft runway cannot. Such situations seem likely to be rare. Furthermore, the number of people who would benefit sufficiently from these special airport locations to justify the higher fare is small compared to the total market for high density short haul service. It does not seem efficient to penalize the many for the few. If a special aircraft type is built to serve a very few routes, the production quantity would be small. The cost will then be much increased and the fare disadvantage of the 2000-ft field length aircraft will be further accentuated.

The likelihood of developing a multi-terminal short haul air transportation system sited separately from existing metropolitan airports is small. Hostility can be expected wherever significant populations are close to the airport -- making community acceptance highly unlikely. Nevertheless, general aviation airports located in growth-oriented communities on the urban periphery may have potential for development as individual additions to the existing system, improving service and relieving congestion at hub airports. It is probable that the runway lengths available, or capable of being made available, at these airports on the urban fringe are not particularly restrictive.

Our final conclusion takes the form of a question. If 3000-ft runway aircraft are so much more economical than 2000-ft aircraft, what is the optimum field length? The findings here suggest that 3500-ft, 4000-ft and possible longer field length aircraft should be studied to locate this optimum. It seems clear that the most economical aircraft will have a field length of at least 3500 feet. Whether that aircraft's greater noise impact will significantly increase the problem of community acceptance is an important trade-off question which also merits further study.

TRAVEL DEMAND - OVERVIEW

The travel demand analysis consists of four separate sections. The first section deals with present traffic levels, both automobile and air. Rail and bus travel are also indicated, but are so small that they are ignored in most of the analysis. Although this study deals only with the Bay Area-Los Angeles corridor, travel demand was estimated for all major city pairs involving the Bay Area as part of a broader study. In addition to the travel levels between the Bay Area and cities within 500 nautical miles, other characteristics are determined which influence transportation demand. These characteristics include population, taxable retail sales, employment level, and the number of telephone instruments. An analysis of a gravity model based on population is selected as the preferred means of correlating historical traffic demand. Data are collected for travel by both automobile and air for the 1970 base period and for the five preceding years, and a modified gravity equation determined which correlates this information. In these correlations, total travel demand, air plus auto, is the dependent variable. The resulting gravity type equation is then used to project the total travel demand between the Bay Area and specific cities within the definition of short haul transportation (50-500 nautical miles) to 1980 and 1985.

The question of modal split is then addressed in the second section. A method of correlating modal data with total preceived costs is developed and calibrated. This method will be applied to split total demand between air and auto in 1980 and 1985, the calculation being done in the systems analysis.

The third section of the travel demand analysis starts with the various predictions of Bay Area total air travel demand (not short haul) that have been made, using, primarily, portions of the BASAR study (Reference 1), which generated an equation that based air travel on population, employment, and income per capita. Using various assumptions for the growth of population, employment and income, many possible projects of total Bay Area air travel were generated by BASAR. A most probable growth assumption, different from any of BASAR's, is selected and a projected total Bay Area air travel for 1980 and 1985 determined.

In addition to the total gross air travel in and out of the Bay Area, the origin-destination characteristics of this total air travel are broken down both by county and into 98 Bay Area zones such as are used in the BASAR study. From this, the projected percentage of total air travel demand from each zone is obtained. This is the output of this part of the study used in the final system analysis.

In a further analysis in section four, the 98 BASAR zones are assigned to each short haul airport in a given system on a basis of minimum access time. For each airport, the percentage of total Bay Area air travel, or, assuming it is the same, the percentage of Bay Area air travel to Los Angeles, can be determined. Combining this with the total air travel to Los Angeles from sections 1 and 2 establishes the demand from each airport to Los Angeles.

A similar percentage analysis in the Los Angeles area is used to split each Bay Area airport's traffic into specific destinations in the Los Angeles area.

BAY AREA SHORT HAUL TOTAL TRAVEL DEMAND FORECAST

To determine the travel demand for all of the city pairs within the 50-500 nautical mile range of the Bay Area would be a monumental and practically impossible task. Therefore, the travel demand study was limited to major cities within the 500 nautical mile range. These cities are:

Bakersfield	California
Fresno	
The greater Los Angeles area	
Monterey	
Sacramento	
San Diego	
Santa Barbara	
Stockton	
Lake Tahoe	
Eugene	Oregon
Portland	
Reno	Nevada
Las Vegas	

The greater Los Angeles area was viewed as Los Angeles-Long Beach, San Bernardino, Riverside-Ontario, Anaheim-Santa Ana-Garden Grove, and Oxnard-Ventura. Sacramento was viewed as consisting of Placer, Sacramento, and Yolo Counties.

The Bay Area consists of nine counties: San Francisco, Alameda, Marin, Contra Costa, San Mateo, Santa Clara, Napa, Solano, and Sonoma.

The object of the travel demand study was to determine the projected travel demand for 1980 and 1985 between the Bay Area and the above cities, and also to determine a statistical breakdown of the origin and destination travel within the Bay Area. To accomplish this, it was necessary to formulate a model, calibrate it on historical data, and use forecasts of the necessary factors to determine the future demand.

General Assumptions

In order to develop a methodology for handling the determination of total travel demand between the Bay Area and the cities in the short haul network, the following assumptions were made.

1. The historical relationships between travel demand and population, employment, and taxable retail sales will continue to be valid for the period through 1985.
2. Growth in travel demand will be unconstrained by capacity limitations through 1985.
3. Passenger traffic carried by trains and buses will be insignificant through 1985 (a reasonable assumption because the train and bus volume is generally less than 5 percent of the travel demand).
4. Through 1985, the stimulation of travel due to new technology will be similar to the experience of the 1960's.
5. There will be neither a major economic recession nor a military conflict to affect travel demand during the period through 1985.
6. Passenger traffic carried by private (general aviation) aircraft will be quantitatively insignificant through 1985.
7. Market-specific projection techniques and analysis may be utilized to take into account the individual nature of specific city-pair markets in the study.

Factors Influencing Travel Demand

In considering the possible factors involved in the determination of travel demand, the following list was generated:

population
taxable retail sales
employment
telephone stations

Population was chosen because it is convenient to obtain and has a mass relationship when inserted into the gravity model. Taxable retail sales was chosen because it represents the same type of component as personal disposable income, that is, a number which represents the amount of money a person has to spend above his necessities for pleasurable items such as travel. In the nonbusiness sector, this factor will be related to the personal disposable income of the average person. Employment correlates with business travel and also is involved with retail sales to the extent that employed persons have more money, generally, than the unemployed. Telephones were used to measure the general economy of the city (a wealthy person will generally have more desire and opportunity for a second or third phone), and to measure the tourism factor because motels and hotels have many phones.

However, in the course of the analysis, it was found that there was very little data in terms of future projections for any of these factors except population. Therefore, historical data for taxable retail sales, employment, and telephone stations are included only for reference in Appendix A for those cities for which it was available.

Travel Demand Model

With the particular factors chosen, a gravity model seemed to be the most appropriate in the form,

$$F_{xx} = k \frac{M_1 M_2}{r^2} ;$$

where: F_{xx} is the total travel demand, all modes, for the year 19xx

M_1 is a factor for city 1

M_2 is a factor for city 2

r is the distance between cities 1 and 2

k is an appropriate coefficient

M_1, M_2 and k are functions of time

Determination of 1970 Travel Demand

Travel demand in California is primarily composed of two segments, automobile and air. Of the two, the automobile is the more difficult to determine. Even though California does 10 percent of the nation's automobile travel, data are not available for city-pair automobile travel demand. Therefore travel demand by auto was estimated using the <u>1970 Traffic Volumes</u>, (Ref. 2), published by the State of California, Division of Highways. The data are in the form of statistically-determined Average Daily Traffic volumes at many locations along all highways in the state. The origin-destination estimates derived therefrom are, at best, quite approximate.

1970 Automobile Travel

The method used to determine the Bay Area city pair automobile travel demand is shown here only for Sacramento-San Francisco but is applicable to all city-pairs with a few exceptions. In Appendix A, the mathematical development of each city's Bay Area travel demand by automobile is diagramed.

Definition of abbreviations used in generation of automobile travel statistics:

1. NLR: Not Logical Route

   Travel along a certain road will get you from one defined node to another, but that route will involve greater distance, no increase in comfort, and more time for travel between the two nodes. Therefore, such a route is not logical for use between those nodes and few people will use it for that purpose.

2. LTT: Local and Through Traffic

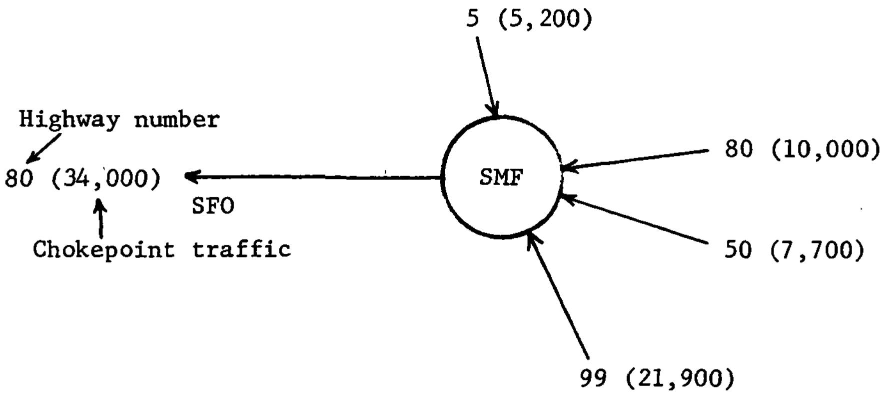
   A reduction in origin and destination traffic passing a point on a highway due to local travel and due to traffic which originates in (or is destined for) a node but continues through (or originated beyond) the other node. Usually, this reduction is taken as 1/3 of the chokepoint traffic or the adjusted chokepoint traffic, whichever is less.

3. Chokepoint

   The point on a route with the minimum traffic volume. Determined from examination of Traffic Census figures, the chokepoint traffic is thus an upper limit to the traffic between the Bay Area and the destination being studied.

Example of Determination of an Auto Travel Statistic: Sacramento-San Francisco

SACRAMENTO (SMF) to BAY AREA



34,000 (chokepoint; 80)
- 200 (NLR; 5) (Originates on Route 5, then proceed on Route 80)
33,800
- 1,000 (NLR; 99) (Originates on Route 99, then proceed on Route 80)
32,800
- 5,875 (Lake Tahoe traffic; 80,50)
26,925
- 3,088 (Reno traffic; 80)
23,837
- 7,946 (1/3 LTT)
15,891 veh/day, SFO-SMF

1. To simplify computations, volumes are assumed to be all in one direction--in this case, from Sacramento and to San Francisco. Computed figures, however, will give total traffic volumes in both directions.

2. Assume all measurable travel from Sacramento to San Francisco begins travel on I-80. Total is 34,000 veh/day at the chokepoint of that highway.

3. 5,875 vehicles are bound to Lake Tahoe (see p. A-5).

4. 3,088 vehicles are bound to Reno (see p. A-4).

5. 1,200 vehicles originate outside of Sacramento area from Routes 5 and 99.

6. Of 23,837 vehicles which do originate in Sacramento, 1/3, or 7,946 vehicles are LTT.

7. Load factor was assumed to be a linear function of distance. The graph used to determine load factors is on p. I-7.

8. 15,891 veh/day x 30 days/mo. x 12 mo./yr. x 2.22 persons/veh = 12,700,087 persons/year.

The 1970 city-pair automobile traffic thus developed is shown as the "Auto Travel" column in Table I-1, pg. I-8.

On page 3 of the <u>1970 Traffic Volumes</u>, Ref. 2, the historical percentage increase in automobile travel for the entire state is given. These percentages were assumed to apply to all city-pair routes and the historical travel data figures were constructed for all applicable city-pairs for the years 1965-1970 from the 1970 total traffic. These are tabulated in Table A-2.

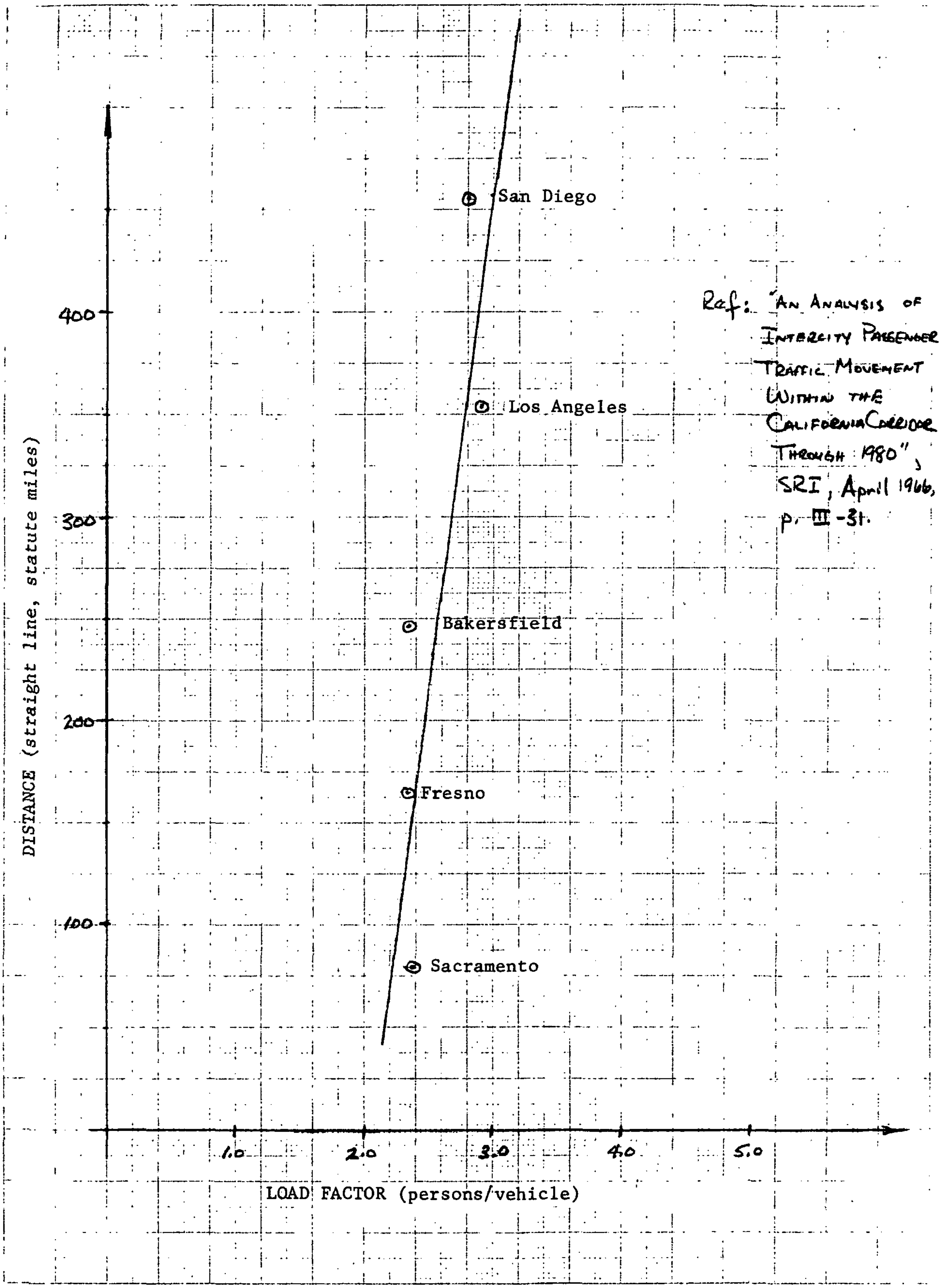
<u>Air Travel Demand</u>

The air travel demand figures are more easily obtainable. The interstate carrier travel is available from the Civil Aeronautics Board's compilation of 10 percent travel sample of origin and destination, published quarterly and based on the previous twelve months. The intrastate records are available through the State of California Public Utilities Commissions who have authority for rates and routes of intrastate carriers in California. The historical data of 1962-1970 is summarized in Appendix A, Table A-3 and is listed for 1970 in Table I-1.

<u>Rail and Bus Travel</u>

These data were obtained from various industry sources and are never more than 4.5 percent of the total traffic for any one city.

Table I-1 summarizes the 1970 travel demand for all city pairs considered, by mode, as well as totals.



Ref: "AN ANALYSIS OF INTERCITY PASSENGER TRAFFIC MOVEMENT WITHIN THE CALIFORNIA CORRIDOR THROUGH 1980", SRI, April 1966, p. III-31.

Figure I-1

TABLE I-1

1970 Annual Intermetropolitan Travel by Modes To and From Bay Area
Number of One-Way Trips

Metropolitan Area	r (st. mi.)	Air Travel[a]	% Air	Rail Travel	Bus Travel	% Rail and Bus	Auto Travel	% Auto	Total
Bakersfield	247	30,700	10.6	0	21,048	7.3	237,773	82.1	289,521
Eugene	441	50,200	27.5	0	4,752	2.6	127,872	70.0	182,824
Fresno	164	98,000	12.2	0	77,280	9.6	630,720	78.3	806,000
Las Vegas	419	149,540	15.6	0	4,872	0.5	802,066	83.8	956,478
Los Angeles	354	5,126,000	36.2	45,480	124,800	1.2	8,870,400	62.6	14,166,680
Monterey	87	44,700	0.6	0	0	0.0	6,989,069	99.4	7,033,769
Portland	541	208,890	22.3	4,680	17,616	2.4	707,414	75.4	938,600
Reno	187	142,690	4.8	0	126,240	4.2	2,712,499	91.0	2,981,429
Sacramento	79	112,370	0.9	0	283,440	2.2	12,700,087	97.0	13,095,897
San Diego	456	594,000	42.4	6,696	19,152	1.8	780,840	55.7	1,400,688
Santa Barbara	271	75,250	25.9	0	7,200	2.5	208,591	71.7	291,041
Stockton	65	9,230	0.1	0	67,152	0.7	9,013,777	99.2	9,090,159
Lake Tahoe	154	4,920	0.1	0	192,600	3.7	5,033,700	96.2	5,231,220

[a] - Ref.: Ltr.; Douglas Aircraft Company, Long Beach, California, C1-25-1274, 22 Feb. 73
Data Source: Civil Aeronautics Board; 10% Origin-Destination Survey, 12 months ending Dec. 31; California PUC Transportation Division

Calibration of Gravity Model Using Population

The Gravity Model was chosen as the best means of predicting future travel demand. In order to calibrate the model, population was chosen as the independent factor. Thus, for the historical data, population and total travel demand were established for the time period 1965-1969 for the California city-pairs, total travel being derived as discussed above and population data being obtained from California Department of Finance studies, Ref. 3. To establish the character of the constant k in the gravity model, an analysis was run on the four region-pairs of Stockton-, Santa Barbara-, Fresno-, and Bakersfield-Bay Area. See Table A-5, page A-17 and Figure A-2, page A-20.

These plots show k to be linear with respect to time for the time frame of 1965-69, and a discontinuity at 1970. This is due to the fact that the 1970 population figures are actual census figures while the 1965-69 population figures are estimates made by the California Department of Finance. The estimates tend to be higher than the actual population figures and, therefore, k is lower. Because of the linearity of the 1965-69 k's and the precise point of k_{1970}, it is reasonable to conclude that the linearity is present before 1970 and the line passes through k_{1970} with the slope determined by the 1965-69 figures, i.e.:

$$k_{19xx} = k_{1970} + mt$$

where k_{19xx} is the k of year 19xx,

m is the slope of the k versus time graph, and

t is the time in years from 1970, which serves as a base year.

The same linearity is assumed to hold for all city-pairs in the study, so only k_{1965}, k_{1969} (determining m), and k_{1970} need to be determined. Table A-6 shows k_{1965} (Column 5), k_{1969} (Column 8), m (Column 9), and k_{1970} (Column 12) for the city-pairs in the study.

Note: The value for k_{1965} for San Diego was not obtainable because the only available references for San Diego, which contained San Diego-Bay Area air travel on PSA (Public Utilities Commission of California, Application Numbers 51080 and 52165, "Origin and Destination Passenger Traffic for Scheduled Air Carriers"), listed data only for 1967. In fact, Bay Area-San Diego total travel could not be obtained independently because the data in the above reference did not include the PSA travel between San Diego International Airport and San Francisco International for any years other than 1967 and 1970. To determine $k_{1980,85}$, an m equal to that of Los Angeles was assumed.

It is interesting to note that the Las Vegas slope (m) is negative. The reason for this is that the population has grown in Las Vegas faster than the travel between Las Vegas and the Bay Area, and is expected to continue its rapid growth (see Table A-6). The value of m, therefore, should continue negative, and k should continue to decrease.

Another interesting observation to be made from the set of k's is that cities which are out of California or have predominantly recreational travel (i.e., Monterey and Lake Tahoe) have higher k's than cities that are in California and have either a mixture of recreational and business travel or predominantly a personal travel demand. There is no discernable pattern in the slopes of m.

Predictions

The k's for future projections were then extrapolated for 1980 and 1985. These k's (the set of k_{1980} and k_{1985}) were then used with the California Department of Finance population estimates and estimates by U.S. Bureau of Census for Nevada and Oregon. Tables A-7, A-8 and A-9 give 1980 and 1985 population forecasts. Table A-6 shows the calculations and the resulting predicted 1980 and 1985 travel demand. The population figures are used to obtain travel demand estimates but are, in themselves, estimates. Therefore, any set of population estimates may be used to obtain a projected travel demand estimate because the k is independent of the population.

Conclusions

In this travel demand study, a methodology based on the use of the gravity model was developed. The use of population as the attracting factor resulted in a constant k which varied linearly with time. By extrapolating the constant to a future year (with 1970 as a current basis), the future travel demand could be obtained from a set of population forecasts.

The total projected intercity short haul travel from the Bay Area in 1985 is projected to be 134,457,153. The total projected travel from the Bay Area to the Los Angeles area is 28,835,691 in 1980 and 40,567,600 in 1985. The projected travel for all city pairs is given in Table I-2.

TABLE I-2

1985 Total Projected Travel between the Bay Area and Various Cities

Metropolitan Area	Projected Travel 1985
Bakersfield	582,126
Eugene	573,667
Fresno	1,789,934
Las Vegas	1,922,998
Los Angeles	40,567,600
Monterey	12,778,276
Portland	2,247,125
Reno	6,777,859
Sacramento	29,810,780
San Diego	4,336,954
Santa Barbara	796,727
Stockton	19,829,046
Lake Tahoe	12,444,061
Total Bay Area Travel	134,457,153

MODAL SPLIT ANALYSIS

The modal split process addresses the question: how will the expected future passenger traffic be divided among the various modes available? The transportation system envisaged for the horizon year of this study, 1985, might include both improved existing modes and possibly entirely new concepts. The planner may reasonably expect the pattern of present allocation of traffic to the existing modes to continue for the short term. However, this assumption is less valid for the long term when new technologies are implemented which could significantly change the transportation system and cause new patterns of passenger behavior.

The data base for this analysis is the existing modal split situation for the short-haul passenger traffic between the Bay Area and seven other cities. One primary result of this analysis is the calibrated modal split model which represents, in analytical form, the preferences of today's travelers in this region and indicates the most likely behavior of tomorrow's travelers.

The basic assumption underlying the model is that passenger preference between modes can be related to certain more-or-less identifiable costs associated with the use of each type of service. Once these cost factors were determined, the model was calibrated using information about the present traffic on each mode. One can expect that the passengers' response to future transportation services will similarly exhibit a relationship dependent on the related costs calculated in a consistent fashion.

The following discussion includes three main topics:

I. General Characteristics of the Transportation System

II. General Attributes of the Short-Haul Intercity Traveler

III. Description of the Modal Split Model

I. General Characteristics of the Transportation System

The transportation system in use in the San Francisco Bay Area region is composed primarily of only two modes: private automobile (AUTO) and commercial aviation (AIR). Bus and train service is available, but little used; the market response in this case is generally so small that in this analysis, these modes are ignored. There is quite significant competition between the air and auto modes, which account for almost 98 percent of all intercity trips.

Because the region lacks sufficient data on commercial ground transportation services, it will be more difficult to ascertain the future competitiveness of vastly improved ground modes. Much information can be obtained, though, from this modal split analysis centered on AUTO and AIR data.

The air mode receives as little as 1 to 10 percent of the market to Sacramento, Reno and Bakersfield, and attracts up to 36 to 42 percent for Los Angeles and San Diego. Hence, there is good range in the available data. The remainder of the traffic to these cities is essentially allocated to the auto mode.

It is important to recognize that the AUTO and AIR modes are offering service at nearly maximum efficiency. That is, the highway system is extensive and largely uncongested, and the air system provides frequent, comfortable jet service without appreciable delay in the air. As a result, the traveler's preference for either AIR or AUTO modes is most likely based on specific cost criteria such as air fare, terminal access cost, and auto operating cost. The study need not be complicated further by cost considerations for highway congestion and airport delays and discomfort--these factors do not strongly influence the present modal split except,perhaps, on a few specific days of the year. Of course, these considerations may become relevant for a future time and should be included in the cost calculations associated with the future transport system if they are applicable.

Prospectus on the Transportation System: In general, improvements in the passenger transportation system will probably come about through individual changes in the operating philosophy of each mode and the introduction of new advanced-technology equipment.

For example, improved existing airline services might be the result of changes in operation such as altering the frequency of flights on various routes and changing the fare structure. Lower costs may result from improved aircraft technology or, on the other hand, higher costs may result from demands for reduced noise and shorter runway requirements. Perhaps the highway department would install bus lanes and toll roads to expedite travel on congested routes, or impose a tax on leaded gasoline. The basic price of fuel may increase sharply. All of these changes in operating procedures and costs for the various modes could significantly affect the modal split.

Present transportation technology has made available for short-haul transportation large capacity airplancs (e.g., DC10, L1011), turbine and steam buses, Metroliner and advanced electric rail (e.g., Tokaido Train, Japan), and anti-emission control for autos and new safety devices.

Further developments of technology may produce shorter take-off and landing aircraft (either STOL or RTOL), vertical take-off and landing aircraft (VTOL), advanced guided ground vehicles (TACV, magnetically suspended, perhaps), and others. Quite obviously, the composition of the future transportation system could be multi-modal and complex. A realistic view of the 1985 possibilities in California eliminates some of these systems, however, so that for purposes of this study, the modes assumed for 1985 will be limited to short haul air systems, either the 2000 ft. runway STOL system or the 3000 ft. runway RTOL system, and an automobile system essentially the same as present.

To reemphasize the central thesis of this study: the passenger market's response to any future transportation system (of whatever composition), is largely dependent on the travelers' perceived costs of each mode's service; and this response can be predicted using a behavioral model based on information about present modal preferences and perceived costs in the San Francisco region. A prime task is to accurately (and consistently) determine the perceived costs to the traveler for any prospective mode not now available.

II. General Attributes of the Short-Haul Intercity Traveler

Trip Purpose: Trip purpose is broadly classified as either business or personal. The assumed proportions are:

(1972) - AUTO mode: business - 20 percent
personal - 80 percent

(1972) - AIR mode: business - 50 percent
personal - 50 percent

Value of Time: The passenger's perceived value of time in transit is perhaps the most important factor influencing his modal preference. Generally, the business traveler values time at a higher rate than the personal traveler.

The figure below depicts qualitatively the probability distribution of the value of time for the intercity travel market, both business and personal travelers, on AUTO and AIR modes.

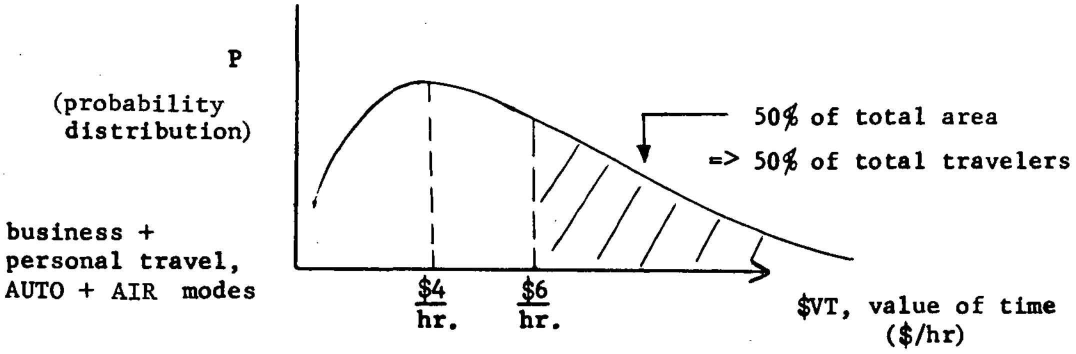


Fig. I-2 Value of Time--Total Intercity Market

It is assumed that the median value of time is $6/hr.[*]: that is, 50 percent of all intercity travelers value time above (or below) this figure. For any

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[*] This figure was used by John Hosford (McDonnell Douglas) in his study of the Northeast Corridor; because the results of his work are quite reasonable, we thought this median value of time could be legitimately employed in this study, too. Furthermore, if travelers value time equal to their hourly rate of pay, then $6/hour (corresponding to a gross annual income of $12,480) seems plausible for the typical traveler.

given value of time, $T, the percentage of travelers with higher values of time is simply equal to the percentage of total area beneath the curve which lies beyond (to the right of) this value.

The most important feature of this display is that the values of time are skewed toward the low side. The reason is that people typically value time according to their income, and the regional income distribution is shifted in similar fashion toward the low side.

There are two considerations which tend to reduce the skewness of the value of time distribution by giving more weight to the travelers who value time more highly than average:

A. Upper income groups take more per capita personal intercity trips than lower income groups;

B. Business travelers may value time at a higher level than their own personal incomes would dictate and are generally members of the upper income group.

Nevertheless, it appears that these two factors do not significantly change the skewness of the distribution. Hence, the largest concentration of travelers is probably centered around the mean value of time of approximately $4/hour.

For purposes of this study, the assumed values of time are:

typical traveler (any mode, any trip) ∼ $6/hour

trip purpose specific
(typical pleasure traveler) ∼ $4/hour
(typical business traveler) ∼ $12/hour

mode specific
(typical auto traveler) ∼ $5/hour
(typical air traveler) ∼ $8/hour

As will be pointed out in greater detail below, the individual who values his time for a particular trip quite highly will most probably prefer the air mode; whereas the auto travelers are drawn largely from the group valuing time much less.

III. Description of the Modal-Split Model

The basic model incorporates data from only two modes: AUTO and AIR. A procedure can be developed extending this method to other modes as well.

The model hinges on the concept of total perceived cost--the dollar cost of the transportation service to the traveler. This all-important quantity is composed of easily determined factors like fares and auto operating costs, and other more subjective elements like the value of time and terminal access costs.

Any analytic representation of the present modal-split preferences of the San Francisco travel market for intercity trips by AUTO or AIR must satisfy these basic criteria which are simple realistic observations of the dynamic nature of the passenger market:

A. If AIR's perceived cost increases relative to AUTO, traffic will be diverted from AIR to AUTO;

B. The rate at which AIR would lose patronage to the AUTO mode under condition (A) is not linear; in fact, AIR patrons are more sensitive to changes in perceived cost of the mode at high levels of patronage than at low levels: (For example, a 10 percent increase in the perceived AIR cost on two routes, SF-LA and SF-SAC, would result in a much heavier percentage loss of AIR patronage for the highly competitive LA route than for the less competitive SAC route.)

Corollary: As the difference in the perceived costs of two competing modes decrease (i.e., as the two modes become more competitive), then the propensity for travelers to be diverted from one mode to the other increases.

<u>The Model</u>: (Taken from "V/STOL Patronage Model," by John Hosford, McDonnell Douglas, 1970.)

$$\%\ \text{AIR} = \frac{\left(\frac{1}{\$\text{AIR}}\right)^{\gamma}}{\left(\frac{1}{\$\text{AIR}}\right)^{\gamma} + \left(\frac{1}{\text{K}\$\text{AUTO}}\right)^{\gamma}} = \frac{1}{1 + \left(\frac{\$\text{AIR}}{\text{K}\$\text{AUTO}}\right)^{\gamma}}$$

$$\%\ \text{AUTO} = 100 - \%\ \text{AIR} = \frac{1}{1 + \left(\frac{\text{K}\$\text{AUTO}}{\$\text{AIR}}\right)^{\gamma}}$$

$$\%\ \text{AIR} = \frac{\text{AIR patronage}}{\text{AIR + AUTO patronage}}$$

$\$\text{AIR}$ = total perceived cost of AIR (one-way trip);

$\$\text{AUTO}$ = total perceived cost of AUTO (one-way trip);

γ = calibration exponent to account for nonlinearity, criteria B;

K = calibration constant (or preference factor) which reduces the total perceived auto cost to account for the inherent advantages of the <u>private</u> auto mode over any <u>public</u> carrier such as AIR (an advantage which cannot be easily quantified explicitly as a cost factor).

For purposes of calibrating the model with 1970 AIR and AUTO data, the following definitions and assumptions are used:

$$\$\text{AUTO} = \text{F}\begin{bmatrix}\text{auto operating cost}\\ \text{distance}\\ \text{occupancy}\\ \text{travel time}\\ \text{value of time}\\ \text{motel fee}\end{bmatrix}$$

H, auto operating cost = \$.05/mile, the incremental cost perceived by the user.

d, distance = average road mileages from SF Bay Area population center, located near South San Francisco

NPPA, occupancy = 2.1 to 2.9 persons per automobile, see Figure I-1, page I-7.

TBA, travel time = assume average speed of 60 mph, which is lower than highway speeds but allows for slower urban driving and stops enroute.

\$T, value of time = \$6/hour -- median value chosen.

\$M, motel fee = \$10.00, this fee is entered whenever a city cannot be reasonably reached by auto in one day (about 9 hours travel time).

$$\$AIR = F\begin{bmatrix}\text{fare,} \\ \text{scheduled enroute time,} \\ \text{value of time,} \\ \text{access/egress cost,} \\ \text{frequency of service cost}\end{bmatrix}$$

FARE = economy jet class (i.e., lowest regular jet fare not including various special discount rates such as military standby, charter, etc.).

T_B, scheduled enroute time = scheduled time between departure from origin to arrival at destination; an average figure including straight-through jet flights, stopovers, and slower propeller service (the jet service is weighted more heavily, e.g., time = 67 percent jet time + 33 percent prop time on routes where propeller service was significant in the 1970 calibration year).

\$T, value of time = \$6/hour

\$OP, access/egress cost = Estimated at \$20.00 for the present AIR system. This cost is levied equally on each city; about 50 to 60 percent of this cost is dependent on access/egress time and value of time, the remainder is the result of out-of pocket expenses such as parking, auto operating expenses, public transit fare (bus, taxi, limousine), car rental expense.

$\$W$, frequency of service cost (waiting cost) = dependent on frequency of flights (which determines interval between flights) and value of time (50 percent normal value of time); average frequency (n) is computed as the total number of daily jet flights plus 50 percent of total number of daily propeller flights (during any 24-hour period); for computation assume 14-hour operating day (approximately 7:00 a.m. to 9:00 p.m.).

T_W, effective average waiting time = 1/2 x 1/2 the time interval between flights

Thus:

$$
\begin{aligned}
\$W = \text{frequency of service cost, } \$ &= T_W \times \$T \\
&= \frac{14_{\text{hour}}}{n} \times 1/2 \times 1/2 \times \$T \\
&= \frac{3.5\ \$T}{n}
\end{aligned}
$$

if $\$T = \$6/\text{hour}$

$\$W = \frac{21}{n}$

Summary:

$$
\begin{aligned}
\$AUTO &= + \text{ per-person operating cost} &&= H/NPPA \bullet d \\
& + \text{ value of trip time} &&= TBA \bullet \$T \\
& \underline{+ \text{ motel fee (if any)} \qquad = \$M}
\end{aligned}
$$

$$\$AUTO = H/NPPA \bullet d + TBA \bullet \$T + \$M$$

$$
\begin{aligned}
\$AIR &= + \text{ fare} &&= FARE \\
& + \text{ value of trip time} &&= T_B \bullet \$T \\
& + \text{ access/egress cost} &&= \$OP + \$T \bullet T_A \\
& \underline{+ \text{ frequency of service cost} = \$T \bullet T_W}
\end{aligned}
$$

$$\$AIR = FARE + \$OP + \$T\ (T_A + T_B + T_W)$$

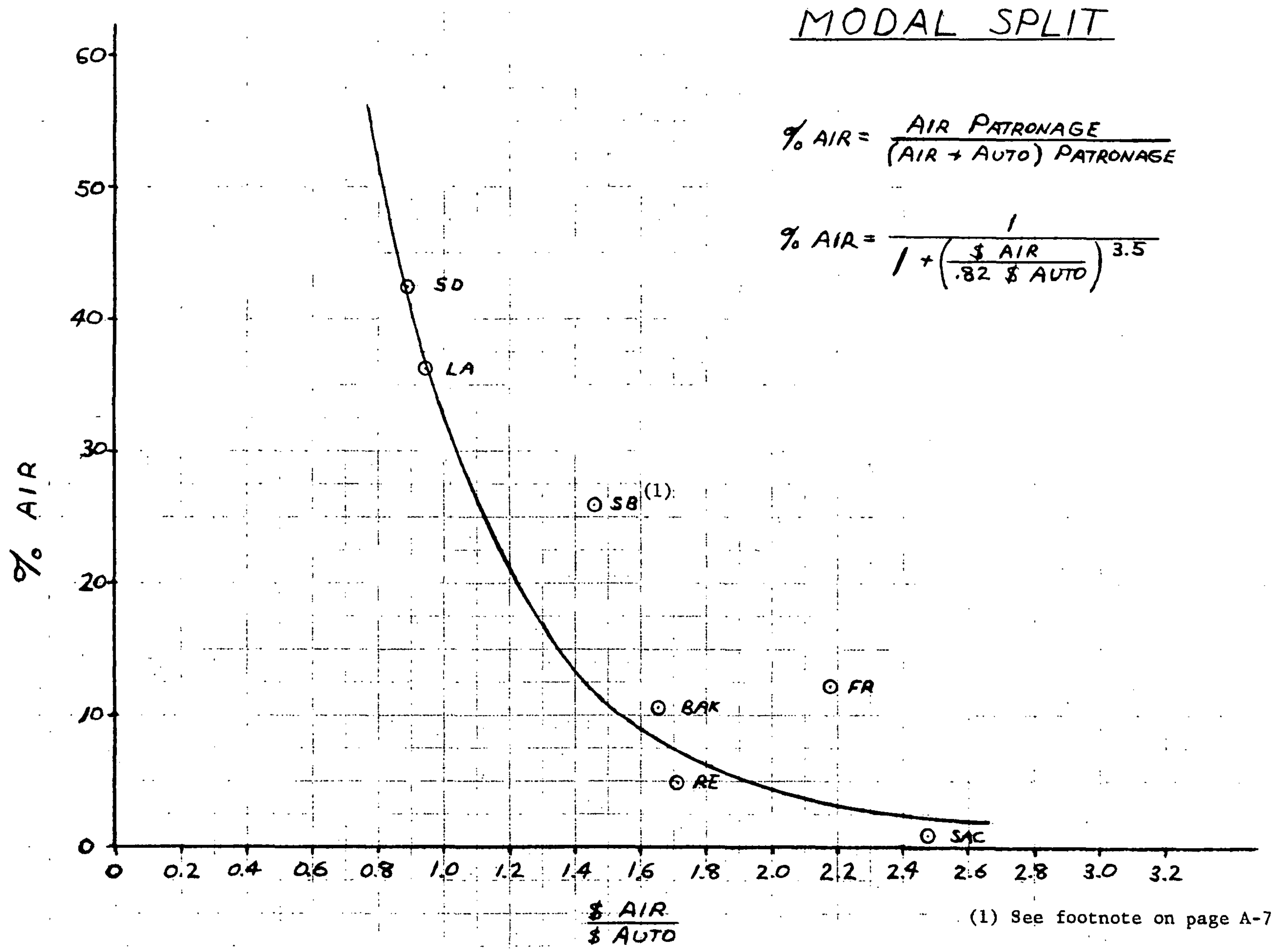
Calibration of the Model: The model was calibrated for seven city pairs using current fares, timetables, and 1970 traffic from Table I-1, page I-8. The model parameters were varied until the curve reasonably fit the data.

Table I-3 shows the data and computations used in establishing the 1970 values of \$AIR, \$AUTO and % AIR. Figure I-3 displays the results of the calibration with $\gamma = 3.5$ and $K = 0.82$.

TABLE I-3

Determination of Total Modal Costs for Modal Split Calibration

	Sacramento	Fresno	Reno	Bakersfield	Santa Barbara	Los Angeles	San Diego
AUTO							
Distance Air Miles	79	164	187	247	271	354	456
Distance Highway Miles	115	175	245	275	320	385	535
Travel time (hr.) at 60 mph	1.92	2.92	4.08	4.58	5.34	6.42	8.92
Per person operating cost at $.05/mile-auto ($)	2.60	3.64	5.02	5.35	6.14	6.90	8.91
Value of travel time at $6/hour-person ($)	11.50	17.50	24.50	27.50	32.00	38.50	53.50
Motel fee ($)	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Passengers per car	2.21	2.4	2.44	2.57	2.61	2.79	3.0
$AUTO	14.10	21.14	29.52	32.85	38.14	45.40	62.41
AIR							
% AIR	0.9	12.20	4.80	10.60	25.90	36.20	42.40
Air Travel Time (hours)	0.5	0.83	0.83	1.25	1.25	1.00	1.75
Schedule Frequency	9	12	8	5	5	60	36
Fare ($)	9.50	19.40	23.00	22.68	24.00	16.50	24.50
Value of travel time at $6/hour-person ($)	3.00	5.00	5.00	7.50	7.50	6.00	10.50
Access/egress Cost ($)	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Frequency of Service Cost ($)	2.34	1.75	2.63	4.25	4.25	.35	.57
$AIR	34.84	46.15	50.63	54.43	55.75	42.85	55.57
$AIR/$AUTO	2.475	2.18	1.715	1.655	1.46	.945	.89



MODAL SPLIT

$$\% \text{ AIR} = \frac{\text{AIR PATRONAGE}}{(\text{AIR} + \text{AUTO}) \text{ PATRONAGE}}$$

$$\% \text{ AIR} = \frac{1}{1 + \left(\frac{\$ \text{ AIR}}{.82 \ \$ \text{ AUTO}}\right)^{3.5}}$$

Figure I-3

(1) See footnote on page A-7

Thus the modal split equation is:

$$\% \text{ AIR} = \frac{1}{1 + \left(\frac{\$\text{AIR}}{.82\ \$\text{AUTO}}\right)^{3.5}}$$

$$\% \text{ AUTO} = \frac{1}{1 + \left(\frac{.82\ \$\text{AUTO}}{\$\text{AIR}}\right)^{3.5}}$$

$$\% \text{ AIR} + \% \text{ AUTO} = 100\%$$

This equation is used to determine the modal split between the air and auto modes in the system analysis. The only differences are that the access times and costs are calculated in detail for each air terminal (see Airport Access Time and Costs, page I-31) and that only jet flights are assumed.

Discussion of the Modal Split Equation:

The calibrated model curve fits the data fairly adequately and satisfies the two qualitative criteria necessary for realistic modeling.

The three basic premises which buttress this modal split technique are, in review:

1. The appropriate median value of time for the entire travel market is \$6/hour;
2. In the process of calculating the total perceived cost for each mode on each route no important costs are overlooked, no extraneous costs are entered, and the costs are recorded with the appropriate relative magnitude.
3. The large majority of travelers actually compute each mode's total cost in a manner consistent with assumptions 1 and 2, and the resultant relative costs of each kind of service is the basis for choosing a mode; the typical traveler will choose that mode which has the lowest total perceived cost.

Hence, if \$AIR = \$AUTO (at \$6/hour, value of time), then for 50 percent of the market with higher values of time, AIR is more attractive than AUTO (i.e., \$AIR < \$AUTO). These travelers would "rationally" choose the AIR mode. By similar reasoning, 50 percent of the market would prefer the AUTO mode.

In fact, according to the actual traffic split and the present method for calculating perceived costs, the calibrated model predicts equal AIR and AUTO patronage when \$AIR = .82 \$AUTO. Apparently the private auto mode possesses inherent advantages over the public air mode (not the least of which is passenger independence and routing flexibility) which is accounted for by the factor, K = .82. This suggests that the real perceived magnitude of the cost to the typical AUTO traveler is about 82 percent of the cost calculated as described above (see \$AUTO calculation).

An alternative explanation is that some important constituent cost is omitted in the calculation of the total perceived cost of AIR, or perhaps given too little weight. It could also be possible that the median value of time is actually somewhat less than $6/hour which would have the effect of reducing the relative cost of the AUTO mode in comparison with AIR.

ZONAL DISTRIBUTION OF TRAVEL DEMAND

Having an estimate of total Bay Area travel to Los Angeles does not help an evaluation of the suitability of air terminal location unless this demand can be divided into specific geographic zones. The BASAR Study, Reference 1, projected population, employment and income for each of 98 zones in the nine county Bay region. These projections were, in turn, used in an empirical formula relating travel demand to these variables. Figure I-4 shows 30 super zones each composed of the zones shown on the figure. Figure B-1 in Appendix B shows the location of all 98 zones.

Reference 1 gave demand data for many combinations of possible projections. An analysis of these combinations led to the selection of still another combination of predictions namely one that used the BASAR preferred predictions for employment per capita and income per capita but a reduced population assumption. The selected population growth assumption is half way between a California Department of Finance prediction in 1968 and zero growth.

Since projected population growth varies greatly between zones, a reduction in this growth changes the travel demand distribution between zones for the 1980 and 1985 predictions.

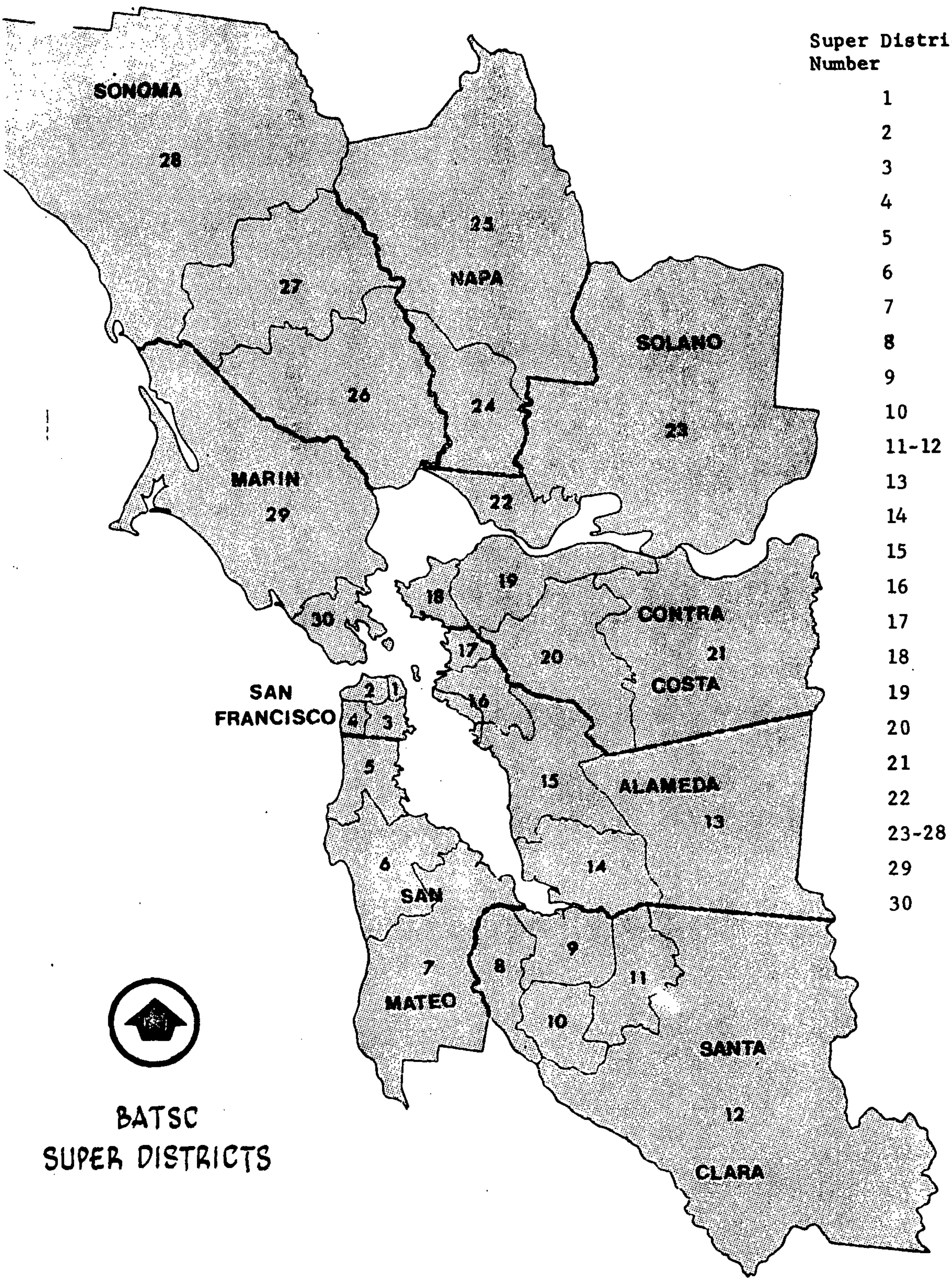
The demand examined by BASAR was for <u>all air travel</u> from the Bay Area but it is reasonable to assume that the distribution among zones will be the same for air travel to and from Los Angeles. The resultant distribution, in percentage of total Los Angeles Area air travel, to and from the Bay Area for each zone is given in Table I-4.

The details of the derivation of the zonal distribution and the total Bay Area air travel are given in Appendix B. Since this study is concerned only with Los Angeles bound air traffic and this is determined by a modal split of the total demand derived in the first section of the travel demand study, only the zonal distribution of Appendix B is actually used in this study. However, the total air travel prediction obtained in Appendix B by modifying the BASAR study is generally consistent with the Los Angeles air travel determined as noted here.

Unfortunately, the same detailed zonal distribution of travelers does not exist for the Los Angeles area. The only available data were found from a 1967 survey by Landrum and Brown (Ref. 4) used in Ref. 5. These data showed the percentage of all Los Angeles travelers originating in 15 zones. Some of the zones were excessively large for use in this study. These zones were further divided, therefore, and the percentage of travelers attributed to the zones split among the sub-zones in accordance with the population distribution shown on the map in Figure I-5. It was then assumed that the percentage of travelers so determined could be applied to the total 1985 Los Angeles area travel.

This approach is not as well based as the finer grid 1985 zonal distributions in the Bay Area which were determined by a judicious selection of possible population and economic trends. The accuracy of the Los Angeles zonal distribution will not significantly affect the essential results of this study, namely the relative economic worth of a 2000 ft. runway STOL system and a 3000 ft. runway RTOL system, and community acceptance in the Bay Area.

The results of the Los Angeles area study in terms of the percentage of total Los Angeles traffic originating in each zone are given in Table I-5. It was assumed that these percentages also represented the shares of Bay Area bound traffic generated in each zone.



BATSC
SUPER DISTRICTS

Super District Number	Zonal Equivalents
1	1-3
2	4-6
3	7-10
4	11-13
5	14-17
6	18-20
7	21-24
8	25-27
9	28
10	29-32
11-12	33-39
13	40-42
14	43-46
15	45-49, 68
16	50-56
17	58-61
18	62-65
19	66-67
20	69-70
21	71-72
22	75-76
23-28	77-93
29	94-96
30	97-98

Figure I-4

Table I-4

Distribution of Bay Area Travelers by Zone

ALAMEDA COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
40	1	.20
41	2	.39
42	2	.39
43	1	.20
44	3	.59
45	6	1.18
46	1	.20
47	3	.59
48	8	1.58
49	14	2.76
50	6	1.18
51	6	1.18
52	6	1.18
53	4	.79
54	5	.99
55	5	.99
56	5	.99
57	2	.39
58	4	.79
59	5	.99
60	4	.79
61	5	.99
TOTAL	100	19.70

CONTRA COSTA COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
62	10	1.09
63	4	.44
64	8	.87
65	6	.65
66	7	.76
67	7	.76
68	8	.87
69	6	.65
70	16	1.74
71	15	1.64
72	1	.11
73	7	.76
74	4	.44
TOTAL	100	10.90

MARIN COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
93	9	.54
94	20	1.20
95	26	1.55
96	9	.54
97	26	1.55
98	10	.60
TOTAL	100	5.98

NAPA COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
81	22	.30
82	41	.56
83	5	.07
84	15	.21
85	17	.23
TOTAL	100	1.37

Table I-4 continued

SAN FRANCISCO COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
1	8	1.56
2	17	3.32
3	7	1.37
4	9	1.76
5	8	1.56
6	11	2.15
7	10	1.95
8	5	.98
9	6	1.17
10	7	1.37
11	3	.59
12	5	.98
13	3	.59
TOTAL	100	19.50

SAN MATEO COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
14	6	.88
15	13	1.91
16	3	.44
17	10	1.47
18	13	1.91
19	11	1.62
20	2	.29
21	16	2.34
22	16	2.34
23	6	.88
24	2	.29
TOTAL	100	14.70

SANTA CLARA COUNTY

BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
25	10	2.23
26	8	1.78
27	3	.67
28	4	.89
29	11	2.45
30	5	1.12
31	4	.89
32	9	2.01
33	7	1.56
34	12	2.68
35	8	1.78
36	6	1.34
37	7	1.56
38	4	.89
39	1	.22
TOTAL	100	22.30

SOLANO COUNTY

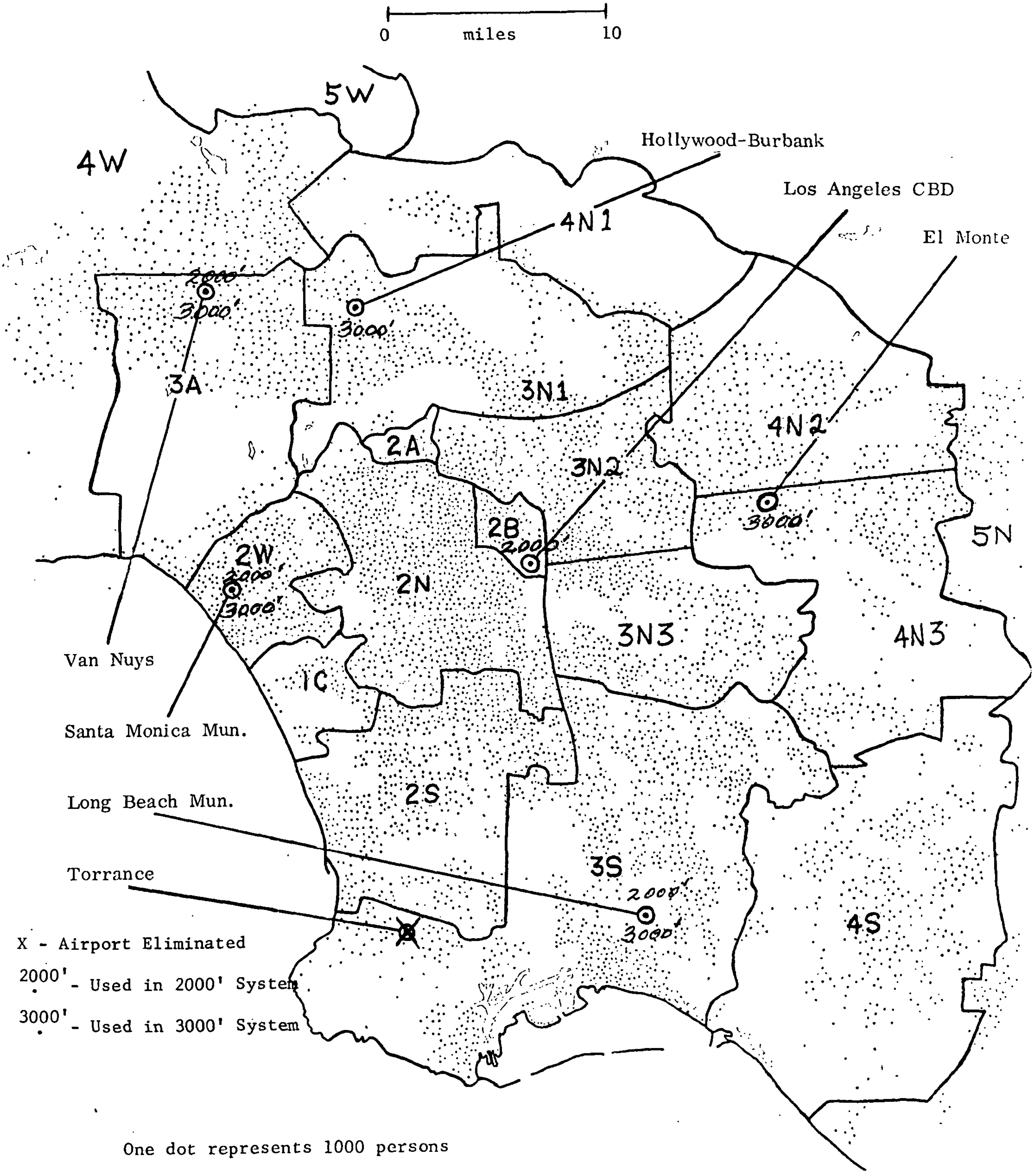
BASAR Zone	% of 1985 Total County Air Traffic	% of 1985 Total Bay Area Air Traffic
75	42	1.09
76	15	.39
77	20	.52
78	2	.05
79	12	.31
80	10	.26
TOTAL	100	2.60

SONOMA COUNTY

86	20	.61
87	12	.36
88	7	.21
89	31	.94
90	12	.36
91	10	.30
92	7	.21
TOTAL	100	3.03

GREATER LOS ANGELES

Travel Zones



One dot represents 1000 persons

Figure I-5

Table I-5

Distribution of Los Angeles Area Travelers by Zone

Zone	Assumed % of 1985 Los Angeles Area Air Traffic
1C	5.47
2A	3.00
2B	9.03
2N	12.83
2S	6.99
2W	7.28
3A	5.86
3N1	3.72
3N2	3.72
3N3	3.72
3S	9.34
4N1	0.80
4N2	3.22
4N3	3.22
4S	7.90
4W	4.50
5N	2.52
5S	5.10
5W	1.77

DISTRIBUTION OF DEMAND BY AIRPORT: AIRPORT ACCESS TIME AND COST

In order to study the relative merits of two air transportation systems, it is necessary to allocate the regional air travel demand among the assumed airports and to determine the travelers' time and cost of access to the most convenient terminal. This has been done by determining the closest air terminal for each geographic zone, and assigning the travel demand from the zone to that air terminal. The average time of access for each zone was calculated by measuring the distance on city streets and on freeways to the terminal and assuming average speeds of 30 miles per hour on streets and 55 miles per hour on freeways. An allowance of 12 minutes is allowed for parking, ticketing and boarding except at San Francisco airport for which a 20 minute allowance is added.

In this analysis, it is assumed that the passengers generated by each zone originate at the center of that zone, and that the passengers will use the air terminal requiring the least enroute travel time.

Access cost (out-of-pocket cost) is calculated using a perceived automobile cost of 5 cents per mile and an average parking cost of $2.00. It is further assumed that the egress cost for the arriving passenger is the same, i.e., the increase in taxi or limousine cost over the automobile compensates for the lack of a parking charge.

Airport demand, access time and cost were originally determined for two sets of six airports in the Bay Area and in the Los Angeles area. The first set assumed a CBD (Central Business District) airport and uses 5 additional logically spaced airports. The runway requirement is 2000-ft. The second set precluded a CBD terminal and therefore uses San Francisco Airport in the Bay Area and Burbank Airport in the Los Angeles area to avoid a degradation of service to downtown users. 3000-ft runway requirements are basically assumed although the impact of a 2000-ft runway requirement on this system is also noted. Runway length itself, of course, does not affect access time and cost or demand. The two original airport sets in the Bay Area were:

System with CBD (Basically the 2000 ft. runway system)

CBD, San Francisco (located one mile south of San Francisco approach to the Bay Bridge

San Carlos Airport, San Mateo Co.

San Jose Municipal Airport, Santa Clara Co.

Hayward Air Terminal, Alameda Co.

Buchanan Field, Contra Costa Co.

*Gnoss Field, Marin Co.

System without CBD (Basically the 3000 ft. runway system

San Francisco International

Palo Alto Municipal Airport, Santa Clara Co.

San Jose Municipal Airport, Santa Clara Co.

Hayward Air Terminal, Alameda Co.

Buchanan Field, Contra Costa Co.

*Gnoss Field, Marin Co.

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* Eliminated in final system

In the Los Angeles area, the corresponding airport sets are:

System with CBD

CBD, Los Angeles (General Patton)

*El Monte Airport

Long Beach Municipal Airport

*Torrance Airport

Santa Monica Airport

Van Nuys Airport

System without CBD

Hollywood-Burbank Airport

El Monte Airport

Long Beach Municipal Airport

*Torrance Airport

Santa Monica Airport

Van Nuys Airport

Table I-6 gives the 1985 percentage of total Bay Area demand associated with each Bay Area airport, and the demand itself in annual one-way trips. Note that this is total traffic if all demand moved by air. The modal split procedure will determine how much of this traffic actually moves by air.

Table I-8 lists similar data for Los Angeles.

Combining these percentages gives the airport-pair demand, e.g., the demand from Hayward is split among the 6 southern terminals in accordance with the percentage share of total Los Angeles demand assigned to those terminals.

The airport-pair total demand, access time and cost is summarized in Tables I-10, I-12 and I-13. The details of the calculations of access cost, access time and percentages of total demand for each zone and each airport are shown in Tables C-1 to C-16 in Appendix C.

The first computer analysis results showed that the traffic generated by El Monte, Torrance and Gnoss Airports was inadequate to sustain a high density service for the systems with the CBD. Torrance and Gnoss were inadequate for the systems without the CBD. These airports were eliminated from the system and the values of demand, access time and cost recalculated. Thus the original systems with 6 airports at each end were changed to 5 STOLports in the Bay Area and 4 STOLports in the Los Angeles area for the 2000-ft system, and 5 RTOLports in the Bay Area and 5 RTOLports in the Los Angeles area for the 3000-ft system.

The location of the airports are shown in Figures I-5 on page I-29 and I-6 on page I-44. Table I-11 lists the air distance ofr each airport pair.

The revised airport demands, access times and costs are given in Tables I-7, I-9, I-14, I-15 and I-16.

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* Eliminated in final system

Table I-6

1985 Bay Area Total Demand Associated with Each Airport

(Demand is total San Francisco-Los Angeles corridor traffic, all modes)
Total Bay Area Demand with Respect to Los Angeles = 40,567,000

System 2000-ft (CBD) →

Airport	CBD	San Carlos	San Jose	Hayward	Buchanan	Gnoss
% of Bay Area Demand	31.65	15.12	18.85	12.39	12.17	8.71
Annual Demand (1-way trips)	12,840,500	6,133,500	7,646,600	5,026,300	4,937,000	3,533,400

System 3000-ft (No CBD) →

Airport	San Francisco	Palo Alto	San Jose	Hayward	Buchanan	Gnoss
% of Bay Area Demand	27.83	10.53	18.18	19.44	13.15	9.76
Annual Demand (1-way trips)	11,290,100	4,271,700	7,375,200	7,886,300	5,334,600	3,959,400

Bay Area 6 Air Terminal Systems

Table I-7

1985 Bay Area Total Demand Associated with Each Airport

(Demand is total San Francisco-Los Angeles corridor traffic, all modes)
Total Bay Area Demand with Respect to Los Angeles = 40,567,000

System	2000-ft (CBD) →				
Airport	CBD	San Carlos	San Jose	Hayward	Buchanan
% of Bay Area Demand	35.90	15.12	18.85	12.39	16.60
Annual Demand (1-way trips)	14,564,000	6,133,500	7,646,600	5,026,300	6,734,122
System	3000-ft (No CBD) →				
Airport	San Francisco	Palo Alto	San Jose	Hayward	Buchanan
% of Bay Area Demand	30.58	10.53	18.18	19.44	20.16
Annual Demand (1-way trips)	12,405,400	4,271,700	7,375,200	7,886,300	8,178,307

Bay Area 5 Air Terminal Systems

Table I-8

1985 Los Angeles Area Total Demand Associated with Each Airport

(Demand is Total Los Angeles-San Francisco corridor traffic, all modes)
Total Los Angeles Area Demand with Respect to Bay Area = 40,567,000

System 2000-ft (CBD) →

Airport	CBD	El Monte	Long Beach	Torrance	Santa Monica	Van Nuys
% of Los Angeles Area Demand	32.30	8.96	22.34	6.99	12.75	16.65
Annual Demand (1-way trips)	12,957,900	3,594,500	8,962,200	2,804,200	5,115,000	6,679,500

System 3000-ft (No CBD) →

Airport	Burbank	El Monte	Long Beach	Torrance	Santa Monica	Van Nuys
% of Los Angeles Area Demand	11.24	12.68	22.34	6.99	34.61	12.13
Annual Demand (1-way trips)	4,509,200	5,086,900	8,962,200	2,804,200	13,884,600	4,866,200

Los Angeles Area 6 Air Terminal Systems

Table I-9

1985 Los Angeles Area Total Demand Associated with Each Airport

(Demand is Total Los Angeles-San Francisco corridor traffic, all modes)
Total Los Angeles Area Demand with Respect to Bay Area = 40,567,000

System	2000-ft (CBD) →				
Airport	CBD		Long Beach	Santa Monica	Van Nuys
% of Los Angeles Area Demand	41.26		25.84	16.25	16.65
Annual Demand (1-way trips)	16,738,000		10,482,500	6,592,100	6,679,500
System	3000-ft (No CBD) →				
Airport	Burbank	El Monte	Long Beach	Santa Monica	Van Nuys
% of Los Angeles Area Demand	11.24	12.68	25.84	38.11	12.13
Annual Demand (1-way trips)	4,509,200	5,086,900	10,482,500	15,460,100	4,866,200

Los Angeles Area 4 and 5 Air Terminal Systems

2000' Runways

Total Traffic		12,840,500	6,133,500	7,646,600	5,026,300	4,937,000	3,533,400
	Origin Dest.	CBD	SCS	SJE	HAY	BUC	GNO
8,962,200	LBH	2,868,568	1,370,224	1,708,250	1,122,875	1,102,926	789,362
3,594,500	ELM	1,150,509	549,561	685,135	450,356	442,355	316,593
6,679,500	VNS	2,137,943	1,021,228	1,273,159	836,879	822,010	588,311
2,804,200	TOR	897,551	428,732	534,497	351,338	345,096	246,985
12,957,900	CBD	4,147,481	1,981,120	2,469,852	1,623,495	1,594,651	1,141,288
5,115,000	SMA	1,637,164	782,021	974,941	640,853	629,467	450,508

3000' Runways

Total Traffic		11,290,100	4,271,700	7,375,200	7,886,300	5,334,600	3,959,400
	Origin Dest.	SFO	PAO	SJE	HAY	BUC	GNO
8,962,200	LBH	2,522,208	954,298	1,647,620	1,761,799	1,191,750	884,530
5,086,900	ELM	1,431,585	541,652	935,175	999,983	676,427	502,052
4,866,200	VNS	1,369,489	518,157	894,612	956,608	647,087	480,275
2,804,200	TOR	789,178	298,592	515,526	551,252	372,889	276,762
4,509,200	BUR	1,269,007	480,139	828,972	886,420	599,609	445,037
13,884,600	SMA	3,907,504	1,478,435	2,552,557	2,729,448	1,846,305	1,370,348

TABLE I-10

<u>1985 TRAVEL DEMAND</u>
12 Air Terminal Systems
Annual One-Way Trips, All Modes

2000' Runways

Air Distance (statute miles)	Origin Dest.	CBD	SCS	SJE	HAY	BUC	GNO
	LBH	380	361	342	363	379	405
	ELM	370	352	333	354	368	395
	VNS	347	329	309	331	346	372
	TOR	374	355	336	358	363	400
	CBD	363	346	327	348	364	391
	SMA	358	339	321	342	358	384

3000' Runways

Air Distance (statute miles)	Origin Dest.	SFO	PAO	SJE	HAY	BUC	GNO
	LBH	371	353	342	363	379	405
	ELM	362	344	333	354	368	395
	VNS	338	320	309	331	346	372
	TOR	365	347	336	358	373	400
	BUR	344	326	315	336	351	377
	SMA	350	332	321	342	358	384

AIR DISTANCE BETWEEN AIRPORTS (s. mi.)
Straight Line Distance plus 20 miles for Take-off & Landing & In-flight Manuevers
12 Air Terminal Systems
Table I-11

2000' Runways

Access Time (hours)		.359	.384	.421	.430	.497	.580
	Origin Dest.	CBD	SCS	SJE	HAY	BUC	GNO
.472	LBH	.831	.856	.893	.902	.969	1.052
.409	ELM	.768	.793	.830	.839	.906	.989
.413	VNS	.772	.797	.834	.843	.910	.993
.420	TOR	.779	.804	.841	.850	.917	1.000
.363	CBD	.722	.747	.784	.793	.860	.943
.291	SMA	.650	.675	.712	.721	.788	.871

3000' Runways

Access Time (hours)		.566	.407	.416	.471	.514	.575
	Origin Dest.	SFO	PAO	SJE	HAY	BUC	GNO
.472	LBH	1.038	.879	.888	.943	.986	1.047
.415	ELM	.981	.822	.831	.886	.929	.990
.339	VNS	.905	.746	.755	.810	.853	.914
.420	TOR	.986	.827	.836	.891	.934	.995
.424	BUR	.990	.831	.840	.895	.938	.999
.407	SMA	.973	.814	.823	.878	.921	.982

TOTAL ONE-WAY TRIP ACCESS TIME (hours)
12 Air Terminal Systems
Table I-12

2000' Runways

Out-of-Pocket Expenses ($)		2.34	2.39	2.51	2.49	2.75	2.96
	Origin / Dest.	CBD	SCS	SJE	HAY	BUC	GNO
2.62	LBH	4.96	5.01	5.13	5.11	5.37	5.58
2.44	ELM	4.78	4.83	4.95	4.93	5.19	5.40
2.49	VNS	4.83	4.88	5.00	4.98	5.24	5.45
2.50	TOR	4.84	4.89	5.01	4.99	5.25	5.46
2.34	CBD	4.68	4.73	4.85	4.83	5.09	5.20
2.20	SMA	4.54	4.59	4.71	4.69	4.95	5.16

3000' Runways

Out-of-Pocket Expenses ($)		2.57	2.38	2.47	2.62	2.78	2.98
	Origin / Dest.	SFO	PAO	SJE	HAY	BUC	GNO
2.62	LBH	5.19	5.00	5.09	5.24	5.40	5.60
2.57	ELM	5.14	4.95	5.04	5.19	5.35	5.55
2.32	VNS	4.89	4.70	4.79	4.94	5.10	5.30
2.50	TOR	5.07	4.88	4.97	5.12	5.28	5.48
2.50	BUR	5.07	4.88	4.97	5.12	5.28	5.48
2.48	SMA	5.05	4.86	4.95	5.10	5.26	5.46

<u>TOTAL ONE-WAY TRIP OUT-OF-POCKET EXPENSES ($)</u>

12 Air Terminal Systems
Table I-13

2000' Runways

Total Traffic		14,564,000	6,133,500	7,646,600	5,026,300	6,734,100
	Origin / Dest.	CBD	SCS	SJE	HAY	BUC
10,482,500	LBH	3,763,300	1,584,900	1,975,900	1,298,800	1,740,100
6,679,500	VNS	2,424,900	1,021,200	1,273,200	836,900	1,121,200
16,738,000	CBD	6,009,100	2,530,700	3,155,000	2,073,900	2,778,500
6,592,100	SMA	2,366,700	996,700	1,242,600	816,800	1,094,300

3000' Runways

Total Traffic		12,405,400	4,271,700	7,375,200	7,886,300	8,178,300
	Origin / Dest.	SFO	PAO	SJE	HAY	BUC
10,482,500	LBH	3,205,600	1,103,800	1,905,800	2,037,800	2,113,300
5,086,900	ELM	1,573,000	541,700	935,200	1,000,000	1,037,000
4,866,200	VNS	1,504,800	518,200	894,600	956,600	992,000
4,509,200	BUR	1,394,400	480,100	829,000	886,400	919,200
15,460,000	SMA	4,727,700	1,627,900	2,810,700	3,005,500	3,116,800

1985 TRAVEL DEMAND
2000' Runway 9 Terminal and 3000' Runway 10 Terminal Systems
Annual One-Way Trips, All Modes

Table I-14

2000' Runways

Access Time (hours)		.403	.384	.421	.430	.654
	Origin / Dest.	CBD	SCS	SJE	HAY	BUC
.455	LBH	.858	.839	.876	.855	1.109
.413	VNS	.816	.797	.834	.843	1.067
.366	CBD	.769	.750	.787	.796	1.020
.317	SMA	.720	.701	.738	.747	.971

3000' Runways

Access Time (hours)		.589	.407	.416	.471	.654
	Origin / Dest.	SFO	PAO	SJE	HAY	BUC
.455	LBH	1.044	.862	.871	.926	1.109
.415	ELM	1.004	.822	.831	.886	1.069
.339	VNS	.928	.746	.755	.810	.933
.424	BUR	1.013	.831	.840	.895	1.078
.408	SMA	.997	.815	.824	.879	1.062

TOTAL ONE-WAY TRIP ACCESS TIME (hours)
2000' Runway 9 Terminal and 3000' Runway 10 Terminal Systems

Table I-15

2000' Runways

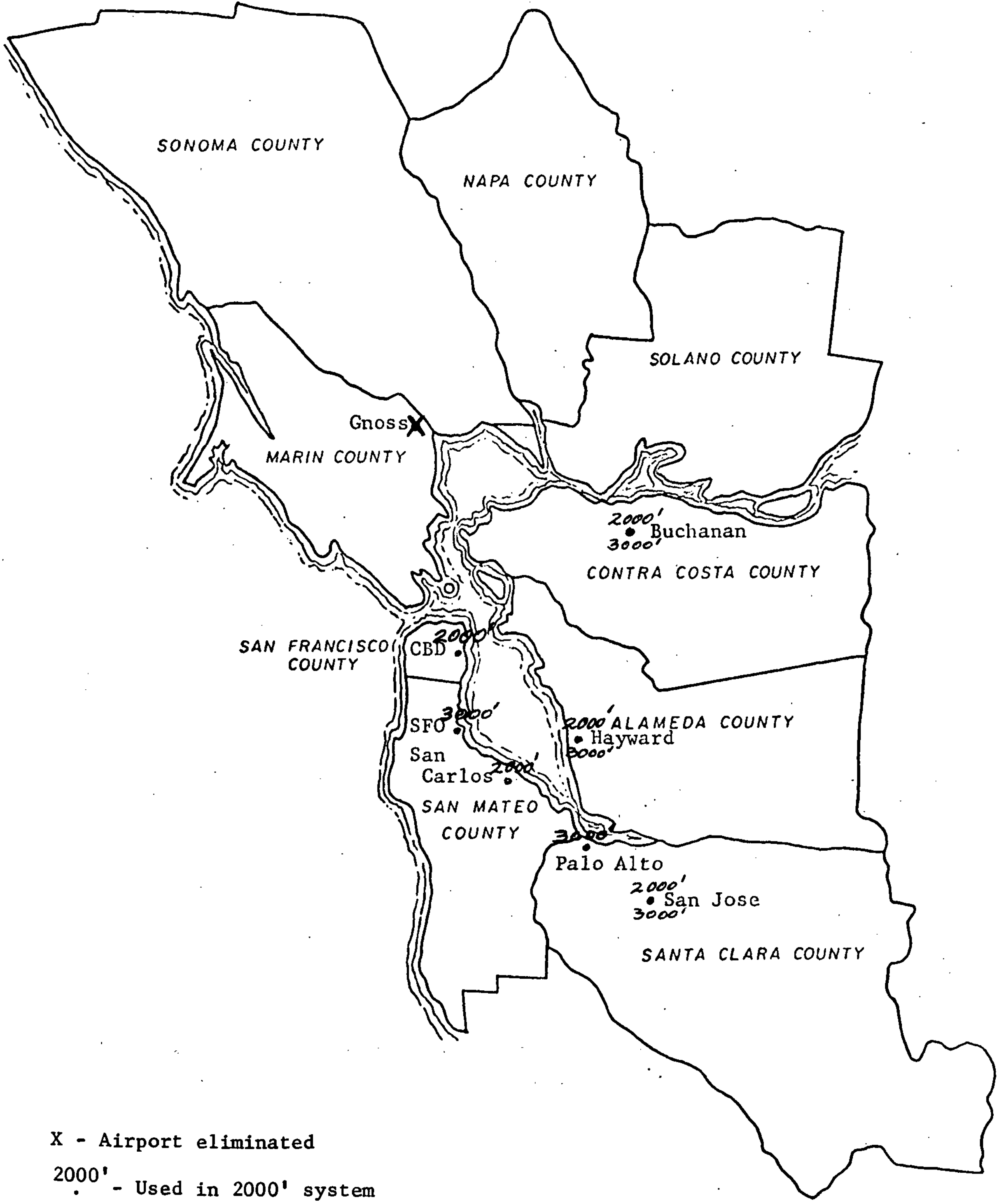
Out-of-Pocket Expenses ($)		2.47	2.39	2.51	2.49	3.08
	Origin / Dest.	CBD	SCS	SJE	HAY	BUC
2.65	LBH	5.12	5.04	5.16	5.14	5.73
2.49	VNS	4.96	4.88	5.00	4.98	5.57
2.51	CBD	4.98	4.90	5.02	5.00	5.59
2.38	SMA	4.85	4.77	4.89	4.87	5.46

3000' Runways

Out-of-Pocket Expenses ($)		2.68	2.38	2.47	2.62	3.19
	Origin / Dest.	SFO	PAO	SJE	HAY	BUC
2.65	LBH	5.33	5.03	5.12	5.27	5.84
2.57	ELM	5.25	4.95	5.04	5.19	5.76
2.32	VNS	5.00	4.70	4.79	4.94	5.51
2.50	BUR	5.18	4.88	4.97	5.12	5.69
2.53	SMA	5.21	4.91	5.00	5.15	5.72

TOTAL ONE-WAY TRIP OUT-OF-POCKET EXPENSES ($)
2000' Runway 9 Terminal and 3000' Runway 10 Terminal Systems

Table I-16



X - Airport eliminated

2000'
• - Used in 2000' system

3000'
• - Used in 3000' system

Figure I-6

References

1) Systems Analysis and Research Corporation, "Bay Area Study of Aviation Requirements - Aviation Forecast," May 1970.

2) California Division of Highways, "1970 Traffic Volumes on the California State Highway System."

3) California Department of Finance, "Preliminary (Population) Projections of California Areas and Counties to 1985," Sacramento, April 20, 1967.

4) Landrum and Brown, "Survey of Los Angeles International Airport Scheduled Air Passenger Market," 1967.

5) McDonnell Douglas Corporation (Douglas Aircraft Company), "STOL System Feasibility Study," PR71-STOL-9286-1, April 19, 1971.

VECHICLE TECHNOLOGY

Introduction

A correct analysis of the worth of any system requires as accurate a statement as possible of the characteristics of all of the parts. There are so many inputs to an air transportation system that significant distortions of any of the many aspects of the system can warp the answers. With a little bit of expertise, it is possible to tilt a dozen inputs to bend the answer in the desired direction.

Obviously the characteristics of the vehicle itself are among the most significant items in the analysis. In a comparative study such as this one, there are two aspects of accuracy involved in selecting vehicle characteristics; one is the level of the numbers, i.e., are they correct?, and the other is the consistency of the data, i.e., are the differences between the configurations being studied properly represented? Both aspects are important but in a comparison of alternate systems, consistency is probably more important.

This study of the relative costs and benefits of a 2000 ft. STOL system and a 3000 ft. RTOL system must depend most critically on the difference between the costs of the two aircraft types although the proper cost level of both should be determined as closely as possible.

With these thoughts in mind, the aircraft characteristics were taken from a recent Douglas aircraft study for NASA-Ames entitled "Study of Quiet Turbofan STOL Aircraft for Short Haul Transportation." (Ref. 1) The Douglas study was based on a consistent analysis of various propulsive lift systems, passenger capacities, and required runway lengths. The aircraft weights and drags are consistent with methods that correlate with existing aircraft, modified by wind tunnel data and analysis for the new systems, such as propulsive lift, innovative power plants and acoustically designed nacelles required to meet the field length and noise criteria. The aircraft were basically designed to a noise level of 95 EPNdb at 500 ft. sideline except where relaxation of 1 to 2 EPNdB gave a very disproportionate improvement in operating cost.

A study of the Douglas data showed that at required runway lengths of 2000 ft. to 3000 ft. the externally blown flap (EBF) aircraft yielded the lowest direct operating costs. Although some alternate lift systems may be competitive, particularly for the 2000 ft. field length, use of EBF data is clearly representative of the lower bound of operating costs. Therefore this study is based on the Douglas EBF aircraft performance and costs. The type of aircraft is shown in Figures II-1 and II-2 taken from the Douglas study.

Required Vehicle Parameters

To determine the relative economic merits of a short-haul transportation system utilizing either Short Take-Off and Landing (STOL) aircraft or Reduced Take-Off and Landing (RTOL) aircraft, the following vehicle-determined parameters are required:

1) Direct Operating Costs (DOC) of both aircraft types for varying ranges, aircraft passenger capacities, and aircraft production quantitites.

2) Aircraft Acquisition Costs of both aircraft types for varying passenger capacities and production quantities.

3) Block Time of both aircraft types for different ranges.

4) Take-off weights and maximum dimensions for airport analysis.

Source of Vehicle Data

As discussed above, to properly compare the STOL and RTOL systems the vehicle parameters must be realistic and, above all, consistent. Therefore the vehicle-determined parameters have been primarily calculated from data supplied by one source, the Douglas Aircraft Co. study "Study of Quiet Turbofan Aircraft for Short-Haul Transportation," Phase I and II, 1972, prepared for NASA's Ames Research Center. Some Lockheed data has been used to verify basic trends as noted below.

Determination of Direct Operating Cost, DOC

Curves relating DOC (cents/available seat statute mile) to range (statute miles) were obtained for baseline STOL and RTOL aircraft designs with specific passenger capacities and production quantities. To simplify input to the computerized systems analysis, it was desirable to seek basic curves to correct for the effects of passenger capacity and production quantity rather than work with a vast family of DOC vs. range curves, each curve for a different field length, capacity, and production quantity.

To investigate the effect of aircraft passenger capacity on DOC, a graph of DOC normalized to the DOC for a 100-passenger aircraft ($DOC/DOC_{100\ pass}$) vs. Passenger Capacity was constructed using data from 8 different Phase I level STOL and RTOL aircraft designs. The resulting curve is shown in Figure II-4(1), "Passenger Capacity Correction for DOC," and indicates that $DOC/DOC_{100\ pass}$ is independent of aircraft lift system and required field length to within ± 4%. Note that Figure II-4 is based on DOC data for a single range, 575 statute miles. When DOC data for different ranges became available, values of $DOC/DOC_{100\ pass}$ for ranges of 200 and 400 miles were computed and found to be the same as that for 575 miles within ± 1.7%. Thus $DOC/DOC_{100\ pass}$ is also independent of range to the accuracy of the data available. As a final check of Figure II-4, values of $DOC/DOC_{100\ pass}$ for the Phase II Douglas final level aircraft and two Lockheed points were plotted when the data became available. They fall well within the original band of data. Consequently, a single curve can be used to evaluate the effect of passenger capacity on DOC for both STOL and RTOL aircraft at any desired range.

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(1) Data points are designated by the Douglas notation, i.e., E = externally blown flap, A = augmentor wing, M = mechanical flap; 100, 150, or 200 designates passenger capacity and the last number, 2000, 3000, or 4000 signifies field length in feet.

Similarly, to investigate the effect of production quantity on DOC, a graph of DOC normalized to DOC for a production quantity of 400 (DOC/DOC_{400}) vs. Production Quantity was constructed using data from 7 different STOL and RTOL designs. The resulting curve is shown in Figure II-6, "Production Quantity Correction for DOC," and indicates that DOC/DOC_{400} is a function of production quantity only and is independent of aircraft lift type, field length, and passenger capacity to within ± 1%. Thus a single curve can be used to evaluate the effect of production quantity on DOC for both STOL and RTOL aircraft.

The level of the DOC* was obtained from Douglas Aircraft in the form of curves of DOC vs. range for an externally blown flap, 150-passenger, STOL aircraft requiring a 2000-ft runway (E-150-2000) and an externally blown flap, 150-passenger, RTOL aircraft requiring a 3000-ft runway (E-150-3000). These curves are based on a production quantity of 400 and are shown in Figure II-3, "DOC vs. Range for STOL (E-150-2000) and RTOL (E-150-3000) Final Level Aircraft." Because the final DOC data is based on 150 passengers, the passenger capacity correction curve for DOC has been adjusted to give $DOC/DOC_{150\ pass}$ vs. Passenger Capacity (Figure II-5).

Figures II-3, II-5 and II-6 allow the simple calculation of DOC for any combination of range, passenger capacity, and production quantity for STOL and RTOL aircraft by use of the following formula:

$$DOC_{d,N,Q} = DOC_{d,150,400} \times \frac{DOC_N}{DOC_{150\ pass}} \times \frac{DOC_Q}{DOC_{400}}$$

where: $DOC_{d,N,Q}$ is the DOC in cents/ASSM of a STOL or RTOL aircraft for a range of d (statute miles), a passenger capacity of N, and a production quantity of Q.

$DOC_{d,150,400}$ is taken from Figure II-3, "DOC vs. Range for STOL and RTOL Final Level Aircraft"

$DOC_N/DOC_{150\ pass}$ is taken from Figure II-5, "Passenger Capacity Correction Curve for DOC of STOL and RTOL Aircraft"

DOC_Q/DOC_{400} is taken from Figure II-6, "Production Quantity Correction Curve for DOC of STOL and RTOL Aircraft."

Determination of Initial Aircraft Cost

The aircraft costs for the RTOL (E-150-3000) and STOL (E-150-2000) final level aircraft were given by Douglas as $\$10.518 \times 10^6$ and $\$13.385 \times 10^6$ respectively based on a production quantity of 400. It was felt that 30% should be added to the aircraft price to account for spare parts and equipment. Thus the total acquisition costs are the following:

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* After the system analysis was complete, it was learned that these basic DOC curves were based on a utilization of 2500 hours per year instead of the 3000 hours per year value used in this study (see pg. IV-4). It is believed that high density routes will be able to achieve a utilization of 3000 hours per year. If the direct operating costs had been based on 3000 hours per year, the DOC would have been approximately 6% lower, and the fares about 3% lower. Since the correction would apply to both the 2000-ft and the 3000-ft systems, there is no significant effect on the subject of this study, i.e., the relative efficiency of the two systems.

$\$13.7 \times 10^6$ for the RTOL aircraft (E-150-3000)

$\$17.4 \times 10^6$ for the STOL aircraft (E-150-2000)

To account for different production quantities and passenger capacities, production quantity and passenger capacity correction curves for Acquisition Cost similar to those for DOC were constructed from available Douglas data. Figure II-7, "Passenger Capacity Correction for Acquisition Cost of EBF Aircraft," shows that Acq. Cost/Acq. $\text{Cost}_{150\text{ pass}}$ vs. passenger capacity is independent of aircraft field length and production quantity to within ± 1.2%. Figure II-8, "Production Quantity Correction Curve for Acquisition Cost of EBF STOL Aircraft," shows that Acq. Cost/Acq. Cost_{400} vs. Production Quantity is independent of aircraft field length and passenger capacity to within ± 1.3%. Using these curves, the acquisition cost of the STOL and RTOL aircraft may be determined for any production quantity or passenger capacity with the following formula:

$$\text{Cost}_{N,Q} = \text{Cost}_{150,400} \times \frac{\text{Cost}_N}{\text{Cost}_{150\text{ pass}}} \times \frac{\text{Cost}_Q}{\text{Cost}_{400}}$$

where:

$\text{Cost}_{N,Q}$	is the acquisition cost for a STOL or RTOL aircraft with a passenger capacity of N and a production quantity of Q
$\text{Cost}_{150,400}$	is the listed acquisition cost for the STOL or RTOL aircraft
$\text{Cost}_N/\text{Cost}_{150\text{ pass}}$	is taken from the Passenger Capacity Correction Curve for Acquisition Cost (Figure II-7)
$\text{Cost}_Q/\text{Cost}_{400}$	is taken from the Production Quantity Correction Curve for Acquisition Cost (Figure II-8).

Determination of Formula for Block Time

The final level curve of Block Time (hours) vs. Range (statute miles) for both STOL and RTOL aircraft was obtained from Douglas and is shown in Figure II-9. Because the curve was a straight line, the formula for block time was easily determined and found to be the following:

$$T = .215 + .002087\, d$$

where T is the block time in hours

d is the range in statute miles.

Aircraft Weights and Dimensions

The aircraft weights and dimensions are shown in Table II-1 and Figures II-1 and II-2.

Fuel Consumption

One major difference between the 2000-ft STOL and the 3000-ft RTOL aircraft is the fuel consumption. The heavier, larger STOL aircraft use approximately 35% more fuel per passenger mile. Fuel burned data are plotted as a function of range in Figure II-10. The data are for the 150 passenger aircraft with externally blown flap from Reference 1.

EXTERNALLY BLOWN FLAP AIRCRAFT

FINAL DESIGN AIRCRAFT

150 PASSENGERS 2000 FT. (610 M.) FIELD LENGTH

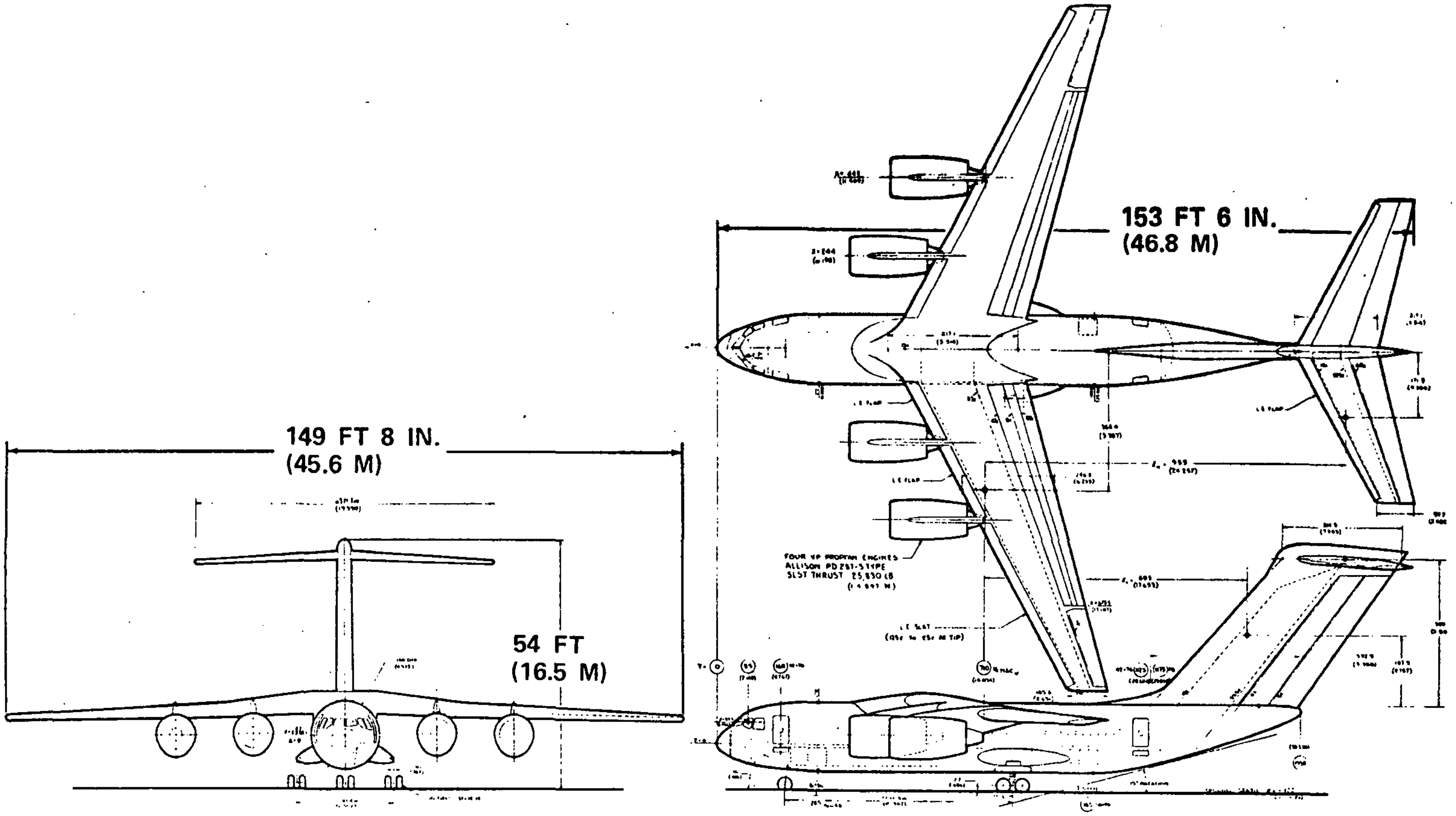


Figure II-1

EXTERNALLY BLOWN FLAP AIRCRAFT

FINAL DESIGN AIRCRAFT

150 PASSENGERS - 3000 FT (914 M) FIELD LENGTH

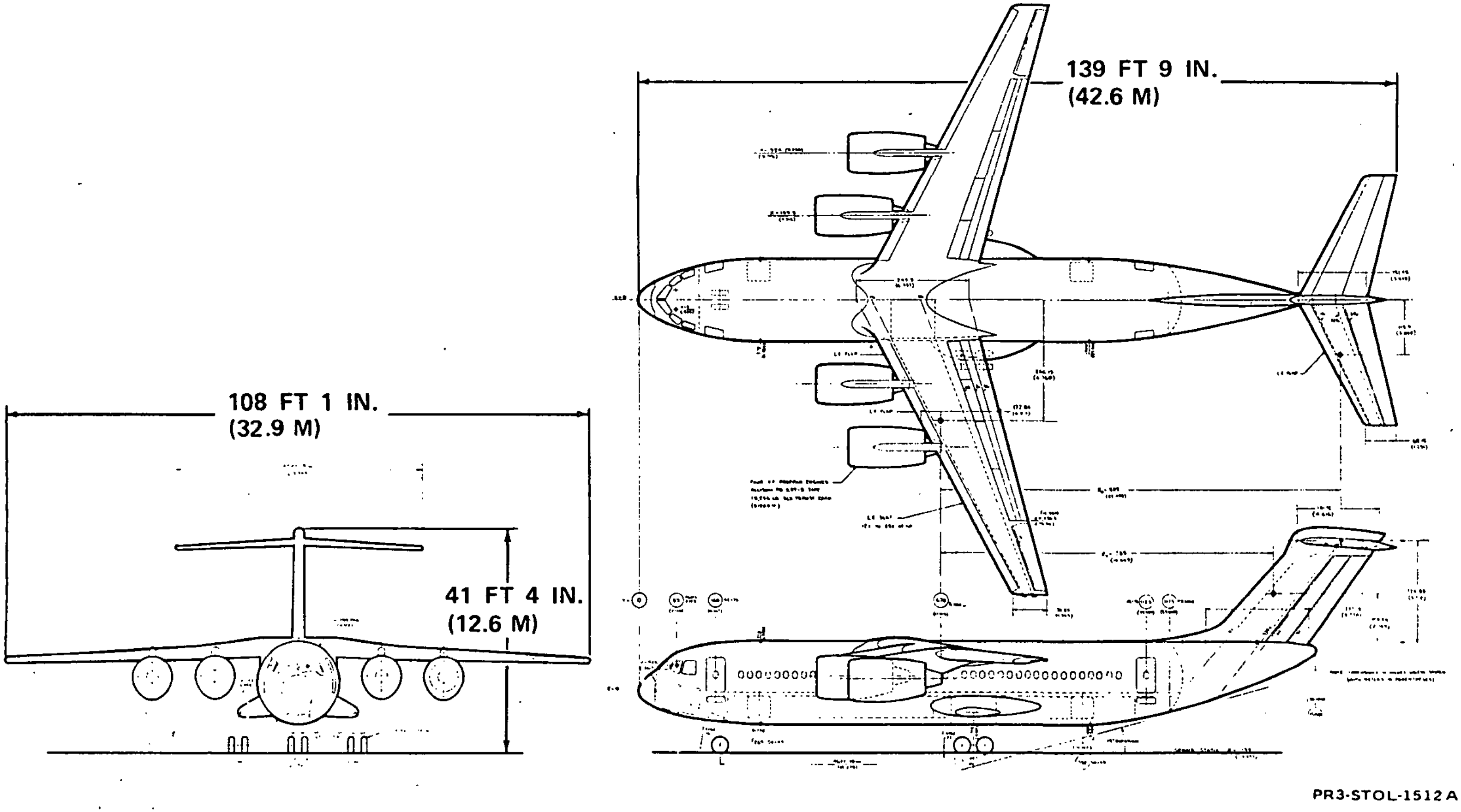
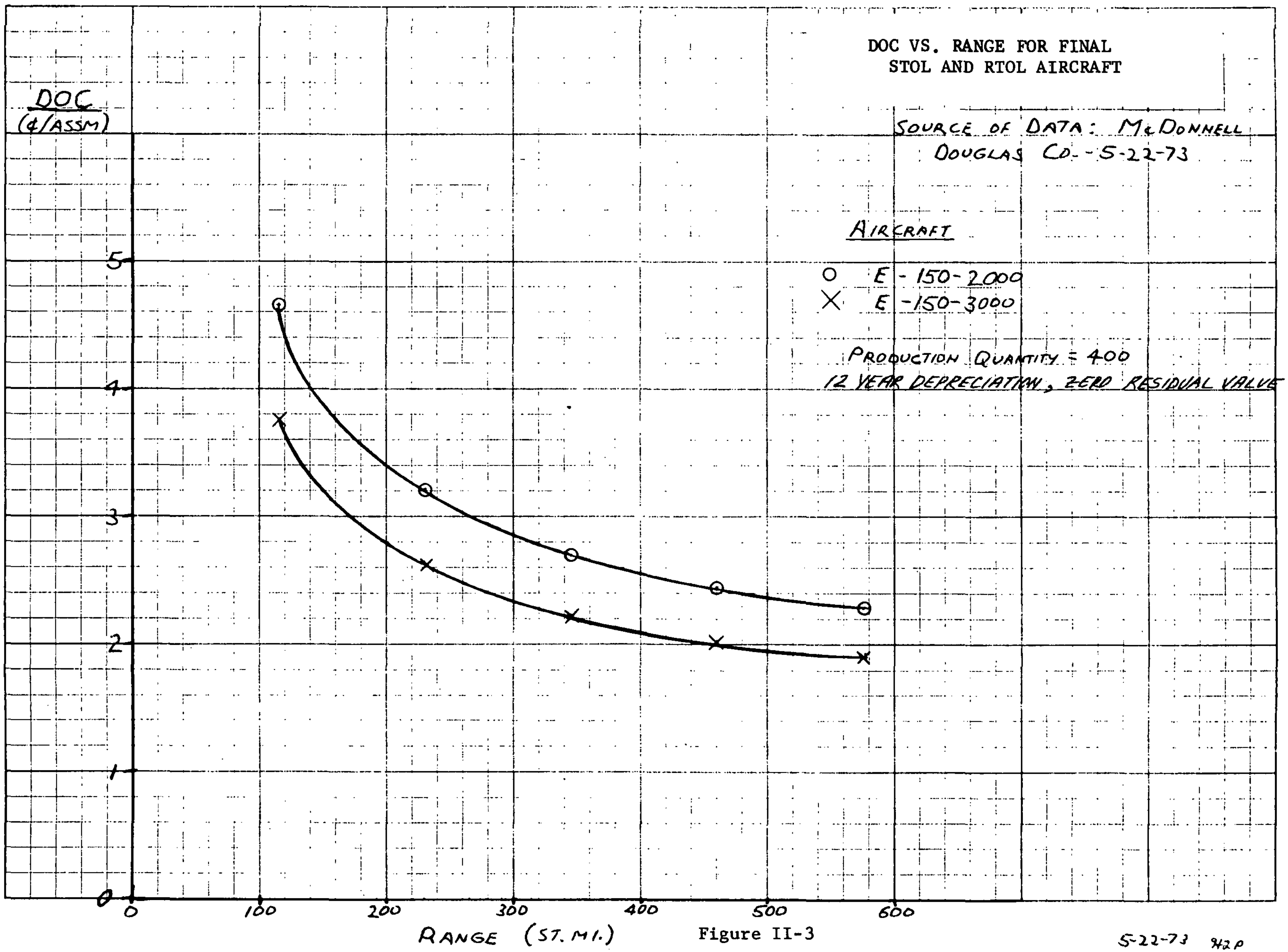


Figure II-2

FINAL DESIGN AIRCRAFT PERFORMANCE SUMMARY

CONFIGURATION		EBF		
PASSENGERS	100	150	200	150
DESIGN FIELD LENGTH (FT)	3000	3000	3000	2000
TOGW (LB)	104,060	149,030	192,030	196,000
WING AREA (SQ FT)	991	1,461	1,920	2,800
THRUST/ENGINE (LB)	13,200	18,260	22,920	25,830
WING LOADING (LB/SQ FT)	105	102	100	70
THRUST TO WEIGHT RATIO	0.508	0.490	0.478	0.527
NUMBER OF ENGINES	4	4	4	4
CRUISE MACH NUMBER	0.69	0.69	0.69	0.74
CRUISE ALTITUDE (FT)	25,000	26,000	26,000	30,000

Table II-1

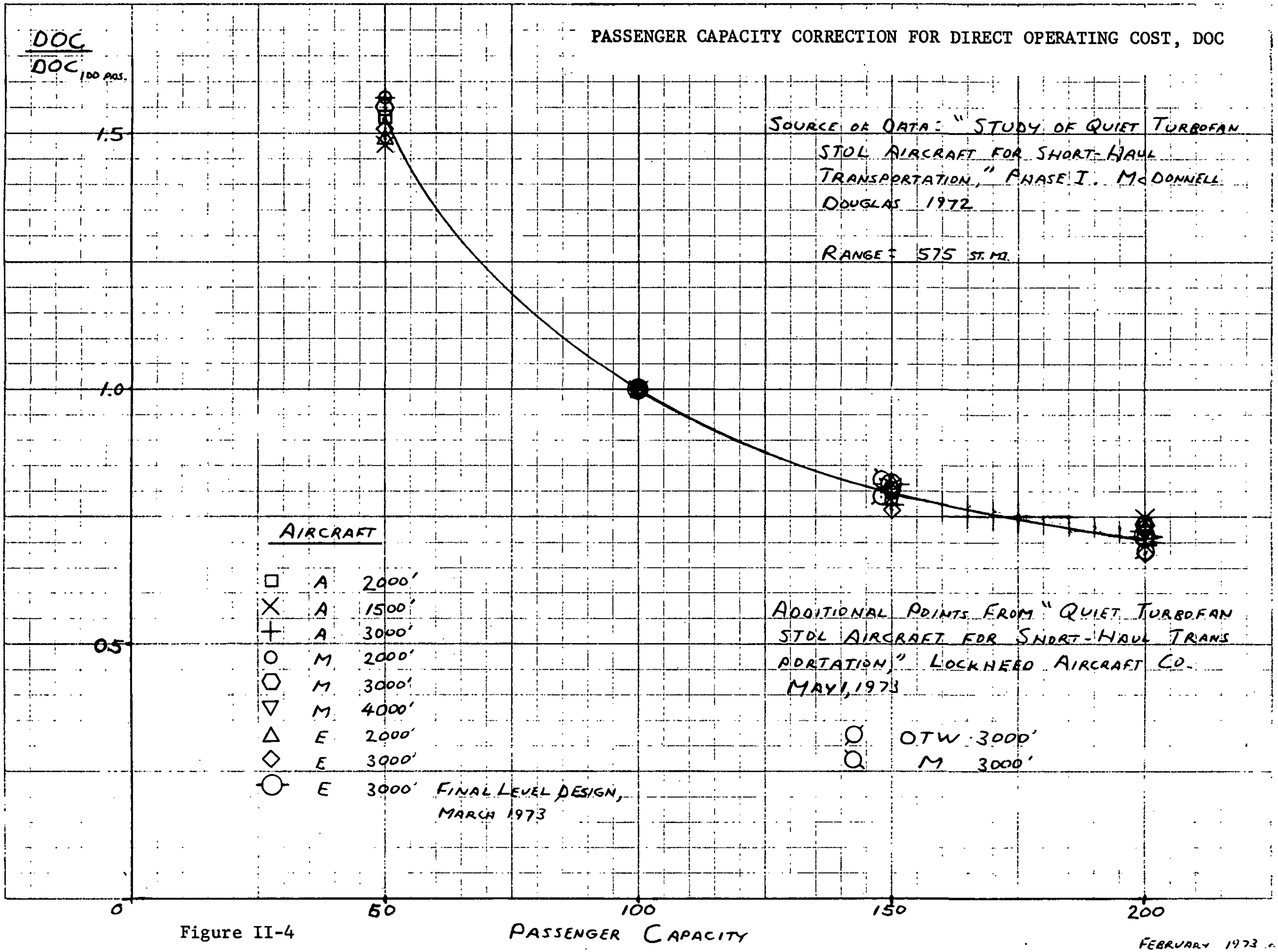

DOC VS. RANGE FOR FINAL
STOL AND RTOL AIRCRAFT

SOURCE OF DATA: McDONNELL
DOUGLAS CO. - 5-22-73

Figure II-3

5-22-73 92p

PASSENGER CAPACITY CORRECTION FOR DIRECT OPERATING COST, DOC



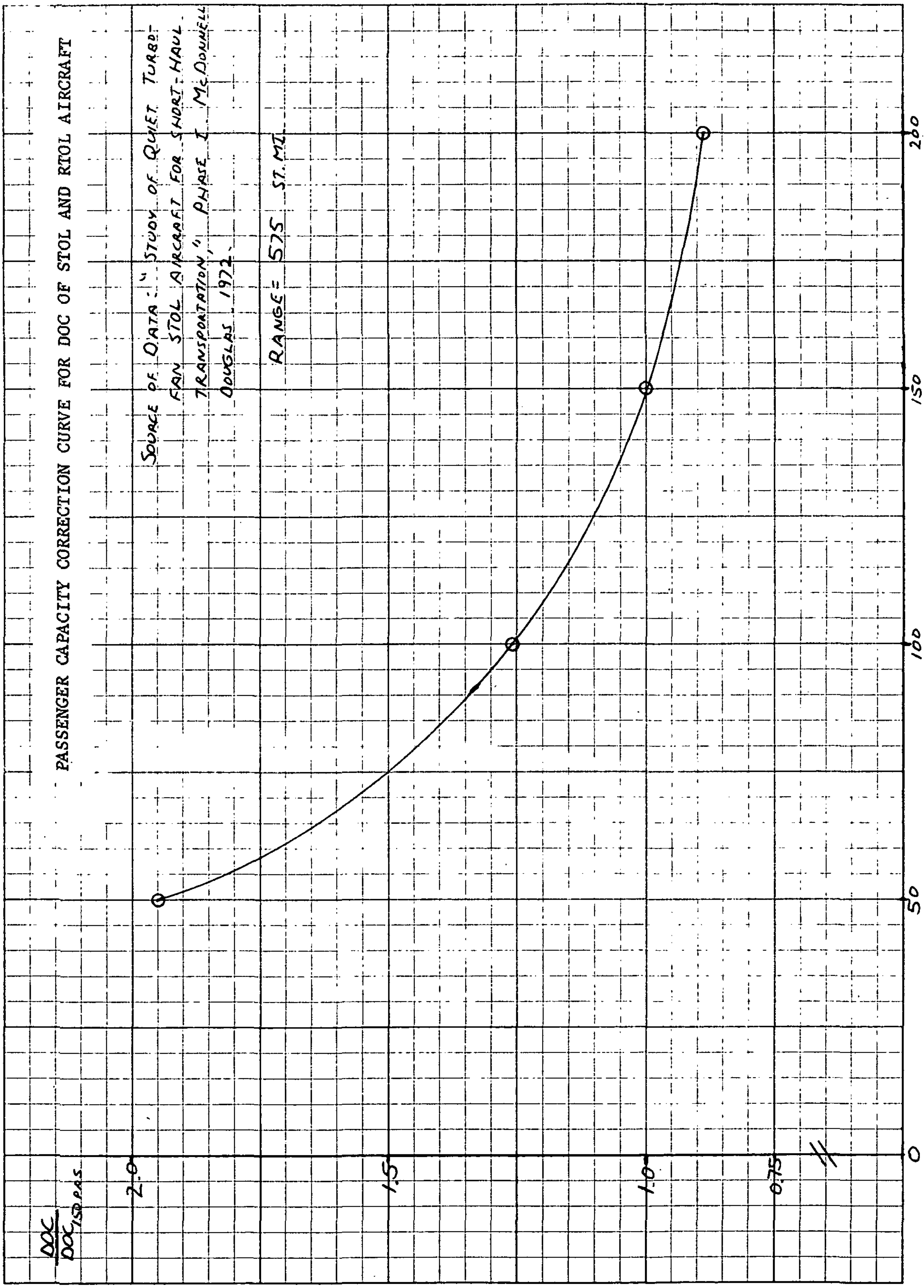
SOURCE OF DATA: "STUDY OF QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION," PHASE I. McDONNELL DOUGLAS 1972

RANGE = 575 ST. MI.

ADDITIONAL POINTS FROM "QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION," LOCKHEED AIRCRAFT CO. MAY 1, 1973

Figure II-4

FEBRUARY 1973



PASSENGER CAPACITY CORRECTION CURVE FOR DOC OF STOL AND RTOL AIRCRAFT

SOURCE OF DATA: "STUDY OF QUIET TURBO-FAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION," PHASE I McDONNELL DOUGLAS 1972.

RANGE = 575 ST. MI.

APRIL 1973

Figure II-5

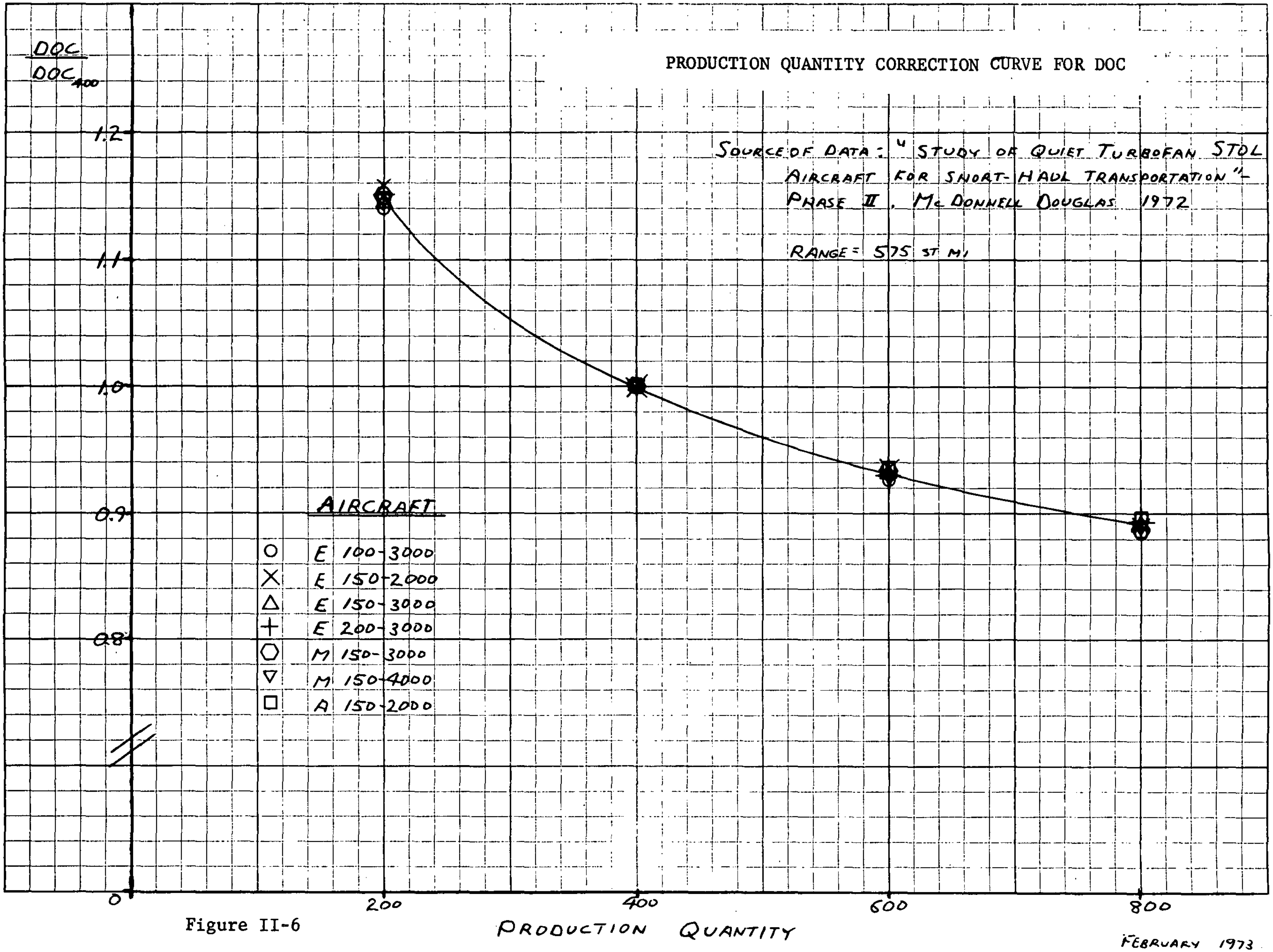
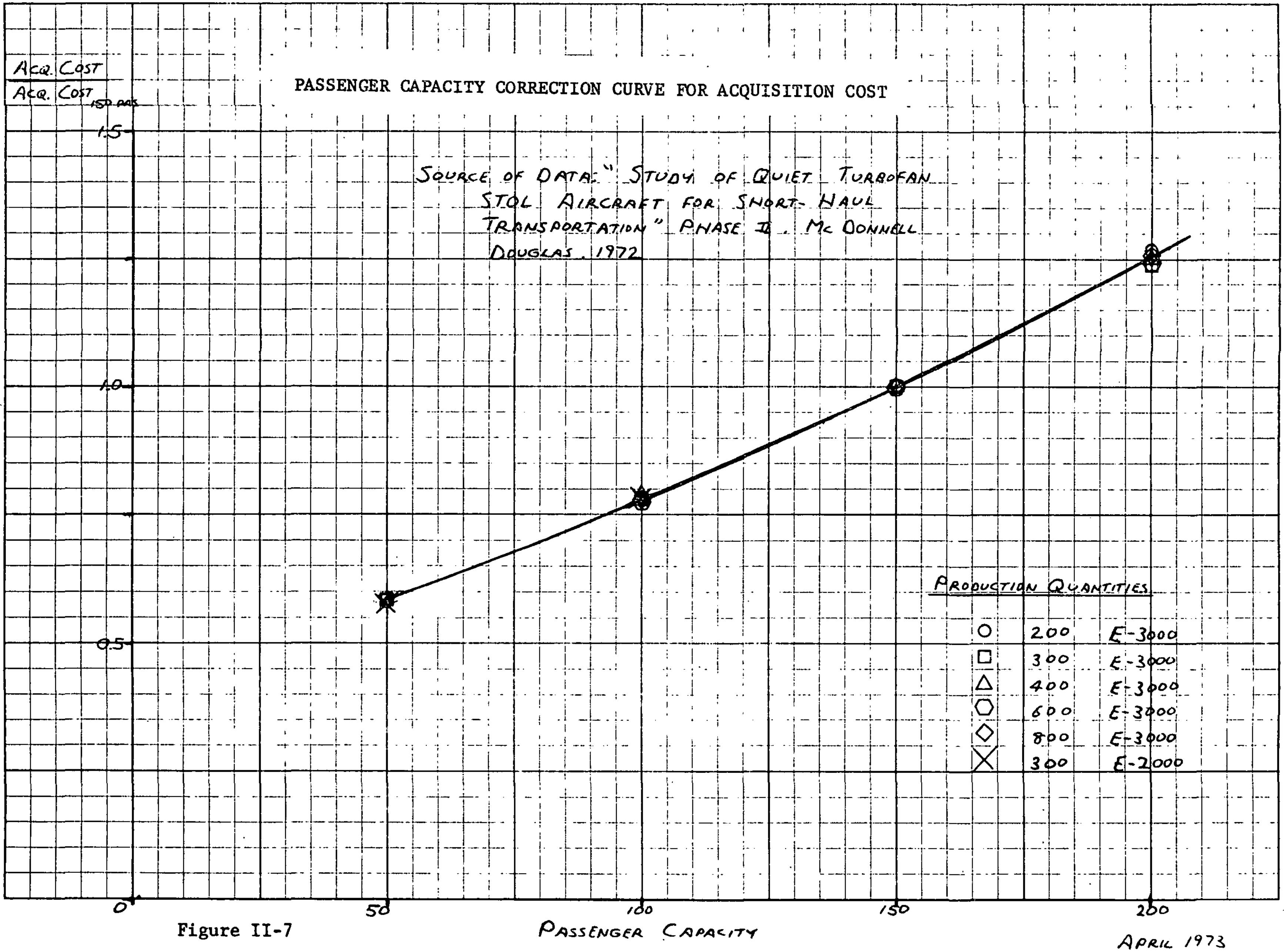

PRODUCTION QUANTITY CORRECTION CURVE FOR DOC

Figure II-6

FEBRUARY 1973

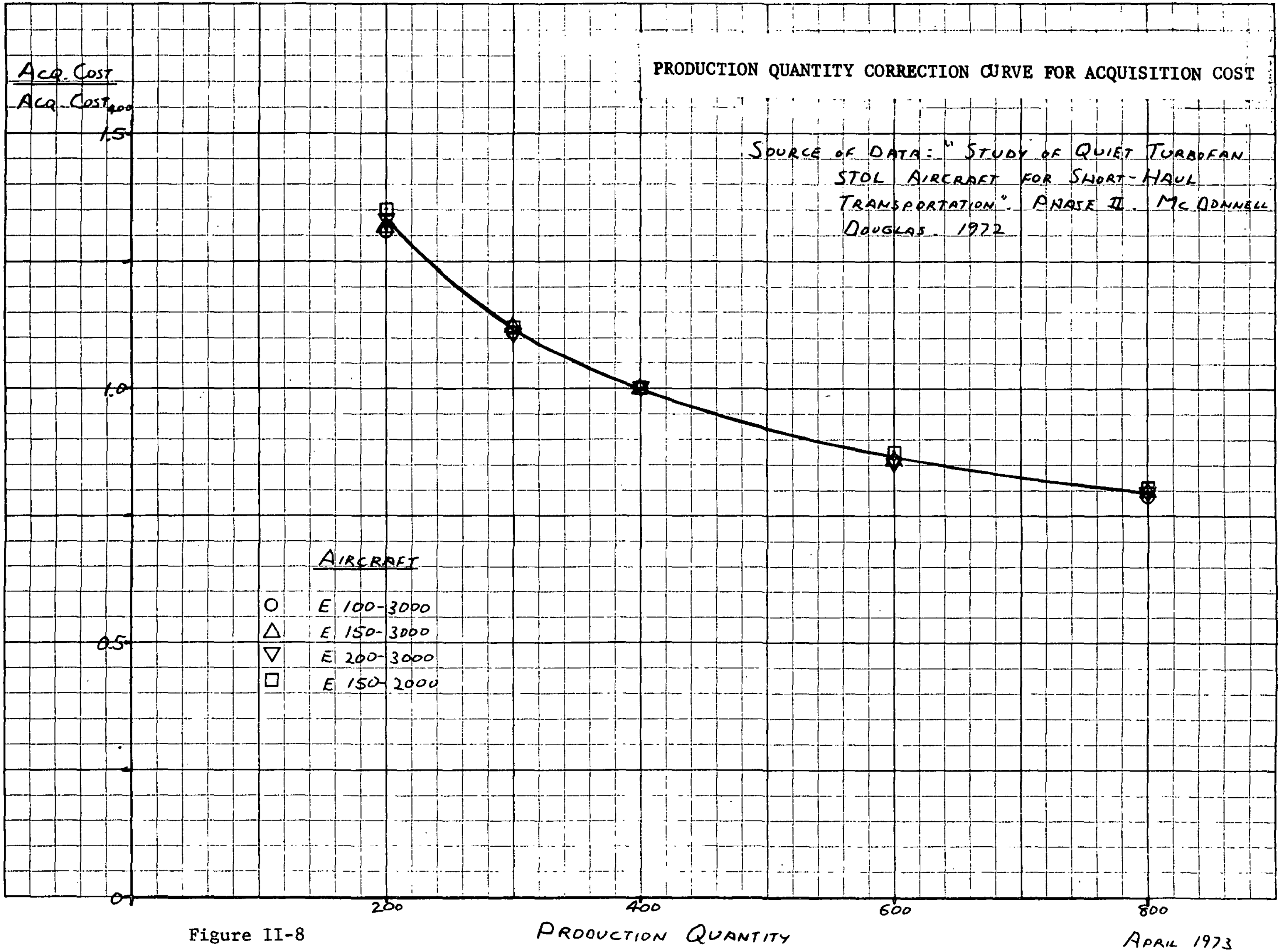


PASSENGER CAPACITY CORRECTION CURVE FOR ACQUISITION COST

SOURCE OF DATA: "STUDY OF QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION" PHASE II. MC DONNELL DOUGLAS. 1972

Figure II-7

APRIL 1973



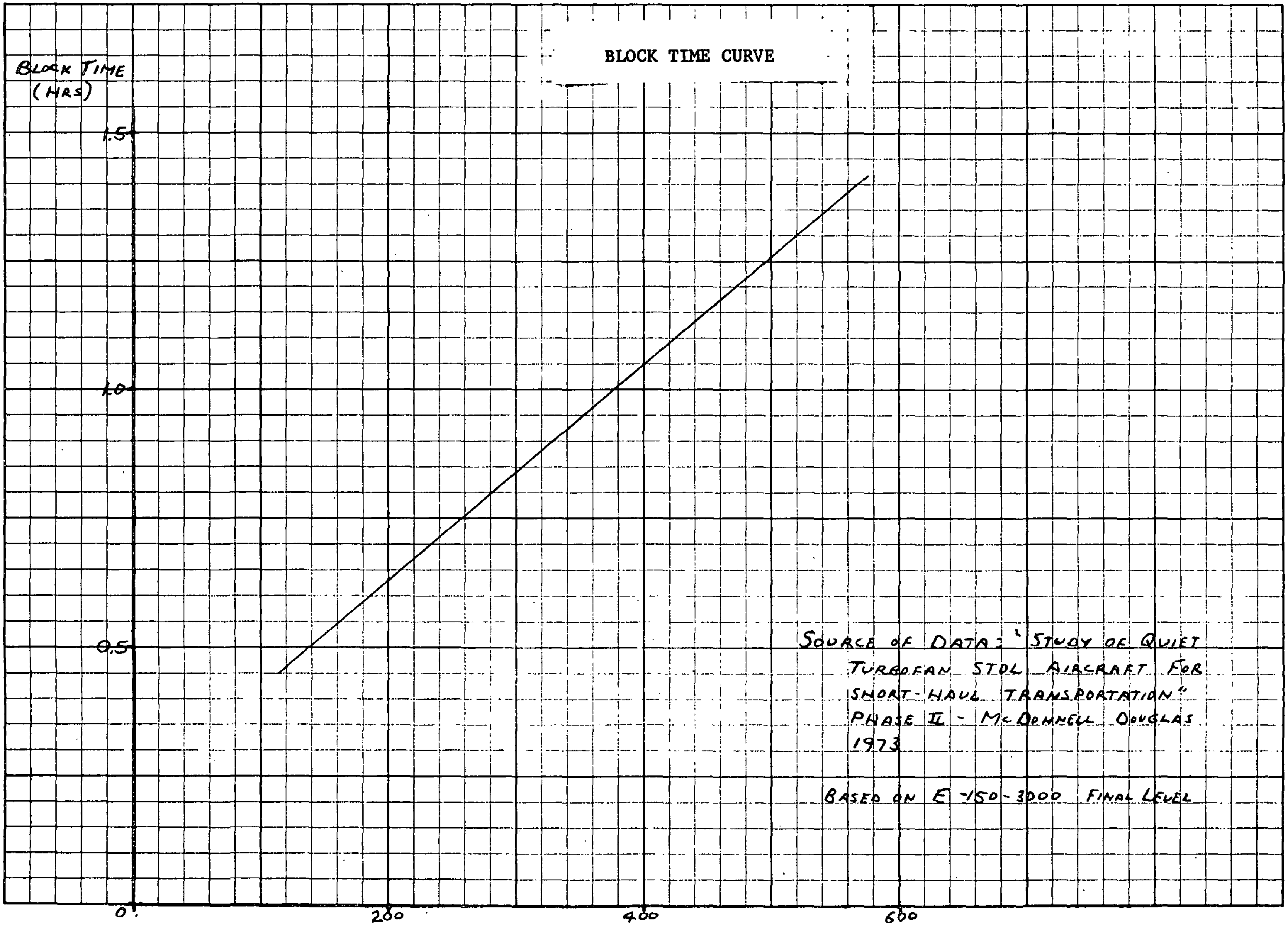
PRODUCTION QUANTITY CORRECTION CURVE FOR ACQUISITION COST

SOURCE OF DATA: "STUDY OF QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION". PHASE II. McDONNELL DOUGLAS. 1972

Figure II-8

APRIL 1973

BLOCK TIME CURVE

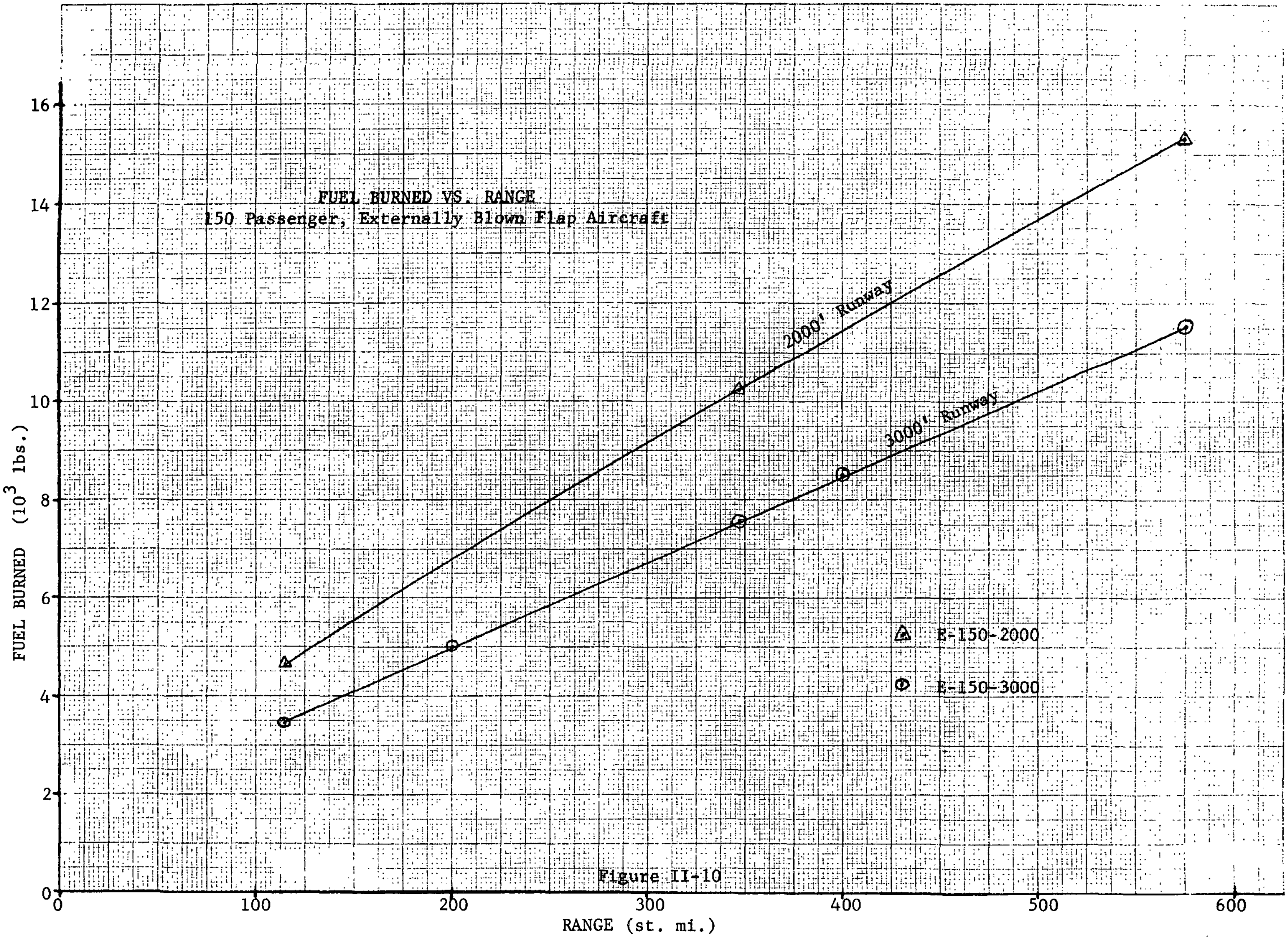


SOURCE OF DATA: "STUDY OF QUIET TURBOFAN STOL AIRCRAFT FOR SHORT-HAUL TRANSPORTATION" PHASE II - McDONNELL DOUGLAS 1973

BASED ON E-150-3000 FINAL LEVEL

Figure II-9

APRIL 1973



FUEL BURNED VS. RANGE
150 Passenger, Externally Blown Flap Aircraft

Figure II-10

References

1) Douglas Aircraft Company, "Study of Quiet Turbofan STOL Aircraft for Short Haul Transportation," MDC J4382, May 2, 1973.

INFRASTRUCTURE

A vital part of a STOL/RTOL system is the supporting system of air terminals. The purpose of STOL/RTOL aircraft is to permit the location of airports close to population centers, thus reducing the traveler's access cost and time and reducing congestion at metropolitan hub airports. To guide the conceptual development of such airport systems in the San Francisco Bay Area and in Los Angeles, certain concepts were evolved:

1. Community resistance to new airports is great. It would be expected to be much easier to expand operations at existing airports than to introduce a completely new site.
2. A large number of general aviation airports already exist in satisfactory locations around the Bay Area and the Los Angeles region.
3. Community acceptance of commercial airline operations at existing airports will vary greatly from one community to another. Each site proposal requires careful and individual analysis.
4. Airports should be selected to minimize the air traveler's access time and cost.

With these principles in mind, some 20 general aviation airports were surveyed in the Bay Area and the six most suitable sites selected for study. An apparently likely candidate, Reid-Hillview Airport, east of San Jose, was eliminated because of a major shopping center in line with its runway. The airports selected for study are shown in Figure III-1.

After analyzing access time and cost and running the systems analysis, Gnoss Field was shown to have inadequate demand to justify high frequency service and was eliminated.

The 2000-ft STOL system assumed a San Francisco Central Business District (CBD) STOLport about a mile south of the Bay Bridge terminus, and a corresponding CBD site in Los Angeles a few miles south of the Civic Center. To obtain a uniform distribution of sites, the 2000-ft system used San Carlos Airport and San Jose Airport. The 3000-ft system used Palo Alto, San Jose and San Francisco International Airport. San Francisco International was included because no alternative site could provide reasonable service to downtown users. There was also no reasonable alternative to San Jose Airport. Hayward Airport and Buchanan Field at Concord are used in both systems. In Southern California[1], the airports used are Van Nuys, Burbank, CBD, El Monte, Santa Monica, Long Beach and Torrance. Torrance, like Gnoss Field, showed inadequate traffic as did El Monte when the CBD existed. Burbank was used only for the 3000-ft system without the CBD.

In the Bay Area, detailed studies of airport costs, community impacts, and community acceptance were conducted. Los Angeles airport costs were estimated from these results. No detailed community acceptance studies of the Los Angeles airports were conducted but some general conclusions obtained in the Bay Area can be applied.

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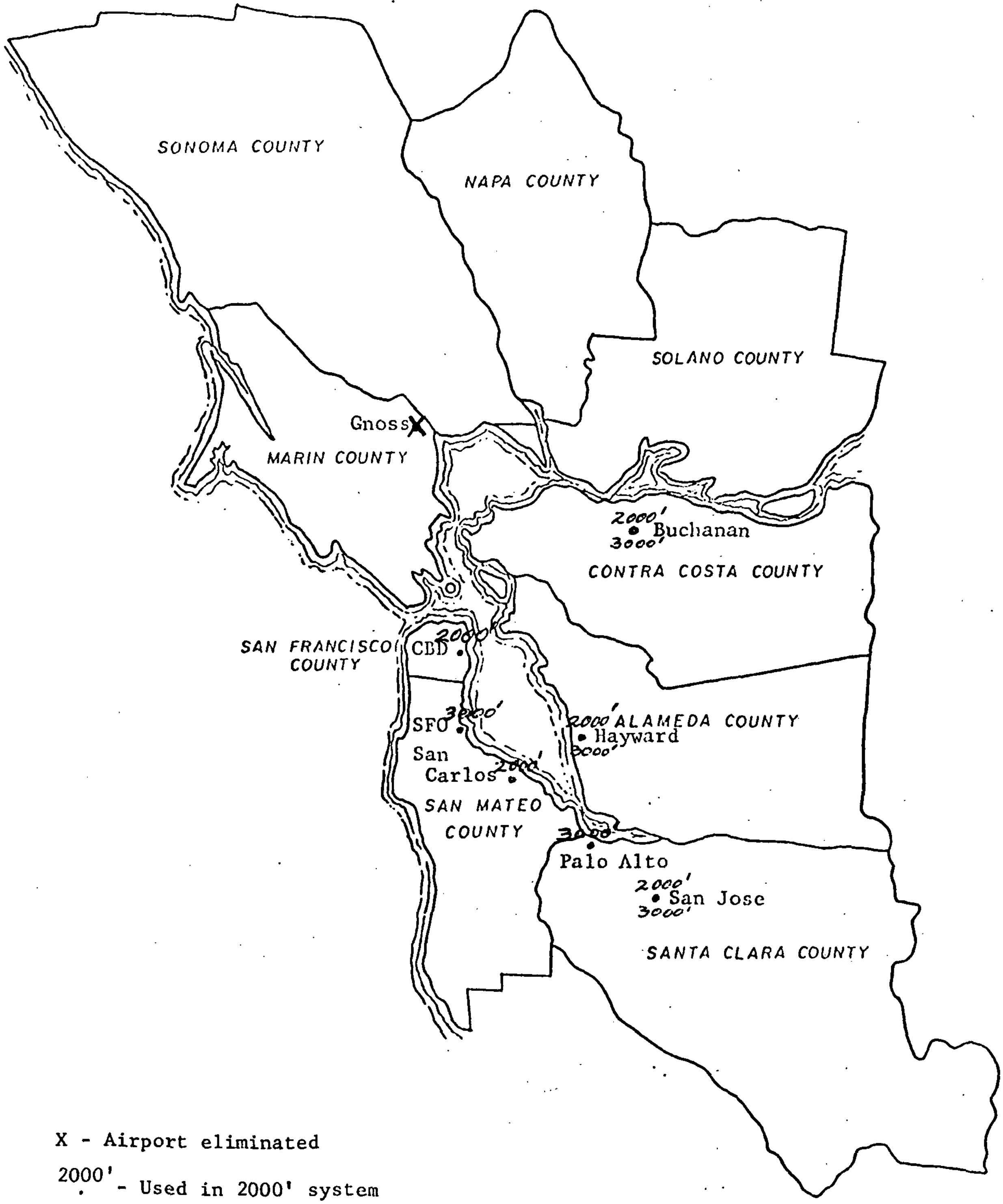
[1] Location of Los Angeles area terminals is shown in Figure III-2



X - Airport eliminated

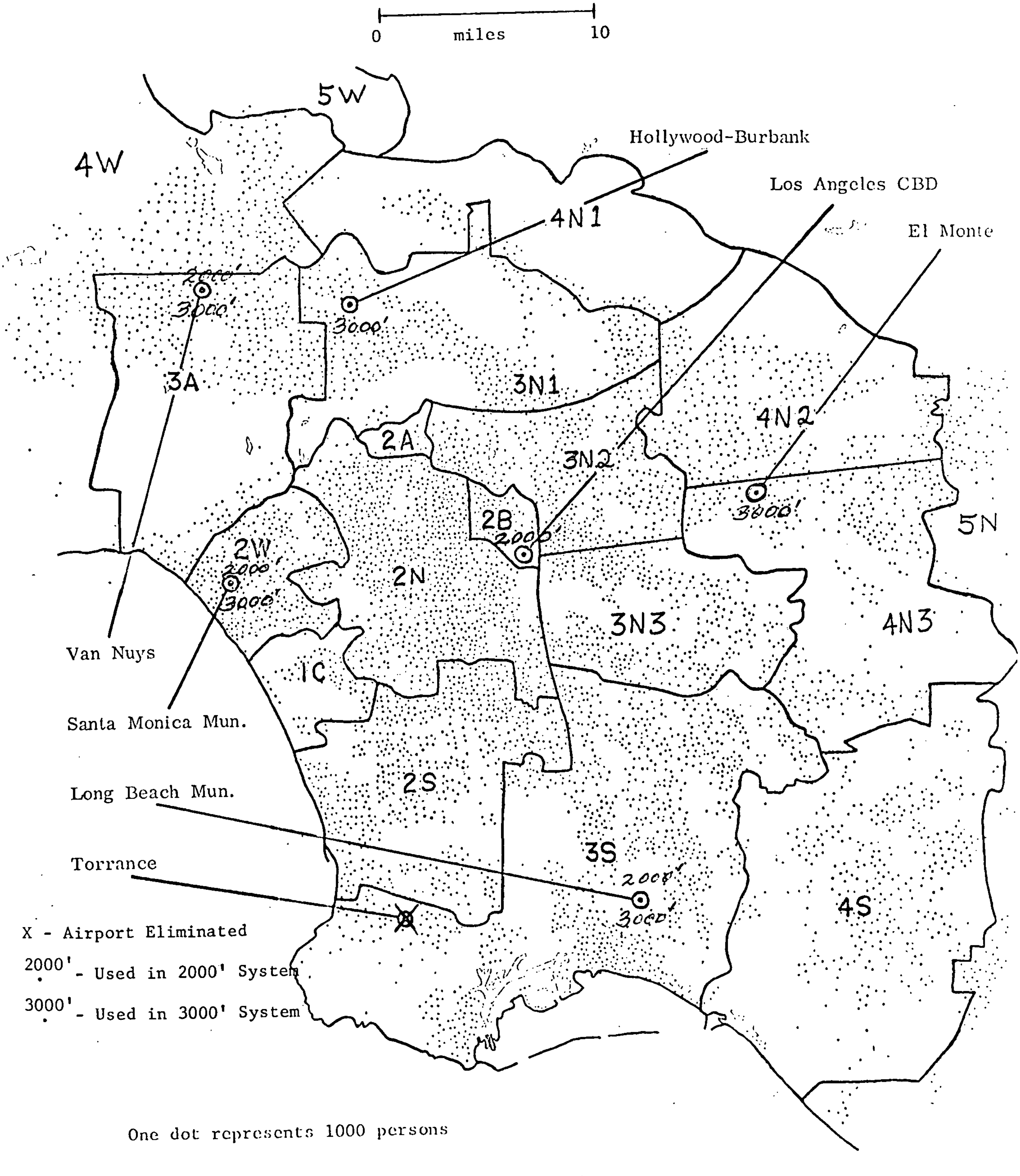
$\overset{2000'}{\cdot}$ - Used in 2000' system

$\overset{3000'}{\cdot}$ - Used in 3000' system

Figure III-1

GREATER LOS ANGELES

Travel Zones



One dot represents 1000 persons

Figure III-2

The first portion of this section is concerned with airport costs. This is followed by a discussion of the air and noise pollution impacts of each airport.

AIRPORT COSTS

Detailed analyses of the cost of converting each Bay Area general aviation airport to commercial short haul use were made. A cost estimate for building a new CBD STOLport was also developed. Appendix D gives the step-by-step derivation of costs for the Palo Alto airport and the San Francisco CBD. Comparable analyses were made for the other Bay Area sites. The results are summarized in Table III-1. Most airports were studies both with 2000-ft and 3000-ft runways. As noted above, some airports were used for both the 2000-ft STOL system and the 3000-ft RTOL system. Others were used only with one system.

The results show total airport costs in the Bay Area as follows:

3000-ft RTOL System	$11,285,000
2000-ft STOL System	$31,315,000

No detailed costs were derived for the Los Angeles terminals. Estimates can be constructed by comparisons with the Bay Area airports. Thus, Van Nuys may be assumed similar to Hayward in runway adequacy and Santa Monica airport is similar to Buchanan Field. Long Beach and Burbank are already capable of handling major aircraft as are San Francisco and San Jose. El Monte may be assumed roughly the same as Palo Alto although its soil quality is superior. The costs of the two CBD's are assumed identical.

The Los Angeles airport costs are then:

3000-ft RTOL System	$11,285,000
2000-ft STOL System	$26,977,000

The total system airport costs are the sum of the costs of the Los Angeles and Bay Area airports. In evaluating the costs to be repaid by the user, it is necessary to note that the Federal Department of Transportation through the Airport Development Aid Program (ADAP) will pay 53% of the costs of runways, taxiways, aprons, access roads and emergency equipment; 82% of lighting system costs and 100% of instrument landing system (ILS) and control tower costs. This averages to about 40% of the total cost including terminals.

	Total Airport Costs	Approximate Airport Costs after DOT aid
3000-ft RTOL System	$22,570,000	$13,542,000
2000-ft STOL System	$58,292,000	$34,975,200

We are assuming that the infrastructure of the least costly of the two systems is amortized through the payment of landing fees included in the aircraft indirect cost used in the system economic analysis. The additional cost of the more expensive system, the 2000-ft STOL system, is to be added to the passenger fares for that system.

Table III-1
AIRPORT CONSTRUCTION COSTS (Millions of Dollars)

	PALO ALTO		SAN CARLOS		HAYWARD		BUCHANAN		CBD
	2000'	3000'	2000'	3000'	2000'	3000'	2000'	3000'	2000'
Land Acquisition	1.470	1.470	.490		0	0	0	0	15.602
Site Preparation	.005	.056	.206		.0002	.0001	.001	.001	*
Paving - Runway	.119	.176	.119		0	0	.020	.042	.133
Paving - Taxiway	.080	.117	.080		.039 ≠	.026 ≠	.041	.048	.242
Paving - Apron	.313	.317	.470		0	0	.022	.022	**
Terminal Construction	1.040	1.040	1.444		1.225	1.790	1.570	1.694	3.387
Maintenance Facilities	.030	.030	.030		0	0	0	0	
ILS	.370	.370	.370		.370	.370	.370	.370	.370
Communication Equipment	.160	.160	.160		.160	.160	.160	.160	.160
Emergency Equipment	.091	.091	.091		0	0	.091	.091	.091
Runway, Taxiway Approach Lighting	.398	.398	.398		.398	.398	.398	.398	.398
Control Tower	.228	.228	.228		.228	.228	.228	.228	.228
Parking Area Grading and Paving	.192	.192	.252		.202	.304	.283	.311	.552
TOTAL	4.496	4.644	4.338		2.622	3.276	3.192	3.365	21.163

* included in runway paving cost

** included in taxiway paving cost

≠ New taxiways at Hayward would be constructed from the turnoff points of the 2000-ft or 3000-ft runway to the existing apron. Due to the shape of the apron, the taxiway constructed to connect the apron and 3000-ft runway would be shorter than that required to connect a 2000-ft runway and the closest apron point.

The additional cost is then:

$34,975,200 - $13,542,000 = $21,433,200

Assuming this cost is amortized over 30 years at 6% interest, the annual cost is $1,543,190.

The annual number of trips on the 2000-ft STOL system is 12,226,400. Thus the additional fare required is $1,543,190/12,226,400 = $0.13.

The conclusion is that the 2000-ft system with 2 CBD's has a higher infrastructure cost by $21,433,000 but that the effect on ticket price is only 13 cents. This is trivally small and can be neglected in the overall economic analysis.

Airport Physical Suitability for Commercial Service

A summary of the suitability of each airport from the standpoint of existing and required facilities is given below.

Palo Alto

Poor subgrade conditions and narrow runway-taxiway spacing require soil conditioning and total reconstruction of a 3000-ft RTOL runway and required taxiway. Land must be reclaimed from a lake and from the adjacent golf course to provide suitable acreage for needed facilities. Adequate physical infrastructure facilities (terminal, tower, navigation and lighting aids) do not exist and must be constructed.

Automobile traffic generated by the airport would cause congestion on Embarcadero, the one artery serving the airport.

Extensiveness of the construction will require closing of the airport to all traffic during the period of conversion to RTOL configuration.

Hayward

Runway, taxiway and apron facilities currently exist at Hayward which are strong enough to support STOL/RTOL aircraft. Paving improvements required would be the widening of sections of taxiway and the construction of some new taxiway segments. Maintenance and emergency facilities exist of suitable standards for STOL/RTOL operation. New terminal, navigation and passenger accomodation facilities would be needed. The allowable level of general aviation operating at Hayward in conjunction with a STOL/RTOLport is estimated to lie between the current level and that predicted by 1985. The configuration of the airport is such that no significant hindrance to general aviation is expected during the STOL/RTOLport construction period.

Peak hour auto traffic generated by the STOL/RTOLport would lead to increased traffic on already congested segments of Hesperian Boulevard.

Buchanan

Paving requirements can be met at Buchanan by overlaying existing segments of runway, taxiway and apron combined with the construction of one new segment of taxiway. Suitable maintenance facilities also exist. New terminal, navigation, and emergency facilities must be constructed.

The proximity of proposed STOL/RTOLport facility construction to the general aviation operations will cause some hindrance to general aviation. The degree of this annoyance cannot be predicted without knowing the exact physical configuration of the STOL/RTOLport facilities.

Peak hour auto traffic generated by the airport could cause problems of congestion on Concord Avenue.

San Carlos

Due to poor subgrade and narrowness of runway-taxiway spacing, runway, taxiway and apron facilities must be entirely reconstructed at San Carlos. This reconstruction will require the relocation of some buildings on the site.

To accomodate all needed STOLport facilities, additional land must be acquired from adjacent plots and from reclamation of some Bayland -- always a controversial problem in the San Francisco Bay region.

The extensiveness of STOLport construction will require the closing of the airport to all operations during the construction period. In addition, the planned use of the airport site after commencement of STOL operations will not allow the current level of general aviation activity. The exact amount of this constraint cannot be determined until the exact physical configuration of the STOLport is determined.

Peak hour auto traffic generated by the airport coincides with peak hour commuter traffic. The additional airport traffic would cause added congestion on sections of Bayshore Freeway which would provide the sole arterial access to the San Carlos STOLport. However, the same impact would be felt further north if San Francisco Airport were being used for this air traffic.

THE IMPACT OF SUBURBAN STOL/RTOL OPERATIONS ON AIR QUALITY

Aircraft operations currently account for approximately 2% of the daily tonnage of organics, nitrogen oxides, carbon monoxide and sulfur oxides in the Nine County Bay Area and 10% of the particulate emissions. (Ref. 1). The introduction of STOL or RTOL aircraft in a regional system of commuter airports would reduce aircraft's total contribution to air pollution tonnage as a result of the improved engine performance of these new aircraft. From a political perspective, however, regionwide gains would be nullified by somewhat higher pollution levels in the immediate environs of general aviation airports which do not currently generate significant contaminant concentrations. The concentration of pollution contaminants in the immediate environs of jet airports is the result of taxiing and take-off, fuel handling, and ground vehicle movement, including passenger and service vehicles. The severity of community impact will be a function of passenger volume, on-site meteorological conditions and background contaminant levels. The air pollution which results from aircraft approach and climb-out is dispersed throughout the region's air basin and therefore will not be considered for the purposes of this community impact analysis.

An air pollution problem can be said to exist 1) when air pollution standards are frequently exceeded or 2) when sizeable numbers of people are dissatisfied with the level of air quality. The first case focuses the research on projecting contaminant levels in units which can be compared against state and federal standards. The second case requires expression of emission impact in terms of a politically intelligible equivalent -- a comparison between airport-related emissions and those, say, of a major industrial pollutor or heavily traveled freeway. Both cases require projection of the air pollution tonnage which will result from airport operations. Four species of contaminants were considered: particulate matter, organics, carbon monoxide and nitrogen oxides.

On the basis of continuing progress in aircraft engine design, it was assumed that STOL and RTOL contaminant emissions per cycle would be one half those of the emission levels associated with the DC-10. Thus, each STOL/RTOL landing/take-off cycle would produce approximately:

11.0 lbs.	of particulate matter
42.6 lbs.	of carbon monoxide
65.6 lbs.	of nitrogen oxides
11.0 lbs.	of organics

Industry estimates obtained by the Bay Area Air Pollution Control District (BAAPCD) were used to project the percentage of the pollution volume that would be emitted during take-off and taxiing -- those parts of each take-off/landing cycle which result in the concentration of emissions in the immediate airport environs. (Ref. 2). The percentages vary for each species of pollutant as a result of the CF6 engine's operating regime:

Particulate matter	67% emitted during taxi and take-off
Carbon monoxide	94% emitted during taxi and take-off
Nitrogen oxides	37% emitted during taxi and take-off
Organics	83% emitted during taxi and take-off

After deriving the number of daily operating cycles from a preliminary estimate of passenger volumes, the daily pollution tonnage for each contaminant was projected using the following expression:

$$\frac{\text{(Number of cycles)(lbs. per cycle)(percent emitted during taxi and take-off)}}{2000}$$

Before gross tonnage can be converted to a unit comparable to the legal standards for ambient air quality, we must estimate contaminants generated by general aviation operations, ground traffic and fuel handling.

The Bay Area Air Pollution Control District has estimated the pollution tonnage that will be generated by 1985-level general aviation activity at each of the Bay Area's municipal airports. The BAAPCD's estimates are constant from airport to airport. At 1985 demand levels, each general aviation airport is expected to produce:

.14 tons of particulate matter daily
50.40 tons of carbon monoxide daily
4.40 tons of nitrogen oxide daily
11.00 tons of organics daily

The BAAPCD's estimates for daily pollution resulting from ground traffic and fuel handling for an airport of 2 million annual passengers -- the rough STOLport average -- were used without adjustment for deviation from the average:

Particulate matter	.14 tons per day
Carbon monoxide	.30 tons per day
Nitrogen oxides	Negligible
Organics	.10 tons per day

The total daily pollution tonnage associated with 1985 airport ground and take-off operations including general aviation and commercial aircraft are shown for each airport in Table III-2.

In order to assess the impact of these emission volumes on air quality, it is necessary to consider the level of pre-existing background pollution, the dispersion of pollutants by wind, and the frequency of climatological conditions which limit the diffusion of pollutants. The severity of pollution impact, in short, depends on the extent to which contaminants are able to mix with clean air that dilutes their toxic or visibility-reducing effect through diffusion.

The concentration of pollution contaminants is expressed in grams of pollutants per cubic meter of air. In order to determine whether STOL/RTOL operations would push ambient pollution levels into frequent violation of state and federal standards, it was necessary to convert emission tonnage into ambient levels that might frequently be reached at a given distance from each airport.

The BAAPCB has developed a diffusion model for such conversions and applied it in determining the contribution of the Bay Area's three metropolitan airports to pollution levels in their surrounding communities. (Ref. 2).

Given a known volume of pollution emissions from hub airport operations the BAAPCD study takes meteorological conditions and background emissions into account to project contaminant concentrations that would be recorded at a monitoring station 1/2 mile from the airport runway. Thus, the method estimates the airport's contribution to the pollution levels monitored at a half-mile distance. By making a number of assumptions, it is possible to roughly project a STOL/RTOLport's contribution to local pollution levels by proportionally adjusting the BAAPCD's hub airport estimates to reflect the emission volumes from STOL or RTOL operations.

The most significant assumption made is that the climatological conditions at each STOL/RTOLport site will roughly approximate those in San Jose. Because San Jose is subject to frequent and prolonged episodes of stagnant air, this assumption would tend to over-estimate pollution concentrations at airport sites with weather conditions more favorable to the dispersion of contaminants. For this reason, the BAAPCD's lower-end estimate of pollution levels in San Jose was used to compensate for this overestimation. The lower-end estimate assumes unstable wind conditions which promote the dispersion of contaminants.

Making this assumption, the concentration of pollutants that would be likely to occur a half-mile downwind from STOL/RTOLport runways can be estimated by the following proportion which contains three known elements:

$$\frac{\text{BAAPCD Estimate of San Jose Airport Emission Tonnage}}{\text{BAAPCD Estimate of Ambient Concentrations 1/2 Mile from San Jose Airport}} = \frac{\text{Estimated STOL/RTOLport Emission Tonnage}}{\text{Concentration of Contaminants 1/2 Mile from STOL/RTOLport}}$$

This expression produces reasonable approximations only in the near airport vicinity where the airport is the primary emission source.

The projected concentrations of pollutants 1/2 mile from each STOL/RTOLport operations and applicable ambient air standards are displayed in Table III-3. We can conclude that, with the exception of nitrogen oxide emissions, STOL/RTOLport operations will not seriously aggravate pollution problems in 1985. Several factors support this conclusion:

1) Despite increasing population, background air pollution levels will be lower in 1985 than today due to improvements in automotive emission control technology.

2) The BAAPCD assesses aviation's contribution to contaminant concentrations in Oakland as "relatively moderate" and only slightly more serious in San Jose given present levels of operation (Ref. 2)

The only STOL-related emissions that would result in frequent violations of state or federal ambient air standards are nitrogen oxides. The seriousness of nitrogen oxide violations is currently a matter of considerable scientific debate. It is generally conceded that existing nitrogen oxide standards are unnecessarily stringent for the protection of health. Thus, some relaxation of nitrogen oxide standards seems likely. Because warm weather conditions and frequent inversion layers promote atmospheric reaction between nitrogen oxides and organics forming photochemical smog, airport-induced nitrogen oxide concentrations cannot be dismissed lightly in the Bay Area or Los Angeles. Photochemical smog is the eye-smarting brownish haze which frequently reduces visibility in the Los Angeles basin.

Conclusions as to the severity of an air pollution impact must be considered tentative. If gas rationing, automobile restrictions, and major public investments in mass transportation are required to meet unamended federal ambient air standards, it seems reasonable to expect that any increase in aviation's contribution to pollution levels would meet with vigorous opposition from the Environmental Protection Agency.

Table III-2

Pollution Tonnage Per Day

(includes take-off, taxiing, general aviation operations, fuel handling and ground traffic)

	PALO ALTO	SAN CARLOS	HAYWARD		BUCHANAN	
	3000'	2000'	2000'	3000'	2000'	3000'
Particulates	.27	.38	.33	.50	.36	.37
Carbon Monoxide	3.10	3.60	3.40	3.70	3.20	3.50
Nitrogen Oxides	.53	.96	.80	.98	.87	.91
Organics	.72	.84	.78	.90	.74	.81

Table III-3

Estimated 1985 Contaminant Concentrations 1/2 Mile from STOLport

	PALO ALTO	SAN CARLOS	HAYWARD		BUCHANAN		Ambient Air Quality Standards
	3000'	2000'	2000'	3000'	2000'	3000'	
Particulates	48 $\mu g/m^3$	68 $\mu g/m^3$	58 $\mu g/m^3$	75 $\mu g/m^3$	61 $\mu g/m^3$	72 $\mu g/m^3$	160 $\mu g/m^3$
Carbon Monoxide	< 2 ppm	< 2 ppm	< 2 ppm	<2 ppm	<2 ppm	<2 ppm	9 ppm
Nitrogen Oxides	.26 ppm	.45 ppm	.38 ppm	.46 ppm	.40 ppm	.41 ppm	.25 ppm
Organics	.15 ppm	.18 ppm	.17 ppm	.20 ppm	.16 ppm	.18 ppm	.24 ppm

THE IMPACT OF STOL/RTOL OPERATION NOISE IN FOUR BAY AREA COMMUNITIES

In this part of the STOL/RTOL comparative study, four of the selected Bay Area airport localities are surveyed in order to project the impact of noise generated by aircraft operations in 1985. Aircraft with 2000-ft and 3000-ft runway capability are compared. The noise impact methodology and its application in a specific community setting is detailed in Appendix E. This section presents a brief summary of noise and its measurement and the results of the noise impact evaluations for the Palo Alto, San Carlos, Buchanan Field and Hayward Airports. The Central Business District STOLport (CBD) will be discussed independently of the four suburban airport locations. The four airport study used noise contours to estimate noise impacted population counts; census tract data to estimate the population characteristics within each noise exposure zone; and maps, aerial photos and on-site inspection to identify noise sensitive land uses such as schools and hospitals. The nuisance value of aircraft noise and the population affected were estimated and translated into a monetary compensation for residents who would suffer airport disbenefits. This quantification of social disbenefit is then considered as part of the total infrastructure cost that must be added to the fares in each system.

Noise and Its Measurement

The basic unit of noise intensity is the decibel (dB). The basic relationship for determining the Sound Intensity Level is given by the expression:

$$\text{Sound Intensity (dB)} = 10 \log_{10} \frac{I}{I_o}$$

where I_o is a standard reference and I is the measured power per unit area of a given sound in a given plane of interest. The use of the decibel is due to the naturally logarithmic response of the human ear.

The Sound Intensity Level does not take any characteristics of the noise into consideration (e.g., the pitch or combination of pitch, etc.). Equations for measuring noise more precisely in terms of particular characteristics have been developed. One such measurement, the Effective Perceived Noise Level (EPNL), takes the approximate response characteristics of the human ear into account (e.g., varying amplitude of response at different frequencies, etc.) as well as the time of exposure to the peak noise intensities. The EPNL is considered a reasonably accurate indicator of jet engine noisiness. Like the Sound Intensity Level, the EPNL is also measured in units of dB. Thus, a given sound level may be expressed as so many EPNdB. It is helpful to note that the perceived noisiness of any given sound effectively doubles each time the EPNL increases by about 10 EPNdB. By the same token, the perceived noise is effectively halved for each decrease of 10 EPNdB from any starting level.

So far, only measurements of noise during one passage of the aircraft have been considered. Since airport operations involve repetitions of jet noise associated with each take-off or landing, a system for noise measurement over an entire 24-hour interval has been developed. The Noise Exposure Forecast (NEF) is currently used by various government agencies and is based on the frequency of flyovers. The NEF, in units of dB, for a particular type of aircraft is calculated from the following equation:

$$\text{NEF, dB} = \text{EPNL} + 10 \log_{10} (N_d + 16.7\ N_n) - 88$$

where: N_d = number of daytime flyovers

N_n = number of night-time flyovers

EPNL = EPNdB for a particular aircraft

Obviously, different EPNL's are associated with the performance characteristics of different aircraft and engines. In order to calculate the composite NEF associated with an airport "mix" of traffic, the ratios of noise-power to reference-power must be summed for each type of aircraft in the mix. In logarithms, this is equivalent to:

$$\text{composite NEF} = 10 \log_{10} \sum_{\substack{\text{all types}\\ \text{of aircraft}}} \text{antilog}\left(\frac{\text{NEF}_{\text{each aircraft}}}{10}\right)$$

For the purposes of this study, we will assume a mix of 200,000 general aviation operations per year and 47,450 STOL/RTOL operations per year at each airport.* The inclusion of general aviation operations in the noise forecasts results in an additional 5 NEF being added to the STOL/RTOL NEF contours at each airport as discussed in Appendix E. The common assumption of 200,000 general aviation operations at each airport was also necessary to meet the research timetable.

Geographical interpretation of noise is made using noise contours superimposed on land use maps. A noise contour is a line of constant noise level (whether measured by NEF or EPNL methods) as projected by an aircraft moving over the terrain. The contours are chosen at convenient intervals (such as multiples of 5 EPNdB or 5 NEF). A "family" of such contours can be laid over the map in order to define, say, five areas which are exposed to five increasing intervals of noise. For the sake of convenience, these are taken as 75-80, 80-85, 85-90, 90-95 EPNdB, and 95-to-higher EPNdB.

In this analysis, 65 daytime take-offs and 65 daytime landings of STOL or RTOL aircraft, and no night flights, are assumed. The NEF's corresponding to the various EPNL values along contours can be calculated from the following expression, with the 75 EPNdB contour being used as an example:

$$\text{NEF}_{\substack{\text{outermost}\\ \text{contour}}} = (75 + 10 \log_{10} 65 - 88)\text{dB} = 5\ \text{dB}$$

After adding 5 dB NEF to each contour value in order to take general aviation into account, the family of NEF intervals is 10-15, 15-20, 20-25, 25-30, and 30-higher dB NEF. These values are shown on contour maps of the four communities in Figures III-3 to III-10.

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* The use of a common estimate of operational level for each airport facilitated early completion of the noise projections without significantly damaging the accuracy of the results. This is the case because noise annoyance forecasting is extremely sensitive to the loudness of each noise event but relatively insensitive to the frequency with which those events occur.

The EPNdB contours appropriate to the 2000-ft STOL and 3000-ft RTOL aircraft were obtained from the McDonnell Douglas Aircraft Company. The contours had been generated for the 150-passenger externally blown flap (EBF) aircraft.

The Impact of Noise on Individuals

The level at which noise becomes harmful to people is still an open issue. Factors which are important in gauging any answer to this question include the repetition rate and duration of each exposure, the intensity level and the frequency content. Although blanket answers may be disputed, it is generally agreed that persistent exposure to noise levels higher than 90 dBA (roughly 103 EPNdB) will result in measurable and often permanent loss of hearing, although the extent of such loss will be highly dependent on the individual. Factors such as age are important, for example.

STOL and RTOL aircraft will not produce a community noise environment which approaches these critical tolerance levels associated with hearing loss. That, however, is not to say that STOL/RTOL operations will not result in community annoyance. The question we must answer is: how much noise is tolerable to an individual in specific situations? This question has been addressed by TRACOR, Inc. in a report prepared for NASA (Ref. 3). The results of that report have been summarized in Appendix E. TRACOR notes that the rate of annoyance in a community will depend, to some degree, on its particular features. One might expect a lower level of annoyance in a severely blighted neighborhood than in an affluent one. The factor of annoyance may even be seasonally dependent. These site-specific nuances were beyond the scope of this study. In the presentation of noise impact statistics in this report, the noise annoyance levels determined by TRACOR in its Seven-City study are projected to the Bay Area and adjusted in light of the population falling within each noise contour zone. The number of residents, housing units, and the number of highly annoyed persons are given for each airport in Tables III-5 to III-8 for 2000-ft and 3000-ft runway systems.

A summary of the predicted number of annoyed persons and complaints is given in Figure III-9. The method of calculating these figures is drawn from the TRACOR study, and is documented in Appendix E.

Noise Sensitive Land Uses

In the assessment of the environmental noise impact of a STOL operation, special consideration must be given to land uses that are particularly sensitive to noise intrusion. These include schools, hospitals and wilderness recreation areas. The in-class "attention factor" would be expected to be impacted negatively by jet noise and it is likely that schools will become primary issues in community STOLport controversy. Other studies have shown that learning ability is detrimentally affected by the noise levels associated with urban traffic. Similarly, where solitude is an important value, in the case of hiking or other open space recreation activities, noise intrusion is likely to be a particularly unwelcome nuisance.

A listing of noise-sensitive uses within the various EPNdB contours is presented in Table III-4 for each of the communities impacted by the Bay Area air terminals discussed in this study. Noise insulation is not considered in projecting the potential for noise annoyance specific to schools, libraries and other public buildings.

Noise Compensation

The benefits and disbenefits of air travel and airport development are not uniformly distributed throughout the urban population. If the users of air transportation were coincident with the population adversely affected by noise and air pollution, there would be no need to consider compensation for the nuisance of aircraft noise. In most communities, however, air travelers and impacted groups are not coincident populations. Both equity and political realism require that severely impacted residents be compensated at a level which reflects the true costs of the disbenefits imposed on them and that this compensation be included in the fare which air travelers pay.

Although the logic which suggests compensation for noise nuisance is straightforward, the implementation of a compensation policy will be extremely difficult. A full compensation strategy is beyond the scope of this research. We can, however, suggest questions that might be appropriately addressed in arriving at a systematic approach to compensation payment.

1. What is the effect of progressively higher noise levels on property values in the airport environs?
2. Does the devaluation of residential property reflect the true cost of noise to neighborhood residents?
3. Should population characteristics be considered in awarding noise compensation? For example, should the difficulty which low income families encounter in finding suitable housing result in a progressive compensation scale?
4. Should characteristics such as neighborhood stability be considered in determining the level of noise compensation?
5. Should compensation be paid to the owners or the occupants of impacted residential property?

These questions suggest the complexity of the issue raised by noise compensation. Without formal answers to these questions, the approach that will be proposed must rely on intuition.

In arriving at a gross estimate of the cost of noise compensation, the following guidelines were considered:

Many people who do not travel but are impacted by noise may seem to be without benefit from an air transportation system. Nevertheless, directly or indirectly, their livelihood may be dependent on the economic stimulation of transportation. Many modern activities make noise. Automobiles, trains, buses, construction activity, emergency vehicles, etc. disturb our tranquility but are accepted without much complaint. Therefore, it would seem that compensation should be paid only to those whose share of the disbenefits are unusually high. Since commercial and industrial activities are usually associated with some noise, it was decided to limit compensation to residential housing units.

Residential property owners will be compensated for depreciation in the value of real property in severe noise impact zones. The occupants of dwelling units in severe impact zones will be additionally compensated for nuisance suffered during the tenure of their occupancy. These payments will be terminated when the original occupant moves from each residence.

The implementation of this approach requires data which is unavailable without field surveys and extensive data analysis beyond the scope of this project. In order to arrive at a gross estimate of the cost of noise compensation using the aggregate population data available to the research team, a compensation scale was developed which hopefully is indicative of the costs involved in the procedure suggested above. The scale was used with an assumption of a 20 year occupancy, a tenure which is sufficiently longer than the actual to incorporate both nuisance payments and the depreciation in property value. The scale was determined after exposing a class of Stanford graduate students to jet noise levels from 75 to 95 EPNdB and evaluating their subjective judgements of the nuisance imposed.

Range of Noise NEF (Based on assumed frequencies of general aviation and STOL/RTOL)	Range of Noise EPNL	$/month/residential dwelling
25-30	90-95 dB	100
20-25	85-90 dB	50
15-20	80-85 dB	25
10-15	75-80 dB	0

These values can no doubt be debated to the end of time; they represent one group's "best guess" approximation of the social cost of noise annoyance.

Schools, hospitals and parks are even more difficult to compensate. If the buildings are well constructed, a noise decrease of 10 to 20 dB can be provided by the structure, eliminating much of the problem. Costs of sound proofing could be a charge against the airport if necessary. No cash compensations for non-residential areas have been included in this study. Noise sensitive uses have been shown because of their potential to provoke objections from community residents.

The costs of noise are shown in Tables III-10 and III-11 for each Bay Area airport. The Bay Area total annual cost is $1,945,200 for the 2000-ft system and $1,792,500 for the 3000-ft system. At any given airport, the number of people impacted by noise is usually greater for a 3000-ft aircraft. However, the 3000-ft system includes Palo Alto, a low noise level site whereas the 2000-ft system replaces Palo Alto with San Carlos, a high noise level site. In the case of Palo Alto, the 2000-ft aircraft has more severe noise impact than the 3000-ft aircraft because its greater sideline noise impacts a larger population. The gains in noise relief achieved due to the 2000-ft aircraft's shorter contours are, in this case, wasted on the waters of San Francisco Bay.

The population impacted by noise from STOL aircraft using a Central Business District site was not projected because the site is located in a now blighted industrial area that will be subject to volatile and unpredictable development and redevelopment trends between now and 1985. The uncertainty of land use trends and population densities in the South of Market area makes accurate projection impossible.

It does seem likely that much of the redevelopment that will occur near the CBD STOLport site will be of a commercial high-rise nature. Sound proofing in these commercial office buildings will probably eliminate virtually all indoors noise annoyance. However, the encroachment of high-rise development upon the airport clearance and the apprehension caused by aircraft overflight make community acceptance of a downtown STOLport site highly unlikely.

Since this study has not included community acceptance or noise studies for the Los Angeles area, the general magnitude of Bay Area costs for noise will be assumed to apply to Los Angeles. Long Beach and Burbank are already major airports with runway lengths that will tend to confine STOL/RTOL noise within the airport. This, of course, is also true of San Francisco and San Jose in the Bay Area. Van Nuys has a long runway with a relatively small noise problem. El Monte and Santa Monica are likely to have higher surrounding populations than Palo Alto, San Carlos, Hayward and Buchanan. This is compensated by having only 1 or 2 community airports in Los Angeles compared to 3 at the Bay Area end. Therefore, the noise compensation costs determined in the Bay Area will be doubled to account for the southern end of the system.

Thus, total system noise compensation costs are:

2000-ft System	$3,890,400 per year
3000-ft System	$3,585,000 per year

The value of the noise costs are thus about $3.5 to $4.0 million. Distributing this among the approximately 16,000,000 annual passengers means a surcharge of about 25 cents per ticket. More importantly, the difference in noise costs between the 2000-ft and 3000-ft systems is of the order of $300,000 per year, or about 2 cents per passenger. Thus, the difference in the noise costs of the two systems can be considered trivial and has no effect on the relative total system costs or the resultant traffic demand.

Table III-4

Noise-Sensitive Land Uses

Hayward:	Noise Level (EPNdB)	Uses Impacted
2000-ft Case	80-85	Longwood School Longwood Park Winton Grove School Russell School
	75-80	Del Rey School Linda Vista School Bohannon School Sunset School St. Joachim School Mohrland School
3000-ft Case	85-90	Longwood School
	80-85	Winton Grove School Russell School Longwood Park
	75-80	Del Rey School Linda Vista School Bohannon School St. Joachim School Mohrland School
San Carlos:		
2000-ft Case	80-85	Marine World Laureola School Monroe School Hoover School
	75-80	Fair Oaks School Garfield School Edison School Burton Park Redwood City Courthouse Redwood City Hall Chestnut Park
3000-ft Case	80-85	Hoover School Chestnut Park Fair Oaks School Marine World Laureola School Monroe School Encinal School Garfield School

	Noise Level (EPNdB)	Uses Impacted
San Carlos:		
3000-ft Case continued	75-80	Nativity School Menlo-Atherton H.S. Laurel School Peninsula School Veterans Hospital, Menlo Park
Buchanan Field:		
2000-ft Case	95 up	Drive-In Theatre
	85-90	Diablo Valley College Hillcrest School
	80-85	Gregory Gardens School Strandwood School College Park H.S. Valley View School
	75-80	Pacheco School Pleasant Hill School Glenbrook School
3000-ft Case	95 up	Drive-In Theatre
	85-90	Diablo Valley College College Park H.S.
	80-85	Strandwood School Gregory Gardens School Valley View School
	75-80	Pacheco School Pleasant Hill School Glenbrook School
Palo Alto:		
3000-ft Case	95 up	Municipal Golf Course Duck Pond & Lagoon
	90-95	Municipal Golf Course Duck Pond & Lagoon Yacht Harbor Sand Point
	85-90	Yacht Harbor Duck Pond & Lagoon Flood Basin Sand Point
	80-85	Flood Basin Sand Point Mt. View Sunshine Park Charleston Slough
	75-80	Baylands Athletic Center

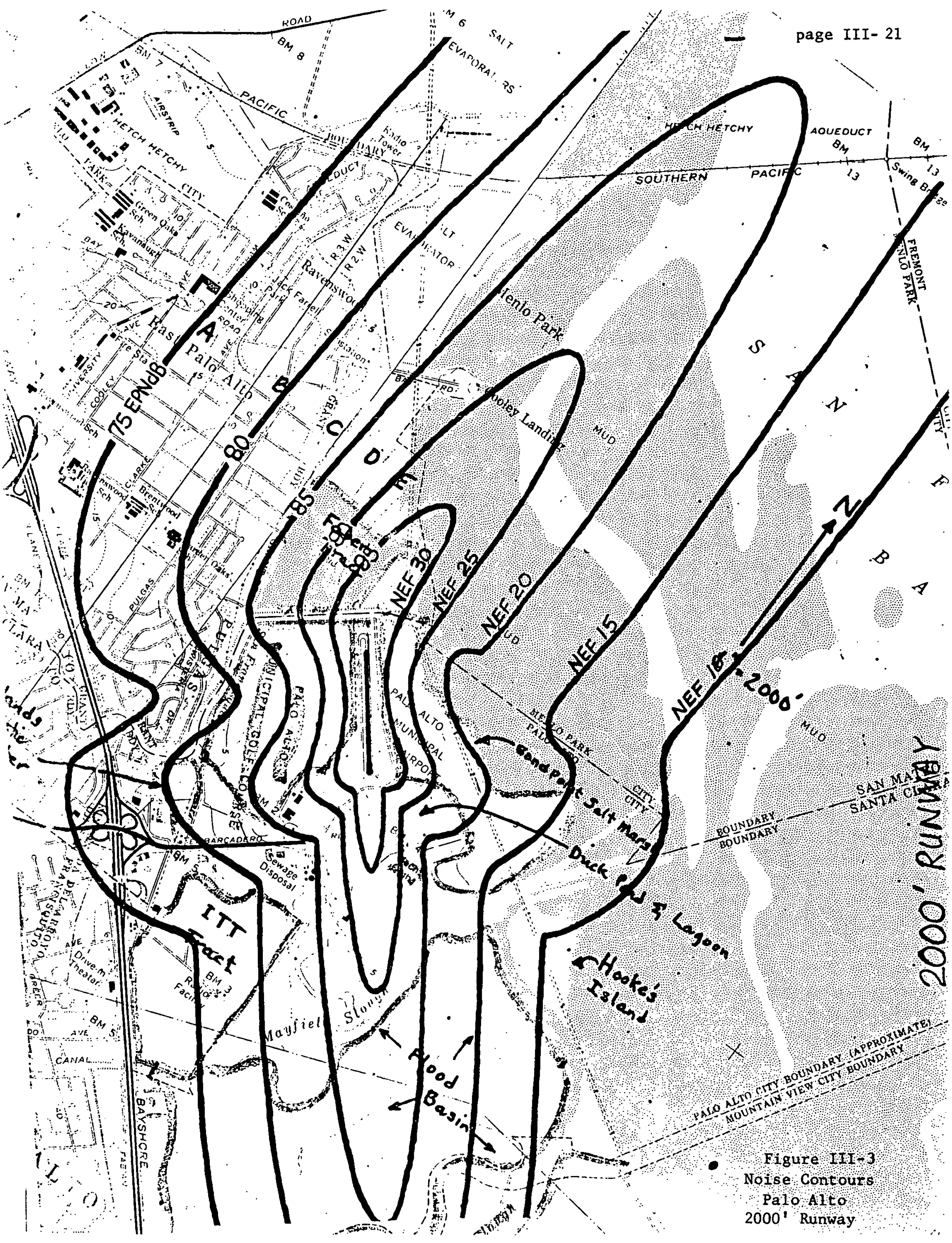

Figure III-3
Noise Contours
Palo Alto
2000' Runway

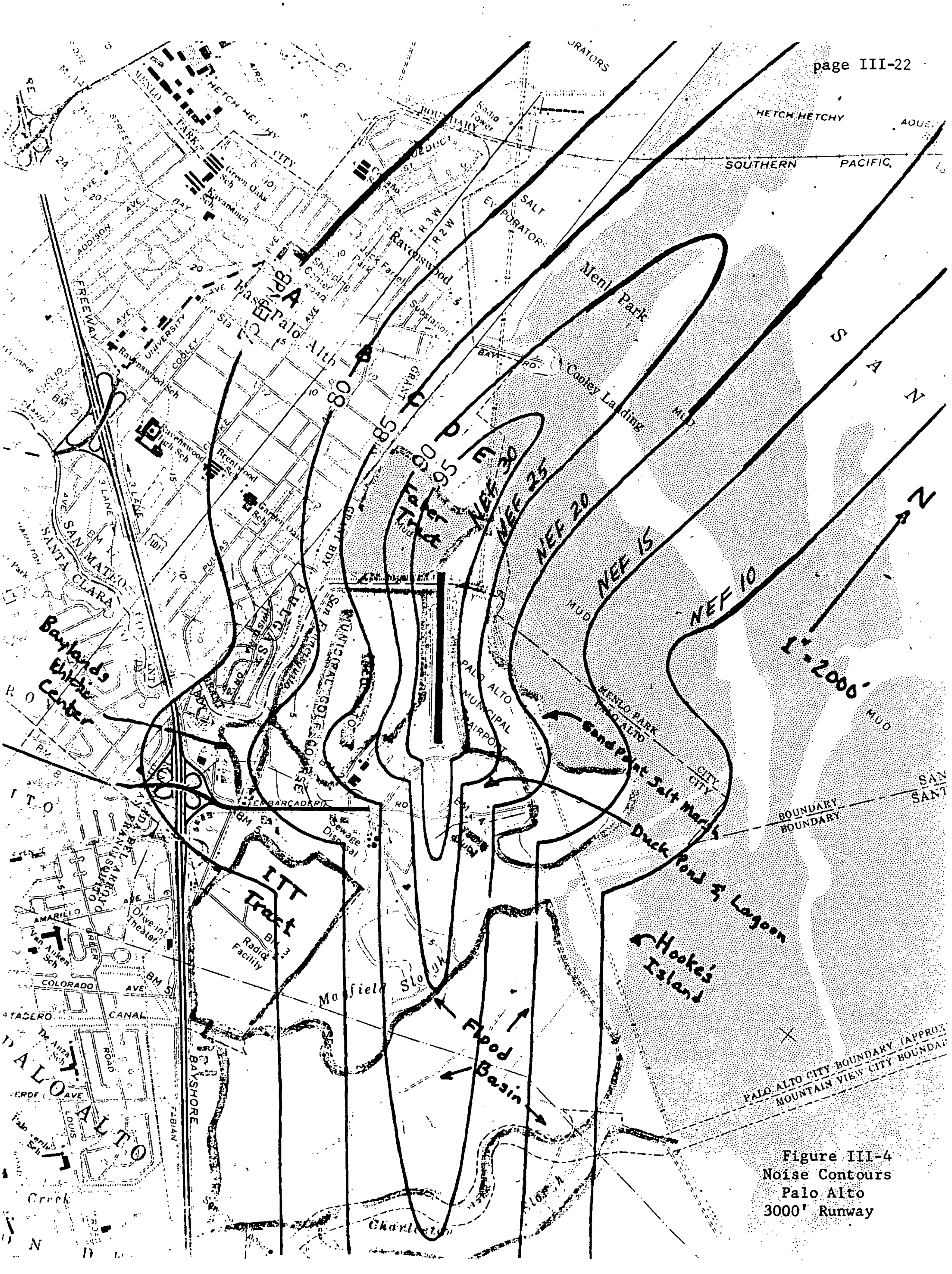

Figure III-4
Noise Contours
Palo Alto
3000' Runway

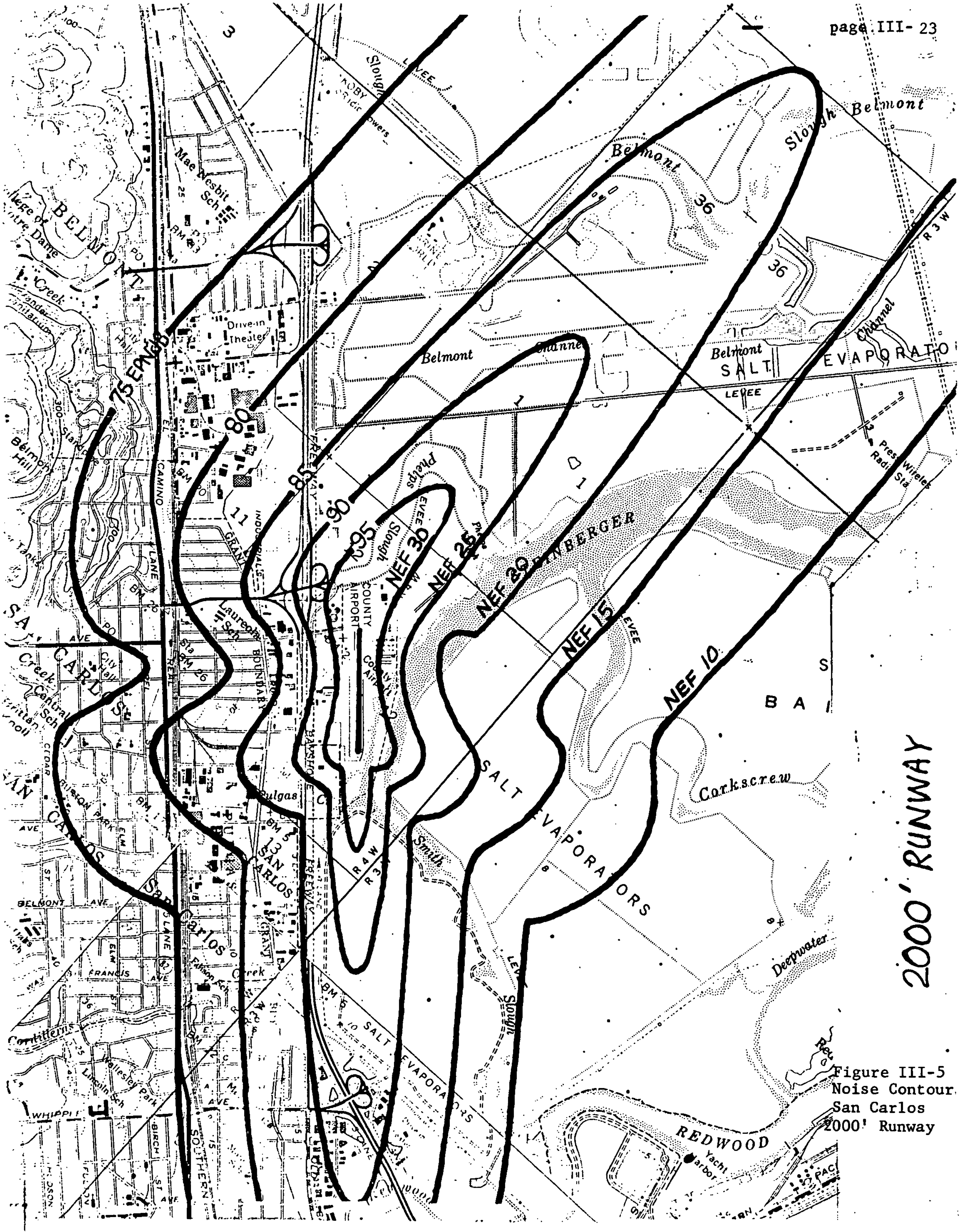

Figure III-5
Noise Contour
San Carlos
2000' Runway

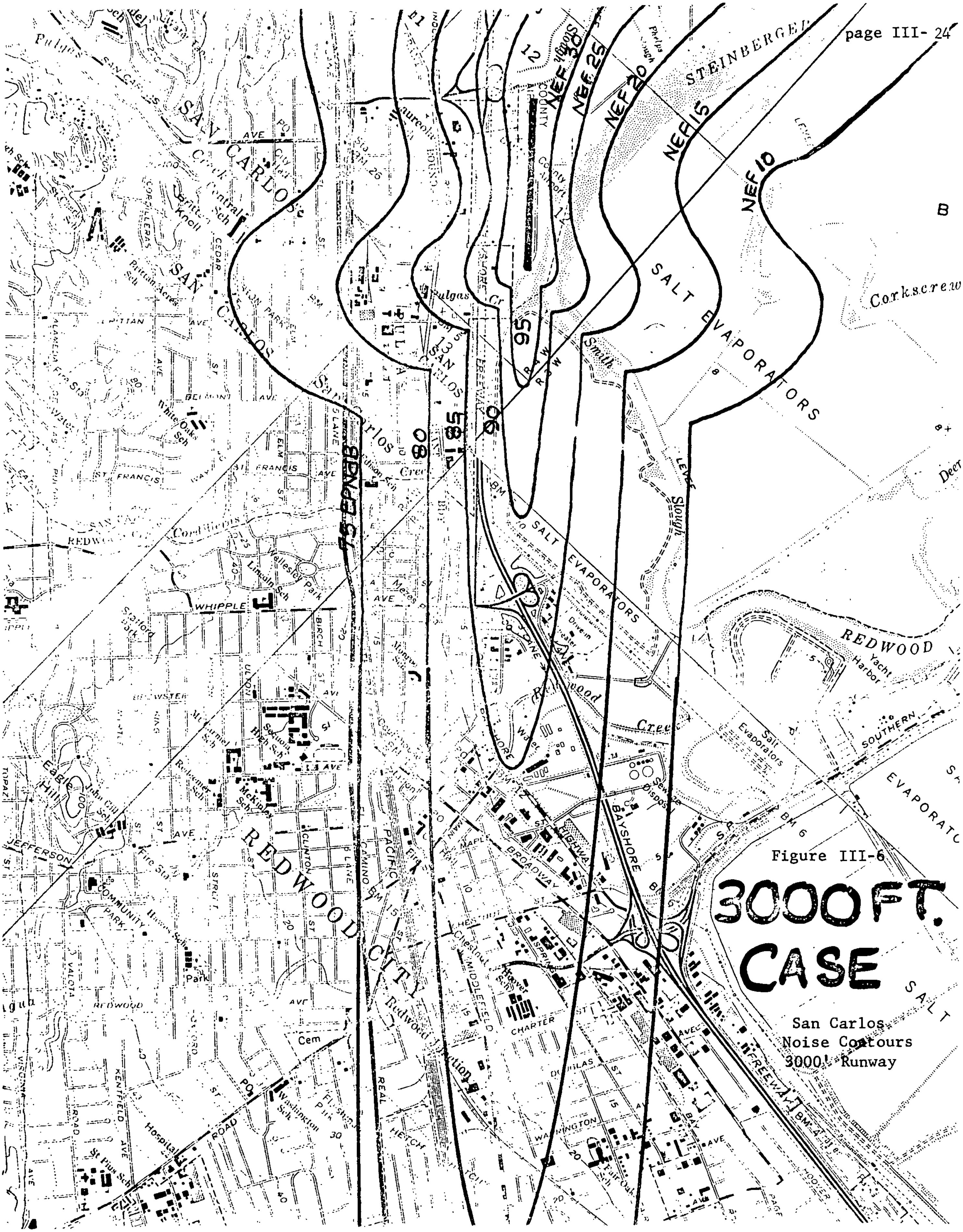

Figure III-6

3000 FT. CASE

San Carlos Noise Contours 3000' Runway

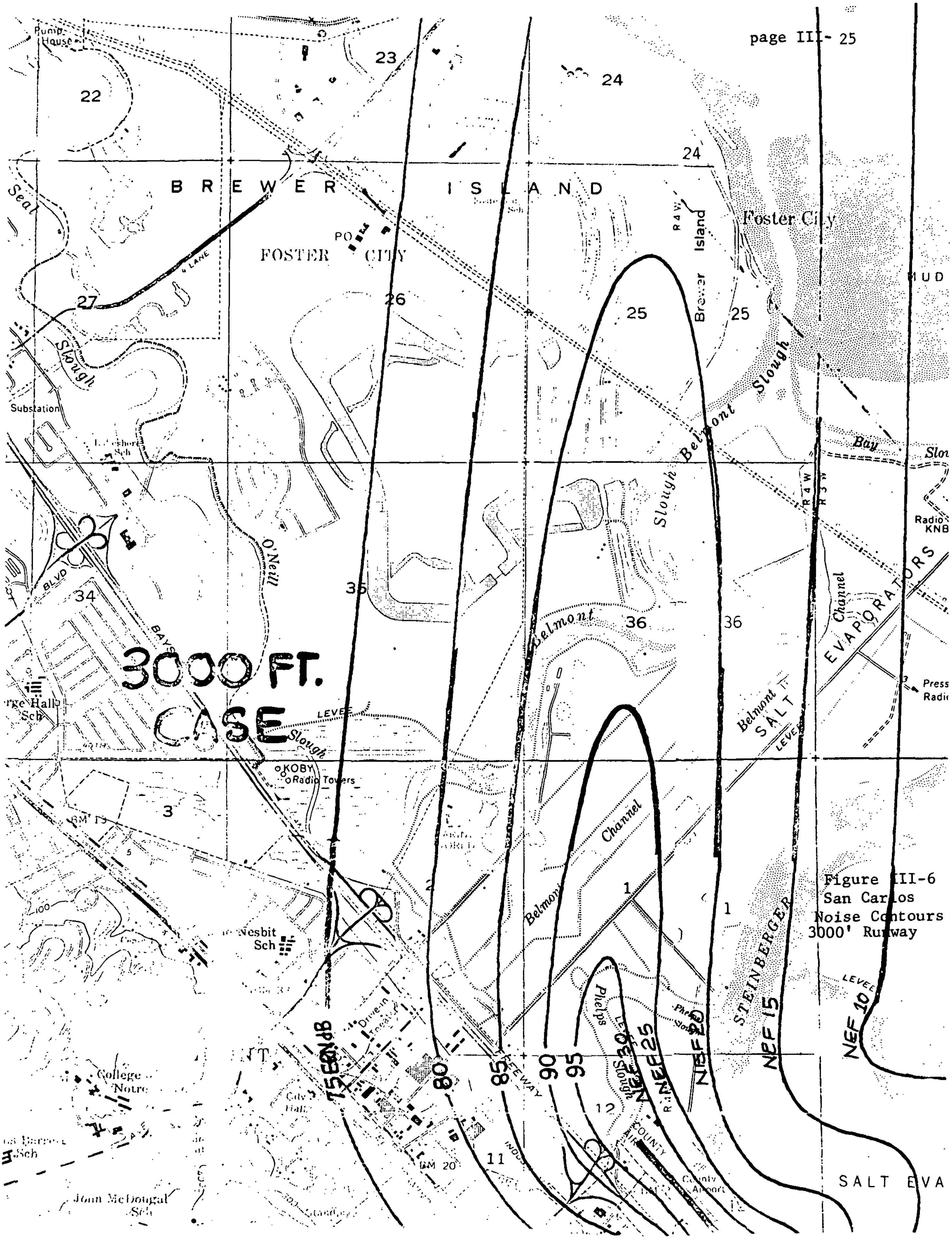

Figure III-6
San Carlos
Noise Contours
3000' Runway

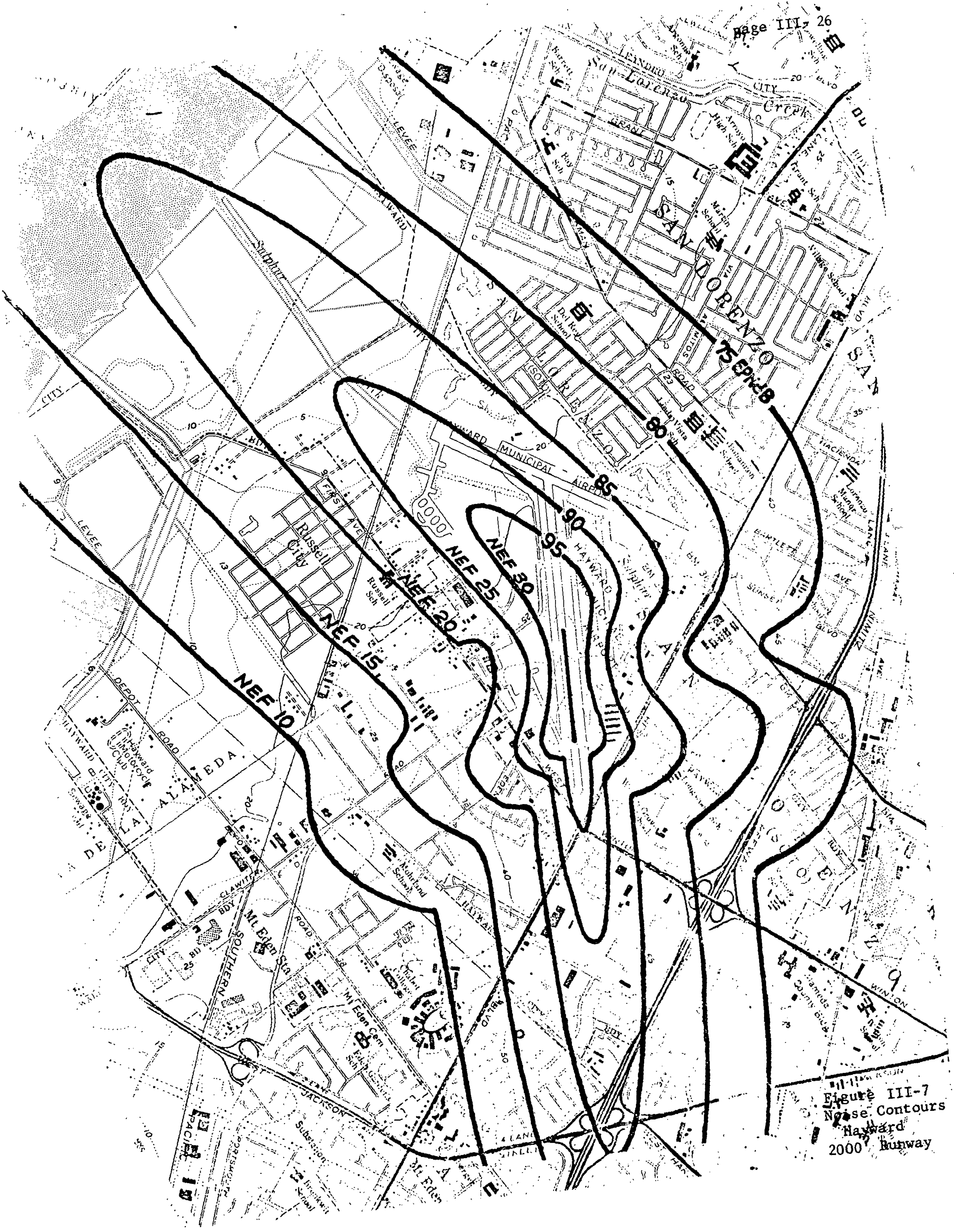

Figure III-7
Noise Contours
Hayward
2000 Runway

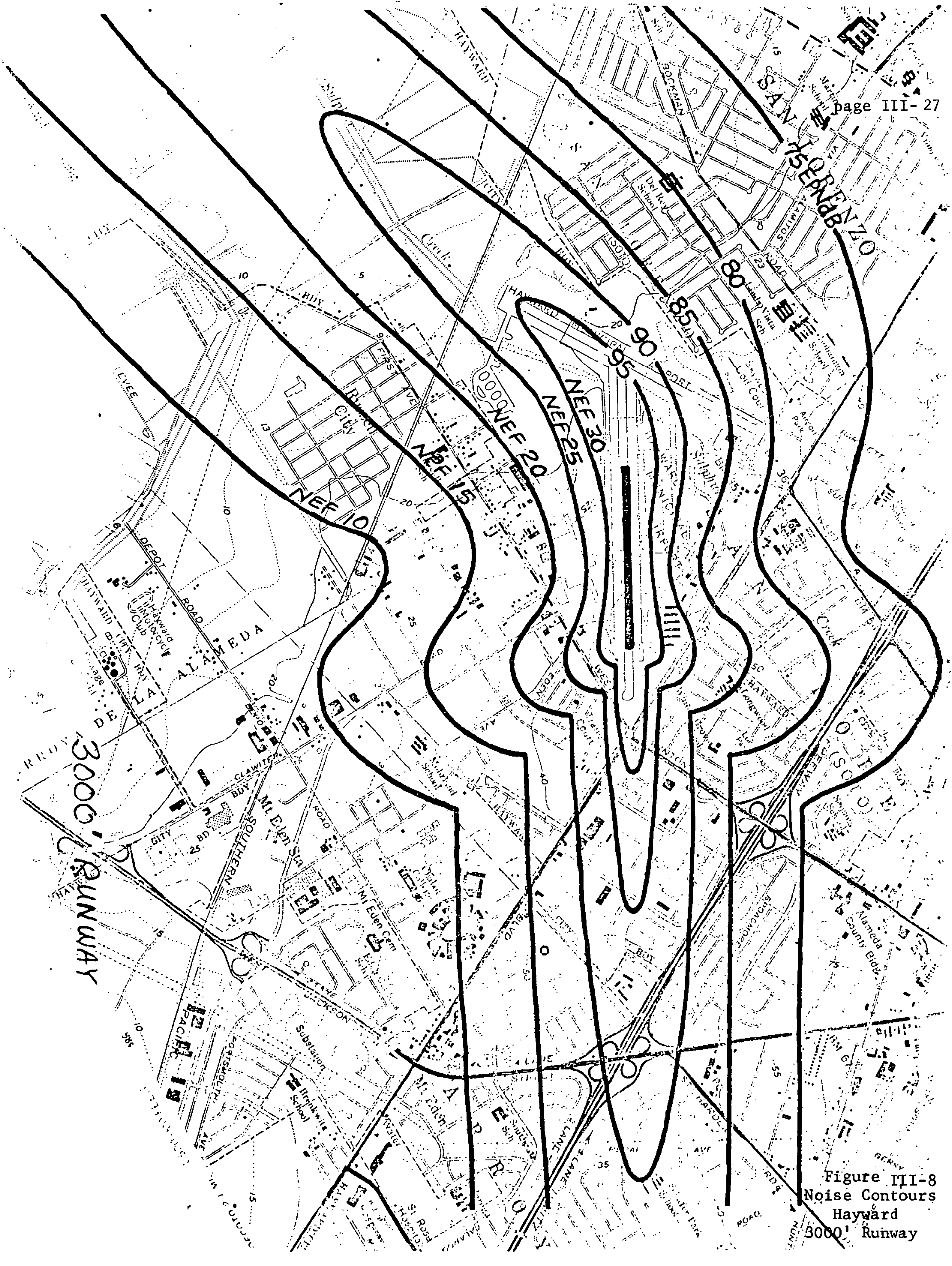

Figure III-8
Noise Contours
Hayward
3000' Runway

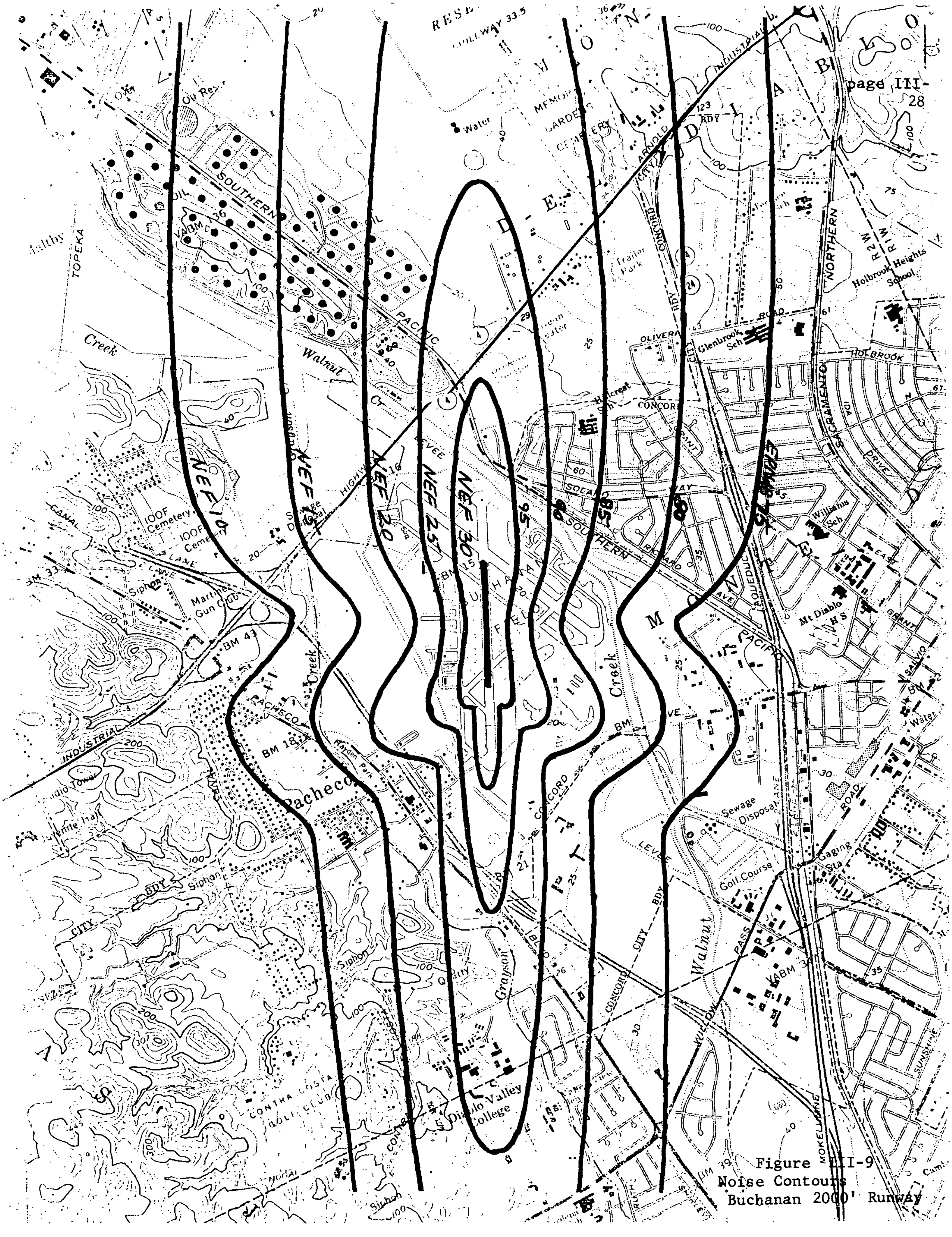

Figure III-9
Noise Contours
Buchanan 2000' Runway

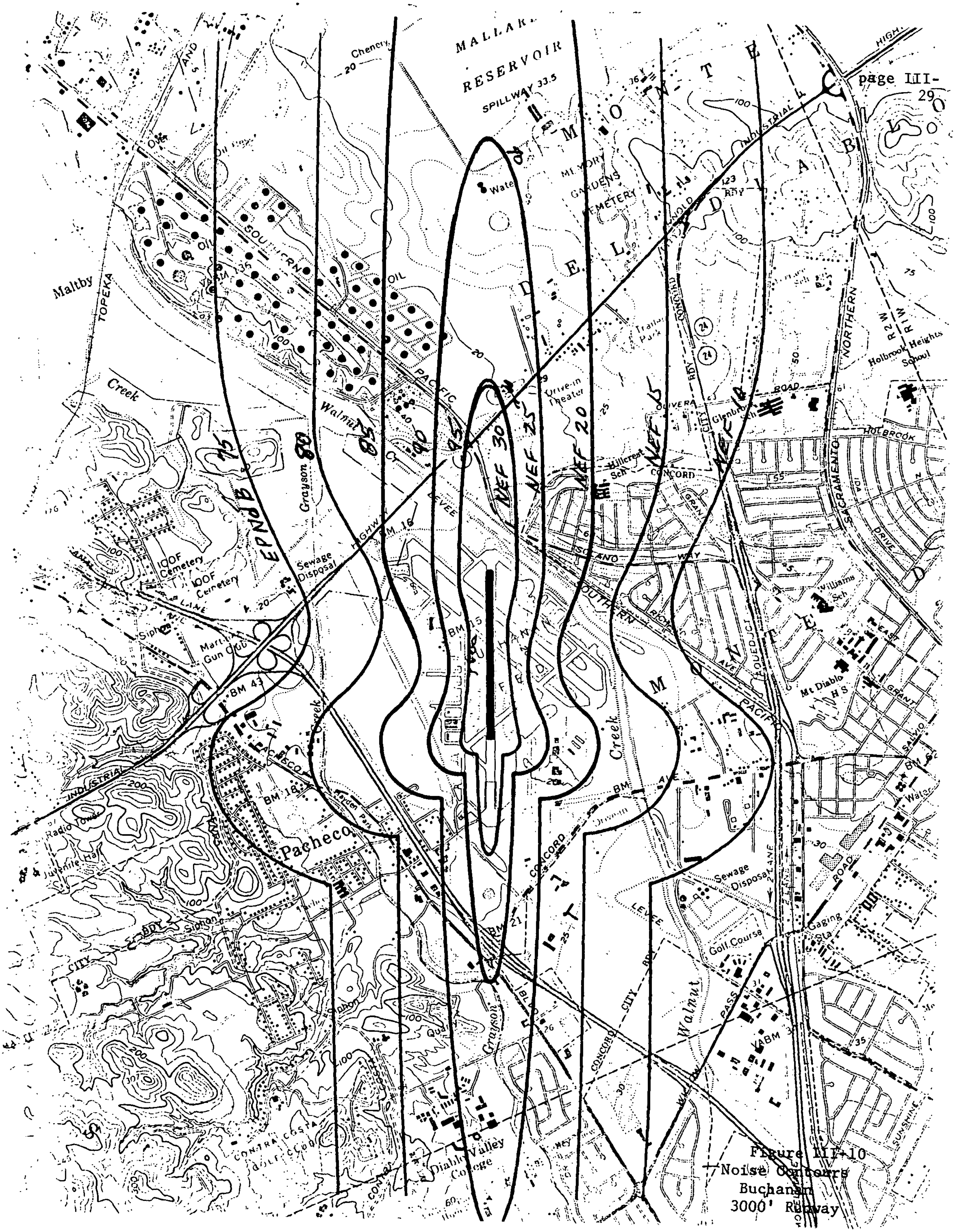

Figure III-10
Noise Contours
Buchanan
3000' Runway

Table III-5

2000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	0	0	0	-	0	-
20 to 25	85 - 90dB	0	0	0	-	0	-
15 to 20	80 - 85dB	1432	86	350	18,000	30%	$140
10 to 15	75 - 80dB	2988	0	740	23,000	20%	$150

3000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	0	0	0	-	0	-
20 to 25	85 - 90dB	0	0	0	-	0	-
15 to 20	80 - 85dB	432	26	100	18,000	30%	$140
10 to 15	75 - 80dB	7358	0	1830	25,000	20%	$160

PALO ALTO AIRPORT STATISTICS

Table III-6

2000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	500	110	120	40k	*	-
20 to 25	85 - 90dB	600	84	150	40k	*	-
15 to 20	80 - 85dB	3700	222	850	35k	*	-
10 to 15	75 - 80dB	15600	-	-	-	-	-

*:insignificantly small

3000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	500	110	120	40K	*	-
20 to 25	85 - 90dB	915	130	225	40K	*	-
15 to 20	80 - 85dB	5015	300	920	35K	600	150.
10 to 15	75 - 80dB	19000	-	-	-	-	-

*:insignificantly small

SAN CARLOS AIRPORT STATISTICS

Table III-7

2000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	326	72	77	23344.	25	137.
20 to 25	85 - 90dB	1709	239	387	24026.	76	145.
15 to 20	80 - 85dB	7568	454	1608	23588.	449	139.
10 to 15	75 - 80dB	17529	-	-	-	-	-

3000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	25	8	10	21800.	3	162.
25 to 30	90 - 95dB	296	65	59	23056.	28	150.
20 to 25	85 - 90dB	2575	361	607	24285.	83	147.
15 to 20	80 - 85dB	12670	760	1975	23413.	1607	144.
10 to 15	75 - 80dB	20014	-	-	-	-	-

HAYWARD AIRPORT STATISTICS

Table III-8

2000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	260	58	46	25K	70	150.
20 to 25	85 - 90dB	2700	380	500	25K	600	150.
15 to 20	80 - 85dB	4860	290	980	25K	700	150.
10 to 15	75 - 80dB						

3000 FT. CASE

RANGE OF NOISE NEF	RANGE OF NOISE EPNL	POPULATION AFFECTED	NUMBER PREDICTED TO BE HIGHLY ANNOYED	NO. OF HOUSING UNITS	AVERAGE HOUSING UNIT VALUE	NUMBER OF RENTERS	AVERAGE RENT
30 and higher	95 dB and higher	0	0	0	-	0	-
25 to 30	90 - 95dB	520	115	105	25K	130	150.
20 to 25	85 - 90dB	2980	420	540	25K	675	150.
15 to 20	80 - 85dB	4700	280	950	25K	700	150.
10 to 15	75 - 80dB						

BUCHANAN FIELD STATISTICS

Table III-9

NOISE IMPACT: POPULATION AFFECTED AND PROJECTED ANNOYANCE

	PALO ALTO		SAN CARLOS		HAYWARD		BUCHANAN	
	2000'	3000'	2000'	3000'	2000'	3000'	2000'	3000'
Population Affected NEF Zones 15-30	432	1420	4800	6430	9600	15,560	7820	8200
Number Predicted to be Highly Annoyed	26	86	420	540	765	1194	728	815
Predicted Number of Complaints	5	15	18	22	30	45	33	40

Table III-10

Community Noise Compensation Summary

2000-ft Case

Range of Noise NEF	Range of Noise EPNL	Monthly Compensation per unit ($)	(PALO ALTO)[1] No. of Housing Units	(PALO ALTO)[1] Monthly Compen-sation ($)	SAN CARLOS No. of Housing Units	SAN CARLOS Monthly Compen-sation ($)	HAYWARD No. of Housing Units	HAYWARD Monthly Compen-sation ($)	BUCHANAN No. of Housing Units	BUCHANAN Monthly Compen-sation ($)
30 & higher	95 dB & higher		0	0	0	0	0	0	0	0
25 to 30	90-95 dB	100	0	0	120	12000	77	7700	46	4600
20 to 25	85-90 dB	50	0	0	150	7500	387	19350	500	25000
15 to 20	80-85 dB	25	350	8750	850	21250	1608	40200	980	24500
10 to 15	75-80 dB	0	740	0	-	0	-	0	-	0
Total Monthly Compensation per Airport				(8750)[1]		40750		67250		54100
Total Annual Compensation per Airport				(105000)[1]		489000		807000		649200

Total Bay Area 2000-ft System Annual Compensation = $1,945,200

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[1] This airport not used in 2000-ft system. Shown for information only.

Table III-11

Community Noise Compensation Summary

3000-ft Case

			PALO ALTO		(SAN CARLOS)[1]		HAYWARD		BUCHANAN	
Range of Noise NEF	Range of Noise EPNL	Monthly Compensation per unit ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)	No. of Housing Units	Monthly Compen-sation ($)
30 & higher	95 dB & higher		0	-	0	-	10	12600*	0	-
25 to 30	90-95 dB	100	0	0	120	12000	59	5900	105	10500
20 to 25	85-90 dB	50	0	0	225	11250	607	30350	540	27000
15 to 20	80-85 dB	25	100	2500	920	23000	1975	49375	950	23750
10 to 15	75-80 dB	0	1830	-			-		-	
Total Monthly Compensation per Airport				2500		(46250)[1]		85625		61250
Total Annual Compensation per Airport				30000		(555000)[1]		1027500		735000

Total Bay Area 3000-ft System Annual Compensation = $1,792,500

[1] This airport not used in 3000-ft system. Shown for information only.

* Noise levels above 95 EPNdB are assumed to be unsuitable for residential use. Therefore the airport must buy the property. 20% is added to the price for relocation. 1/3 of the cost is assumed recovered by conversion to compatible land use. Remaining cost is amortized over 30 years at 6%.

References

1. Bay Area Air Pollution Control District, "Source Inventory of Air Pollutant Emissions in the San Francisco Bay Area," BAAPCD, San Francisco, 1971.

2. Bay Area Air Pollution Control District, "Aviation Effect on Air Quality in the Bay Region," Regional Airport Systems Study Commission, Berkeley, 1971.

3. TRACOR, Inc., "Community Reaction to Aircraft Noise," NASA, 1972

SYSTEMS ANALYSIS

The systems analysis may be described as the portion of a study where "we put it all together." It is also the place where a great many inputs are dumped into a computer and the printed output is often treated as a close approximation to pure wisdom. Whether the results are wisdom or rubbish depends upon the validity and sometimes more importantly, the consistency of the inputs, the correctness of the analysis, and a sensible choice of the figures of merit from which conclusions are drawn.

This section of the report is intended to provide an understanding of the systems analysis procedures used in this study including the figures of merit, the assumptions used in their calculation and the details of the computation program. It is intended to highlight the fundamental assumptions to ensure their consistency and to allow the reader to judge, with relative ease, their validity.

OBJECTIVE

The primary objective of this study was to compare the relative costs and benefits of two alternative aircraft systems applied to the short haul passenger market between the San Francisco Bay Area and the Greater Los Angeles Area, projected to 1985 and operating in competition with the automobile. Table IV-1 indicates the differences and implications associated with the two basic systems being compared.

Table IV-1

Study of Alternative Short Haul Aircraft Systems

2000-Ft Field Length	vs.	3000-Ft Field Length
· Higher DOC		· Lower DOC
· Allows CBD Site		· No CBD Site
· Lower Airport Costs		· Higher Airport Costs at Same Airport
· Lower Noise Costs		· Higher Noise Costs at Same Airport
	· Community Acceptance of Both	

The basic difference is in the field length requirement for the two systems, 2000 feet versus 3000 feet. Do the advantages associated with shorter runway requirements offset the increase in aircraft costs as take-off and landing performance requirements are increased? As indicated in Table IV-1, aircraft designed to operate from 2000-ft runways exhibit higher direct operating costs than those designed for 3000-ft runways. On the other hand, the 2000-ft field length allowed the assumption of a central business district (CBD) site and therefore an advantage with regard to access time. For those sites which are common to both systems, the airport costs are less for the shorter field length system because of lower construction costs when runway and taxiway widening and strengthening are involved and because of lower real estate and construction costs when airport area expansion is required. Noise costs are less for the 2000-ft system because the noise footprint for the higher performance aircraft typically impacts a smaller ground area than that for the longer field length aircraft of comparable passenger capacity.

Probability of community acceptance of the airport site for both systems was assessed. This, however, is treated separately from the systems analysis which is essentially based on economics. The economic results of the two aircraft systems are adjusted, however, for the economic costs of noise, as discussed in the infrastructure section of this report. These noise costs are included,along with the other infrastructure costs, as an "add-on" in the analysis discussed below.

SOURCES OF DATA

The input data are developed in the travel demand, vehicle technology and infrastructure sections of this report. A brief overview of the methods and results of these sub-studies is given here to clarify the systems analysis process.

Travel demand projections were determined using current airline statistics and a synthesis of considerable automobile highway traffic data using a gravity model method. Distribution of the travel demand among zones was accomplished for both the Bay Area and Los Angeles ends of the system. For the San Francisco Bay Area, results from the 1970 BASAR study (Ref. 1), in which the originating air travel was defined as distributed among 98 zones, were modified in detail based on more recent assessments of population growth trends. An older, more approximate set of data (Ref. 4) was used for defining the Los Angeles area distribution.

The second major step was to define the major elements of the short haul systems, the aircraft types and airport sites. Results of a very recent study (Ref. 3) by McDonnell Douglas, in which a wide range of types and sizes of aircraft configurations were assessed for short haul application, were very useful in selecting consistent aircraft types. The configurations considered utilized turbofan engines, were all designed to sideline noise level criteria of 95-98 EPNdB and included such lift concepts as conventional mechanical flap, externally blown flap (EBF), upper surface blowing (USB), augmentor wing, and internally blown flap (IBF). For the 2000 to 3000-ft field lengths being considered in the present study, the EBF was selected as providing the lower boundary of direct operating costs and relatively representative of the entire group.

Six airport sites were originally selected at each end for each of the two systems. With the exception of the CBD site at each end of the 2000-ft system, these were at existing airport sites. Site selections were based on minimizing the access time to the air terminals by as uniform a distribution as possible of the terminals throughout the regions. It was assumed that all origin and destination traffic between the regions used these systems.

The initial computer runs showed that some of the originally selected sites failed to generate sufficient traffic to justify reasonable flight frequencies. These sites were therefore eliminated and new terminal systems were generated.

The 2000-ft runway system with CBD STOLports has 5 airports in the Bay Area and 4 in the Los Angeles area. The 3000-ft runway system has 5 airports at each end of the corridor.

Vehicle characteristics were defined including direct and indirect operating costs, initial aircraft acquisition costs, block speed and noise footprints. Pollution aspects were assessed, but used only in the community acceptance studies.

Infrastructure costs were analyzed by defining the modifications necessary to develop the selected airports, e.g., land acquisition, where applicable, runway strengthening and/or lengthening, addition of gates, terminals, parking areas, etc. and by identification of social disbenefit costs associated with noise.

SYSTEMS ANALYSIS METHOD

Development of a systems analysis method required the preparation of a computer program which combined the demand, vehicle and infrastructure information to produce a comparative form of total system cost to the user. Essential elements of this procedure were (1) computations of fare (based on a desired return on investment) and other perceived costs associated with the value of time and out-of-pocket expenses and (2) a modal split defining the percentage of total travelers choosing air and auto modes based on the perceived costs. Outputs of the program yielded optimum aircraft size, required fleet size, fares, and system cost for each system.

Figure IV-1 shows an extremely simplified schematic of the systems analysis method. Using initial assumptions on maximum load factor, return on investment for the airline, value of time, and aircraft size (passenger capacity), the first block performed those computations specific to each route (36 routes in each system). Inputs to the first block included total travel demand for that airport pair, block time, access time and cost, and operating costs based on an initial assumption of aircraft buy quantity. This block contained an iterative loop between total traveler cost computations and the modal split, and produced, for each aircraft size, the number of air travelers on that route, flight frequency, the final fare and other costs associated with access and waiting time, and number of aircraft required to serve the route. The second block summed these outputs for all routes in the system to provide total system cost in terms of average cents per passenger mile and fleet size. At this point, the fleet size value was used to check the initial assumption on aircraft buy quantity, and if significantly different, the entire process was repeated using DOC's and acquisition costs based on the new buy quantity.

Once system cost and fleet size was defined for the assumed aircraft size, a new size was assumed and the process repeated over a desired range of sizes. These results were then plotted as system cost (cents/passenger mile) versus aircraft size for each system. The minimum cost value defined the optimum aircraft size for each system. Finally the incremental infrastructure costs (difference between the infrastructure costs defined for the 2000-ft and 3000-ft systems) were amortized over a 30 year period at 6% interest rate allocated on a cents/revenue passenger mile basis and added to the optimum system cost of the appropriate system.

The system costs for the two systems were then directly compared. Sensitivity studies were conducted to investigate the effect on the results of varying the assumed return on investment (ROI) value and the cost of fuel.

SCHEMATIC OF SYSTEMS ANALYSIS METHOD

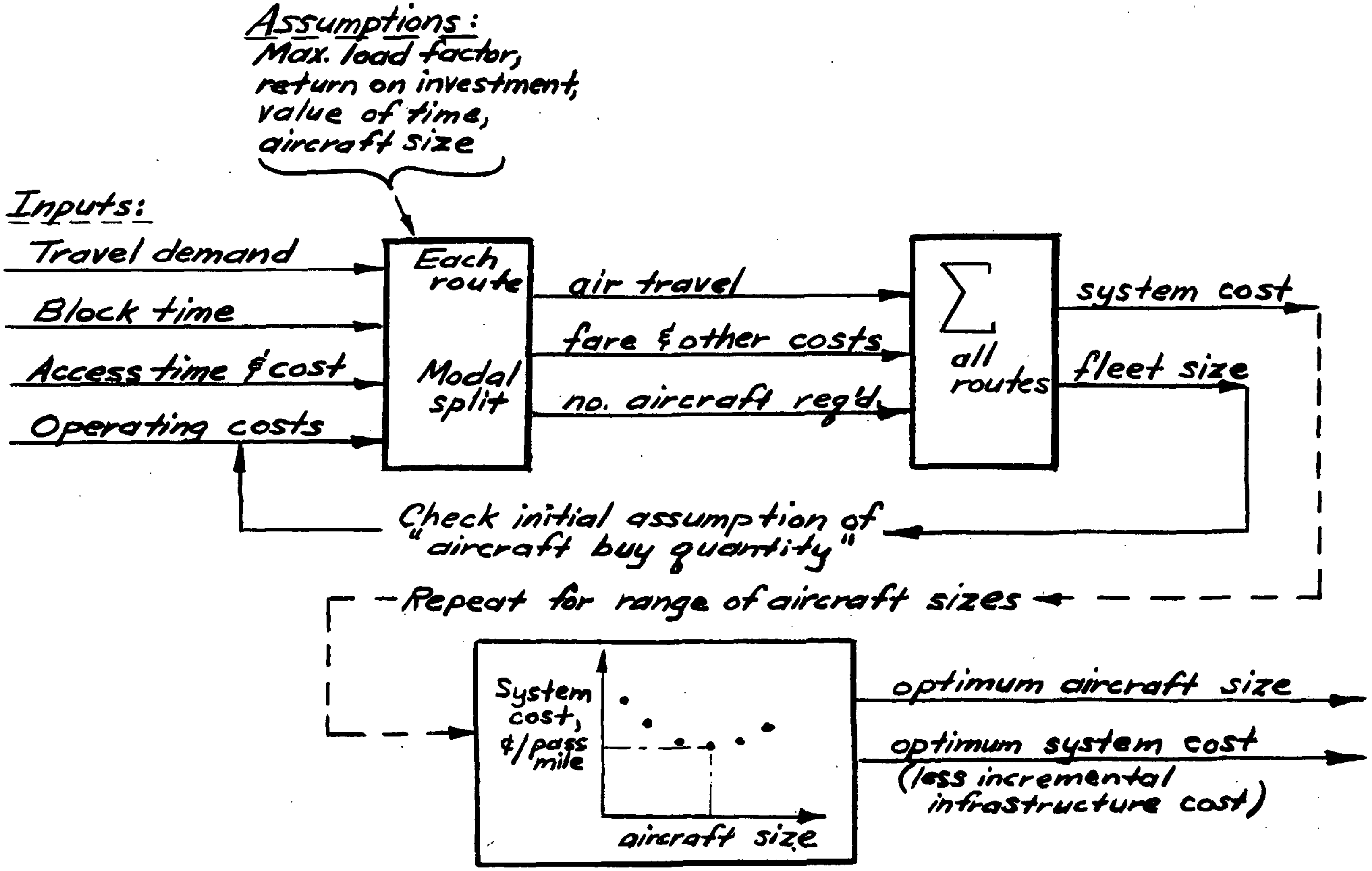

Figure IV-1

Fare Determination - Rate of Return on Investment

The fare of a transportation system must be set at a level that covers the direct and indirect operating costs plus a profit that provides a reasonable return on the capital invested. Methods of calculating return on investment are many but the present value, or discounted cash flow, method is generally preferred. In Appendix F, the derivation of a fare based on a discounted cash flow rate of return is derived and compared to other approaches. It is shown that for a typical aircraft in this study, a 12% after-tax rate of return based on discounted cash flow leads to a fare that is about 15% less than that resulting from a 12% after-tax simple annual rate of return based on the initial investment, and corresponds to a profit percentage in each ticket, above total operating costs, of about 40%.

The fare equation for discounted-cash-flow rate of return is:

$$\text{Fare/passenger/trip} \overset{(1)(2)}{=} \frac{T_B\,(A)\,IC}{U \cdot lf \cdot N} + \frac{T_B\,(B)\,L}{U \cdot lf \cdot N} + \frac{TOC \cdot d}{lf}$$

where:

A and B = constants dependent upon rate of return and depreciation period

IC = total initial cost of the aircraft, \$ per unit (1.3 times the individual aircraft cost to account for equipment and spares)

T_B = flight block time (hours)

U = aircraft annual utilization (hours per year) = 3,000

lf = load factor, the ratio of passengers to available seats

N = number of available seats per aircraft

L = salvage, or residual value

TOC = total operating cost (\$/statute mile) = DOC + IOC

DOC = direct operating cost

IOC = indirect operating cost

d = air distance, statute miles

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(1) This method assumes that each segment has a fare that provides the desired return on investment. The computer solution requires an iteration relating demand, number of flights, load factor and fare. In some cases, particularly with low flight frequencies, this process does not converge. It is then necessary to select average values from the close but not identical demands that bracket the solution. Errors introduced are small and over a large number of routes can be expected to largely cancel.

(2) This fare definition omits the current 8% tax. Applying this tax, and correcting the DOC to a utilization of 3000 hours (see page II-3) would raise the fare for both systems by about 5%. Air demand would decrease modestly but the relative economic performance of the 2000-ft and 3000-ft systems would not be significantly affected.

For a 12 year depreciation period, the values of A and B for various rates of return are:

Rate of Return	A	B
6%	.0692	.0460
8%	.0948	.0586
10%	.1219	.0701
12%	.1503	.0803

In this study, the residual value is assumed to be zero after a 12 year depreciation period and the basic rate of return is taken as 12%. Thus:

$$\text{Fare} = \frac{T_B\ (.1503)\ IC}{U \bullet lf \bullet N} + \frac{TOC \circ d}{lf}$$

Travel Demand

The total (all modes) travel demand between the San Francisco Bay area and the Los Angeles area was determined in Section I. Furthermore, this demand was analyzed and assigned to each of the possible airport pairs and, accompanied by average values of access time and cost for each terminal, was a primary input to the systems analysis program.

Figure of Merit

The figure of merit to be used as a reasonable basis of choice between the two alternative aircraft systems could be the number of passengers served by each system, the average total system cost per passenger-mile, or the total annual system cost. Since the nature of the modal split with the automobile is such that a lower total trip cost will always attract more patronage, the first two measures will always lead to the same selection. On the other hand, the lowest system annual cost could come from very small patronage and high fares, obviously not a preferred system. Therefore, the specific system cost based on the average total system cost per passenger mile was used as the primary figure of merit.

Modal Split

The modal split equation, explained in detail in Section I, defines the fraction of total travelers anticipated to travel by air and is given by:

$$\%\ \text{AIR} = \frac{1}{1 + \left(\frac{\$AIR}{K\ \$AUTO}\right)^{\gamma}} \doteq \frac{1}{1 + \left(\frac{\$AIR}{.82\ \$AUTO}\right)^{3.5}}$$

where $AIR is the total cost to the air passenger for a trip including access cost and the value of time, and $AUTO is the corresponding perceived cost per person travelling by automobile. K is an adjustment factor for an observed choice preference of auto over air. Since K turns out to be less than 1.00, it signifies that the cost of the air trip has to be less than (not just the same as) the cost of the auto trip before there is a 50% distribution of travelers to each mode. While the K factor can account for costs which were not included in the total air trip cost, such as the cost of a car rental at the destination, more likely it accounts for the flexibility in scheduling and private nature of auto travel as opposed to public air travel. The γ

exponent determines the degree of curvature with a greater curvature associated with a higher value of γ. The K and γ terms were defined by a fairing through the distribution of data points representing a modal split analysis of recent short haul traffic originating in the San Francisco Bay Area.

Modal Costs

The cost of travel by auto (\$AUTO) consists of an operating expense term and a time expense term, and is derived along with air travel costs, \$AIR, in section II .

$$\$AUTO = \frac{H}{NPPA} \cdot d + \$T(TBA)$$

where:

H = perceived operating cost of the auto (\$/s. mi.)

$NPPA$ = number of passengers in the auto (found to be a function of distance from Figure I-1, page I-7)

d = distance by road (s. mi.)

$\$T$ = value of time (\$/hour)

TBA = auto block time = $\frac{d}{V_{av}}$, where V_{av} is the average auto velocity (60 mph)

If the block time exceeds 9 hours, \$10 is added as a motel charge (never the case in this study).

The cost of travel by air (\$AIR) consists of three terms: a fare term, an airport access-egress term, and a time expense term:

$$\$AIR = FARE + \$OP + \$T\ (T_A + T_B + T_W),$$

where:

$FARE$ = price of airline ticket (\$)

$\$OP$ = out of pocket expense for airport access-egress, including parking costs and/or ground transportation to and from the airports (\$)

$\$T$ = value of time (\$/hour)

T_A = access-egress time (time it takes to get to and from the airports)(hour)

T_B = block time (actual flight time) (hour)

T_W = average waiting time (penalty time for a fixed departure schedule) (hour)

$$T_W = 0.5\left(\frac{14}{n} \bullet 1/2\right)$$

where:

n = frequency of departures at airport

14 = hours of airline operation per day

$\frac{14}{n}$ = time between flights

$\left(\frac{14}{n} \times 1/2\right)$ = average waiting time between flights

0.5 = factor which accounts for the fact that the average traveler will not arrive immediately after a flight departure

The FARE, as noted above is given by the equation:

$$\text{FARE} = \frac{T_B\ (.1503)\ \text{IC}}{U \bullet 1f \bullet N} + \frac{\text{TOC} \bullet d}{1f}$$

The direct operating costs are developed and described fully in section II. The direct operating costs are composed of three terms: a base cost per available seat mile for the type of aircraft specified with a 150 passenger capacity, a production quantity of 400 and chosen at the desired range, a term which relates the DOC of a 150 passenger configuration to that for the actual capacity, and a term which relates the DOC for an aircraft production quantity of 400 to that for the actual aircraft production quantity.

Thus:

$$\text{DOC} = \text{DOC (d)} \times \frac{\text{DOC (N)}}{\text{DOC}_{150}} \times \frac{\text{DOC (Q)}}{\text{DOC}_{400}}$$

where:

DOC (d) = DOC for 150 passengers, production quantity of 400, and a range of d

$\frac{\text{DOC (N)}}{\text{DOC}_{150}}$ = correction for passenger capacity, N

$\frac{\text{DOC (Q)}}{\text{DOC}_{400}}$ = correction for production quantity, Q

DOC (d) for the 2000-ft field length and the 3000-ft field length aircraft, $\frac{\text{DOC (N)}}{\text{DOC}_{150}}$, and $\frac{\text{DOC (Q)}}{\text{DOC}_{400}}$ are given in section II.

Similarly, acquisition cost, IC, is obtained from section II in the form:

$$IC_{N,Q} = IC_{150,400} \times \frac{IC(N)}{IC_{150}} \times \frac{IC(Q)}{IC_{400}}$$

The indirect operating cost formula adapted from Reference 5 is based on the experience of PSA (Pacific Southwest Airlines) and is representative of an efficient commuter airline:

$$\text{IOC, cents per available seat mile} = lf \left(\frac{300}{d} + .625\right)$$

where:

lf = load factor

d = air distance, statute miles

Modal Costs for Evaluation of Fuel Cost Effects

In the latter part of the study, the effects on air travel demand and costs due to a continuing rise in the cost of fuel was included. The cost of fuel in the equation for \$AUTO is contained in the term H. For this study, H, the perceived direct operating cost, is given a value of \$.05/mile. The breakdown of this cost is:

Maintenance Costs = \$.0234 per mile
Total Fuel Costs = \$.0266 per mile

In turn, the fuel cost consists of a fuel cost and a tax. For a total fuel cost at the pump of 39.9 cents per gallon, 12.9 cents is tax and 27 cents is actual fuel cost. On a \$/mile basis, assuming 15 miles per gallon,

Fuel only cost = \$.0180 per mile
Fuel tax cost = \$.0086 per mile

The fuel only cost, \$.0180 per mile, is 36% of the total automobile perceived operating cost.

The \$AUTO equation on page IV-7 was modified to enable the cost of fuel to be a parameter in the following manner:

$$\$AUTO\ (NF) = \left[.64\right] \frac{H \cdot d}{NPPA} + \$T\ (TBA)$$

$$\$AUTO\ (F) = \left[.36 \left(\frac{C_2}{.27}\right)\right] \frac{H \cdot d}{NPPA}$$

$$\$AUTO = \$AUTO\ (NF) + \$AUTO\ (F)$$

where: C_2 is the future "fuel only" cost/gallon

(NF) refers to non-fuel portion of cost

(F) refers to fuel portion of cost.

The cost of fuel in \$AIR is found in two places: \$OP and DOC. The modification of \$OP was done in a similar manner as the \$AUTO changes -- subtracting the parking costs from the driving and parking costs combination, separating the fuel cost percentage of the driving cost and modifying it as above, then adding the three terms back together:

$$\$OP^{*}(NF) = (\$OP - 4.00)\ (.64)$$

$$\$OP\ (F) = (\$OP - 4.00)\ (.36)\left(\frac{C_2}{.27}\right)$$

$$\$OP = \$OP(NF) + \$OP(F) + 4.00$$

The percentage of the DOC which is made up of the fuel cost for the route distances we are concerned with is given the name B (.128 for the 2000-ft runway aircraft, .116 for the 3000-ft runway aircraft,) based on a \$.115/gallon cost of jet fuel. The DOC equation was modified in the following manner:

$$DOC\ (NF) = DOC\ (1.00 - B)$$

$$DOC\ (F) = DOC\left(B \bullet \frac{C_1}{.115}\right)$$

$$DOC = DOC\ (NF) + DOC\ (F)$$

where: C_1 is the future jet fuel cost in \$/gallons.

The fuel costs studied included the present costs, 100% increases and 200% increases in fuel (only) prices. The resulting fuel costs are:

	Auto (fuel only) \$/gallon	Auto (pump price) \$/gallon	Aircraft jet fuel \$/gallon
Present	.27	.399	0.115
100% Increase	.54	.669	0.230
200% Increase	.81	.939	0.345

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* \$OP applies to out-of-pocket access cost at both ends of the system

The Computer Program

The computer program developed to determine system costs and characteristics is shown schematically in Figure IV-2. The program determines, for each route segment and airplane capacity, the air demand in one-way trips, number of flights, fares, total cost per passenger trip, and number of aircraft required. After all city pairs have been analyzed, total system aircraft quantity is determined, the production quantity for the world market is calculated and the costs adjusted by iteration for the new production quantity. The data listed above are then printed for the entire Bay Area-Los Angeles system for each airplane capacity. Input to the program are the following limitations and assumptions:

Minimum daily flight frequency on any segment = 2

Maximum allowable load factor on any segment = 0.65

Average value of time = $6.00 per hour

Aircraft Utilization = 3000 hours per year

Intercity automobile average speed = 60 miles per hour

Production quantity of aircraft = 6 times Bay Area-Los Angeles system quantity

The production quantity is based on a ratio of world market to California Corridor market of 12 (Ref. 3) It is assumed that a manufacturer would hope to capture 50% of the world market or 6 times the San Francisco-Los Angeles Corridor market.

A listing of the program is given in Appendix G.

AIRLINE OPERATIONS PROGRAM

AIRCRAFT SIZE SELECTION, FARES & SYSTEM COSTS

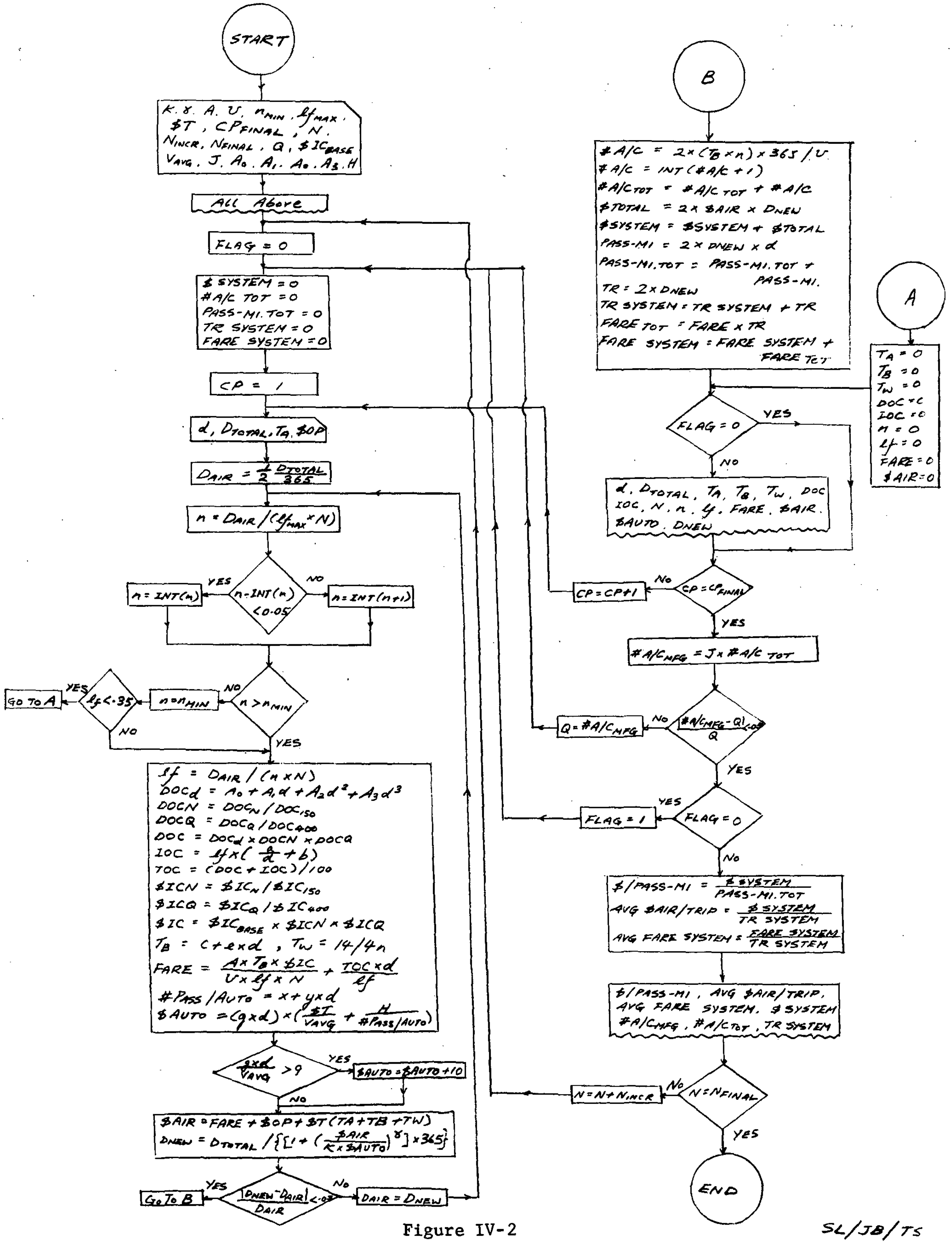

Figure IV-2

SL/JB/TS
4/73

Table IV-2

Variable Names for Systems Analysis Program

Name in Flow Chart	Name in Program	Explanation of Function
K	K	Weighting factor for modal split equation
γ	G	Exponent for modal split equation
A	AROI	Constant (depending upon ROI) for fare calculation
U	U	Yearly Utilization (hours) of A/C
$\$T$	ST	Dollar value of time
$\$OP$	SOP	Out-of-pocket expenses ($)
n_{MIN}	NMIN	Minimum allowable frequency
lf_{MAX}	LFMAX	Maximum allowable load factor
CP_{FINAL}	M	Number of airport pairs in system
N	N	Size (Number of seats) of A/C
N_{INCR}	NINCR	Increment in A/C size
N_{FINAL}	NFINAL	Final allowable A/C size
Q	Q	Initial assumed production quantity of A/C
$\$IC_{BASE}$	SICB	Initial cost of base A/C (400 Q, 150 N)
c	0.215	Constant in block time equation
e	0.00416	Constant in block time equation
FLAG	FLAG	Flag to signify termination of production quantity
CP	L	Airport pair identifier
d	DIST(L)	Distance between airport pairs
D_{TOTAL}	DTOT(L)	Total round trips by all modes for each route

Table IV-2 continued

Name in Flow Chart	Name in Program	Explanation of Function
T_A	TA(L)	Access time for each route
D_{AIR}	DAIR	Total round trips by air for each route
n	NF	Frequency of departures from Bay Area airports
lf	LF	Load factor on air trips
DOC_d	DOCD	Component of DOC that is a function of distance
A_0	A0	Constant in DOC_d equation
A_1	A1	Constant in DOC_d equation
A_2	A2	Constant in DOC_d equation
A_3	A3	Constant in DOC_d equation
DOCN	DOCN	Component of DOC that is a function of plane size
DOCQ	DOCQ	Component of DOC that is a function of quantity
DOC	DOC	Direct Operating Cost (cents/statute mile)
IOC	IOC	Indirect Operating Cost (cents/statute mile)
TOC	TOC	Total Operating Cost ($/statute mile)
$ICN	SICN	Component of Initial Cost of A/C that is a function of size
$ICQ	SICQ	Component of Initial Cost of A/C that is a function of quantity
$IC	SIC	Initial cost of given A/C
T_B	TB	Block time of air trip
FARE	FARE	Fare for air trip

Table IV-2 continued

Name in Flow Chart	Name in Program	Explanation of Function
T_W	TW	Waiting time for air trip
a	300	Constant in IOC equation
b	.625	Constant in IOC equation
$AUTO	SAUTO	Auto costs for trip on ground
H	H	Constant in $AUTO equation
# pass./auto	NPPA	Number of passengers assumed to be in auto
g	1.17	Constant in $AUTO equation
V_{AVG}	VAVG	Average velocity of auto
D_{NEW}	DNEW	New generated number of round trips by air
x	2.025	Constant in # pass/auto equation
y	0.0021	Constant in # pass/auto equation
$SYSTEM	SSYS	Total cost of air travel, all trips, all routes
# A/C TOT	ACTOT	Number of A/C required to cover system
PASS-MI	PM	Trips times distance per route
# A/C	NAC	Number of A/C on a route
$TOTAL	STOT	Total cost of air travel, all trips, per route
PASS-MI TOT	PMTOT	Total passenger-miles, all trips, all routes
$/PASS-MI	SPPM	Cost of air travel per passenger mile weighted average, all routes
# A/C MFG	ACMFG	Production Quantity for world market for one A/C manufacturer

Table IV-2 continued

Name in Flow Chart	Name in Program	Explanation of Function
J	J	Percentage of world A/C market to California market, per manufacturer
TR	TR	Number of trips, one way, per route
TR_{SYSTEM}	TRSYS	Number of trips, one way, all routes
$FARE_{TOT}$	FTOT	Total air fare, all trips, per route
$FARE_{SYSTEM}$	FSYS	Total air fare, all trips, all routes
AVG $AIR/TRIP	ASAT	Average air cost per trip in entire system
AVG FARE SYSTEM	AFS	Average air fare in entire system

SYSTEMS ANALYSIS RESULTS

System Configurations Analyzed

Computer analyses were performed for ten differing systems. The two basic systems were the 2000-ft and 3000-ft systems based on 12% return on investment (ROI). Comparison of the relative costs of these two systems was the primary objective of the study. Eight other systems were included to investigate the effects of varying ROI and the effect of increased fuel costs, a matter of considerable uncertainty and current concern. Elements of the program which were modified to reflect increased fuel costs were the aircraft direct operating costs (DOC), the automobile perceived DOC, and the airport access costs. The tax rate (cents per gallon) on fuel was assumed constant at the present level. The ten systems studied are described in Table IV-3.

Table IV-3

Identification of the Various Aircraft Systems Analyzed

System Designation (Field length/ROI/fuel price ratio)*	Runway Length (feet)	ROI (percent)	Fuel Cost Factor
2000/12	2000	12	1
2000/8	2000	8	1
2000/0	2000	0	1
3000/12	3000	12	1
3000/8	3000	8	1
3000/0	3000	0	1
3000/12/2x	3000	12	2
3000/8/2x	3000	8	2
3000/12/3x	3000	12	3
3000/8/3x	3000	8	3

Elimination of Uneconomical Routes

The computer results show that a few city-pairs may be dropped from the system when the aircraft capacity exceeds certain levels. This results from the systems analysis procedure which requires that the fare for each route be adequate to pay the total operating costs plus the specified rate of return on investment, and that there be at least two departures per day. If the route demand is low and the airplane capacity is large, the load factor may be low, say 50%, even in the first iteration. The required fare is then high and the modal split check shows fewer air passengers than first assumed. This further lowers the load factor, further raises the fare and, on the next modal split check, shows even lower air demand. If this process diverges to the point where the load factor decreases below 35%, the route is dropped. In effect, the system eliminates uneconomical routes.

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* Fuel price, if noted, is either 2 or 3 times the base or 1972 values

The initial study with 6 terminals at each end of the system showed many such uneconomical city-pairs. As a result, Gnoss Field, El Monte and Torrance were deleted from the 2000-ft system and Gnoss Field and Torrance were eliminated from the 3000-ft system.

In the resultant 20 and 25 city-pair systems, a few city-pairs were still dropped at the higher aircraft capacities. In a perfect analysis, even this small dropped demand should be further redistributed to the nearest air terminal having flights to the desired destination. The computer program does not do this and the demand is ignored. The dropped demand is small, no more than about 3% of the total system demand for the largest aircraft size studied, and only 0 to 1% for the aircraft sizes leading to the lowest operating costs. Therefore, the dropped demand has no significant effect on the study conclusions.

An alternative method of analysis would be to use the overall system load factor to determine fares. This is a realistic and possibly preferable approach but the resulting system might include very uneconomical routes that drag down the overall system efficiency.

Comparison of 2000- and 3000-ft Systems

A comparison of the total system results for the 2000-ft and 3000-ft systems at 12% ROI is shown in Table IV-4. Total air travel cost in cents per passenger mile (includes fare, access costs, and value of time) and average system fare have been plotted versus aircraft passenger capacity in Figure IV-3. The optimum aircraft size for both systems was 140 passengers based on minimum cents per passenger mile. Corresponding costs were 14.21 and 12.61 cents per passenger mile for the 2000-ft and 3000-ft systems respectively, and average system fares were $32.38 and $25.40. Thus the total cost to the air traveler was approximately 13% more expensive for the 2000-ft system than for the 3000-ft system. The fare was 27% higher for the 2000-ft system.

The total number of one-way trips carried daily by each system was 33,497 and 43,558, or 30 and 39% of the total travel market for the 2000-ft and 3000-ft systems, respectively. The corresponding annual traffic was 12,226,400 and 15,898,700. Table IV-5 identifies the city-pairs for each system and number of daily departures on each route. Table IV-6 presents the breakdown of daily one-way trips by route. Detailed computer printouts for both systems at the optimum aircraft size (N = 140) are provided as a sample in Appendix G. These printouts provide additional information by route and total system information.

Effect of Varying ROI

Total system results obtained using 8% and zero ROI are shown in Table IV-7. The 3000-ft system costs are plotted versus aircraft passenger capacity for ROI values of 0, 8 and 12% in Figure IV-4 Reducing the ROI from 12 to 8% reduces the total system cost from 12.61 to 11.51 cents/passenger mile or about 9%; while a reduction to the non-profit case of zero ROI reduces the cost to 9.97 cents/passenger mile, or 21% less than the cost for the 12% ROI system.

Average system fares were $25.40, $21.72 and $16.24 for the optimum 12%, 8% and zero ROI cases, respectively. A reduction in ROI from 12% to zero resulted in a 36% reduction in fare! This leads to an obvious but seldom appreciated conclusion. The surprisingly large reduction in fare from eliminating the profit resulted from two causes: (1) a relatively high aircraft "first cost" and thus a large investment, and (2) the increase in the number of air travelers as fare is reduced, thereby increasing aircraft production quantity and reducing the manufacturing cost. The large resulting increase in traffic increases frequency thus reducing waiting time and encouraging an even larger proportion of the travel market to transfer to the air mode. The effect of ROI on the number of daily trips is shown in Figure IV-5.

The aircraft "first cost" effect on fare can be understood by recalling that the fare equation is made up of two basic terms: (1) a profit term containing the product of an ROI constant and the investment costs and (2) the total operating costs (which also are influenced by aircraft first cost).

$$\text{Fare} = \frac{T_B\ (A)\ IC}{U \bullet lf \bullet N} + \frac{TOC \bullet d}{lf}$$

for 12% ROI: $A = 0.1503$
$U = 3000$ hours

Referring to the sample printout for the 3000-ft system,

airport pair 1: $T_B = 0.99$, $\$IC = 13.756 \times 10^6$, $LF = .629$, $N = 140$, $DOC = 2.27$, $IOC = 0.90$, $d = 371$.

$$\text{Fare} = \frac{(.99)(.1503)(13.756 \times 10^6)}{(3000)(.629)(140)} + \frac{(3.17)^{*}(371)}{(.629)}$$

$$= 7.74 + 18.69$$

$$= \$26.43$$

Thus, in order to return 12% on the investment in this example, the profit term was 29.3% of the total fare and equalled 41.4% of the total operating cost. Initial costs per seat of present conventional jet transports used in short haul service are on the order of one-half the initial cost per seat of the aircraft in this study. After allowing for the lower DOC of such aircraft (by about 25%), 12% ROI would require a profit term on the order of 19% of the total fare. The conclusion is that as aircraft first cost per seat increases, the profit portion of the fare becomes significantly greater.

These ratios of the profit portion of the fare to the fare or to the total operating cost are also higher for a given ROI than in typical airline operation because of the low IOC's associated with high density commuter service. These IOC's are about 40% of the DOC. If the IOC were equal to the DOC, roughly the experience of the trunk airlines, the profit portion for 12% ROI would be about 22% of the fare and 29% of the total cost - even operating these STOL/RTOL aircraft.

---

[*] 3.17 is the sum of the DOC (2.27) and the IOC (0.90)

Another observation is that the variations of fare and cents/passenger mile with changing aircraft size were not always in the same direction. In the zero and 8% ROI curves of Figure IV-4 fare levels continued to decrease as aircraft size was increased above 160 passengers while cents/passenger mile did not. This is primarily the effect of the increased waiting times as flight frequencies were reduced with increasing aircraft size.

Figure IV-5 compares the daily air demand of the 2000-ft and 3000-ft systems at 0, 8 and 12% ROI as influenced by aircraft passenger capacity. For the 3000-ft system with zero ROI, there are 66,724 daily one-way trips or 60% of the total market.

As the ROI is decreased, the relative difference between the 2000- and 3000-ft systems is significantly reduced. Figure IV-6 presents crossplots showing the optimum system parameters (cents/passenger mile, average fare, optimum passenger capacity, daily air trips) as influenced by varying ROI. The cost per passenger mile for the 2000-ft system is only 3% greater than for the 3000-ft system at zero ROI while the fare difference is reduced to 14%. This is the result of the large decrease in fare ($32.38 to $18.77) for the 2000-ft system as ROI was decreased from 12% to zero and the corresponding increase in number of daily travelers (33,497 to 63,996).

The total cost per passenger mile was relatively insensitive to variations in aircraft size within a band about the optimum, as reflected by the bands in Figure IV-6. (The band widths correspond to acceptable variations from the optimum values of 0.5% for cents/passenger mile and 1.0% for daily air demand.) For example, the 3000-ft system results (cents/passenger mile and daily air demand) with 12% ROI were nearly constant for aircraft sizes from 125 to 155 passengers. This is the result of compensating cost effects. As aircraft size increases, the direct operating costs and aircraft first cost per seat decrease, while wait time between departures increases and the reduced production quantity increases the costs. The band width increased with decreasing ROI indicating that sensitivity to aircraft size decreases with decreasing ROI.

Effects of Increased Fuel Costs

The effects of increasing the fuel cost factor are shown in Table IV-8 for the 3000-ft system at 8 and 12% ROI. System cost per passenger mile and fare versus aircraft passenger capacity are shown in Figure IV-7 and daily air demand versus passenger capacity in Figure IV-5. Crossplots of cents/passenger mile, fare, optimum aircraft size, and air demand versus fuel cost factor are shown in Figure IV-8.

At 12% ROI, tripling the fuel cost increased the total cost to the passenger from 12.61 to 13.56 cents/passenger mile, or 7.5%, while fare increased from $25.40 to $27.88, or about 10%. See Figures IV-7 and IV-8. At 8% ROI, cents/passenger mile increased 8% and fare 11%.

Although aircraft operating costs increase with increasing fuel costs, the automobile operating costs are more heavily impacted. Fuel cost, without tax, represents approximately 6 to 9% of total operating costs for the STOL/RTOL aircraft and approximately 30% of the perceived operating costs for the automobile. Therefore, it was anticipated that the effect of increased fuel costs would be to shift a large amount of the travel market to the air mode from the automobile. As shown in Figures IV-5 and IV-8 the air demand does increase with increasing fuel costs, but not as much as anticipated. At 12% ROI, tripling fuel costs increased the number of daily air travelers from 43,558 to 47,658, or about 9.5%. The reason the shift is not larger is that the total perceived cost (on which one bases his choice of travel modes) includes the value of the time involved. For the automobile, the travel time cost becomes a large part of the total perceived cost and although the perceived operating costs may rise by over 70% with the three-fold fuel cost increase, the total perceived cost is affected to a much smaller degree.

Table IV-9 provides a summary of the selected optimum aircraft size and corresponding parameters for each of the ten systems studied.

None of the foregoing results have included the cost adjustments for infrastructure development costs or the hypothesized noise compensation payments. Because of the large volume of traffic in this high density corridor, the impacts of these costs, and especially the differences in these costs between the 2000-ft STOL system and the 3000-ft RTOL system, are extremely small. On page III-4 it is shown that the 2000-ft system has a higher capital cost of $21,433,200 after Federal airport aid. The corresponding amortization cost is $1,543,190 per year. This requires a fare increase of only $0.13 per passenger. The noise impact costs are shown on page III-18 to be $3,585,000 to $3,890,400 per year with the 2000-ft system having the higher cost. These costs could be defrayed by about $0.25 per passenger. The difference between the systems is only $300,000. Adjusting for the larger volume on the 3000-ft system, the difference represents an increased cost to the 2000-ft system of $.09 per passenger. (This higher noise cost for the 2000-ft system is because of the particular airports chosen and cannot be generalized.) The total infrastructure increment is an additional fare on the 2000-ft system of $0.22. The system analysis was not re-adjusted to react to this change since the increment is less than 1% in the fare and simply further adds to the higher cost of the 2000-ft system.

Table IV-4 TOTAL SYSTEM RESULTS - 12% ROI

N Aircraft Capacity	¢/PASS·MI	NO. A/C SYSTEM	AVG. $AIR/TRIP	AVG. $FARE	TRIPS/DAY	RTS. DROPPED*
		2000-FT SYSTEM				
100	15.39	50.1	54.46	36.76	27068	–
110	15.02	49.4	53.16	35.42	29015	–
120	14.48	48.7	51.27	33.50	31971	–
130	14.54	46.6	51.44	33.60	32322	–
140	14.21	44.5	50.30	32.38	33497	–
150	14.37	41.5	50.87	32.80	32886	–
160	14.39	38.3	51.01	32.74	32466	–
170	14.40	34.8	51.05	32.49	31717	–
180	14.45	32.1	51.33	32.85	30460	9,19
190	14.51	30.0	51.53	32.82	30205	9,19
200	14.66	28.8	52.07	33.31	29905	9,19
		3000-FT SYSTEM				
100	13.20	72.5	46.00	27.78	39966	–
110	12.92	70.1	45.01	26.75	42322	–
120	12.79	66.7	44.57	26.23	43388	–
130	12.66	61.7	44.15	25.67	43722	–
140	12.61	57.1	44.00	25.40	43558	17
150	12.71	54.1	44.34	25.62	43301	17
160	12.73	49.1	44.44	25.60	42124	12,17
170	12.74	46.1	44.52	25.64	42064	7,12,17
180	12.83	42.7	44.84	25.77	41150	7,12,17
190	12.88	39.7	44.99	25.68	40787	7,12,17
200	12.87	39.0	44.98	25.71	41432	7,12,17

* KEY FOR ROUTES DROPPED:
2000-FT SYSTEM: #9 Hayward - Van Nuys, #19 Hayward - Santa Monica
3000-FT SYSTEM: #7 Palo Alto - El Monte, #12 Palo Alto - Van Nuys, #17 Palo Alto - Burbank

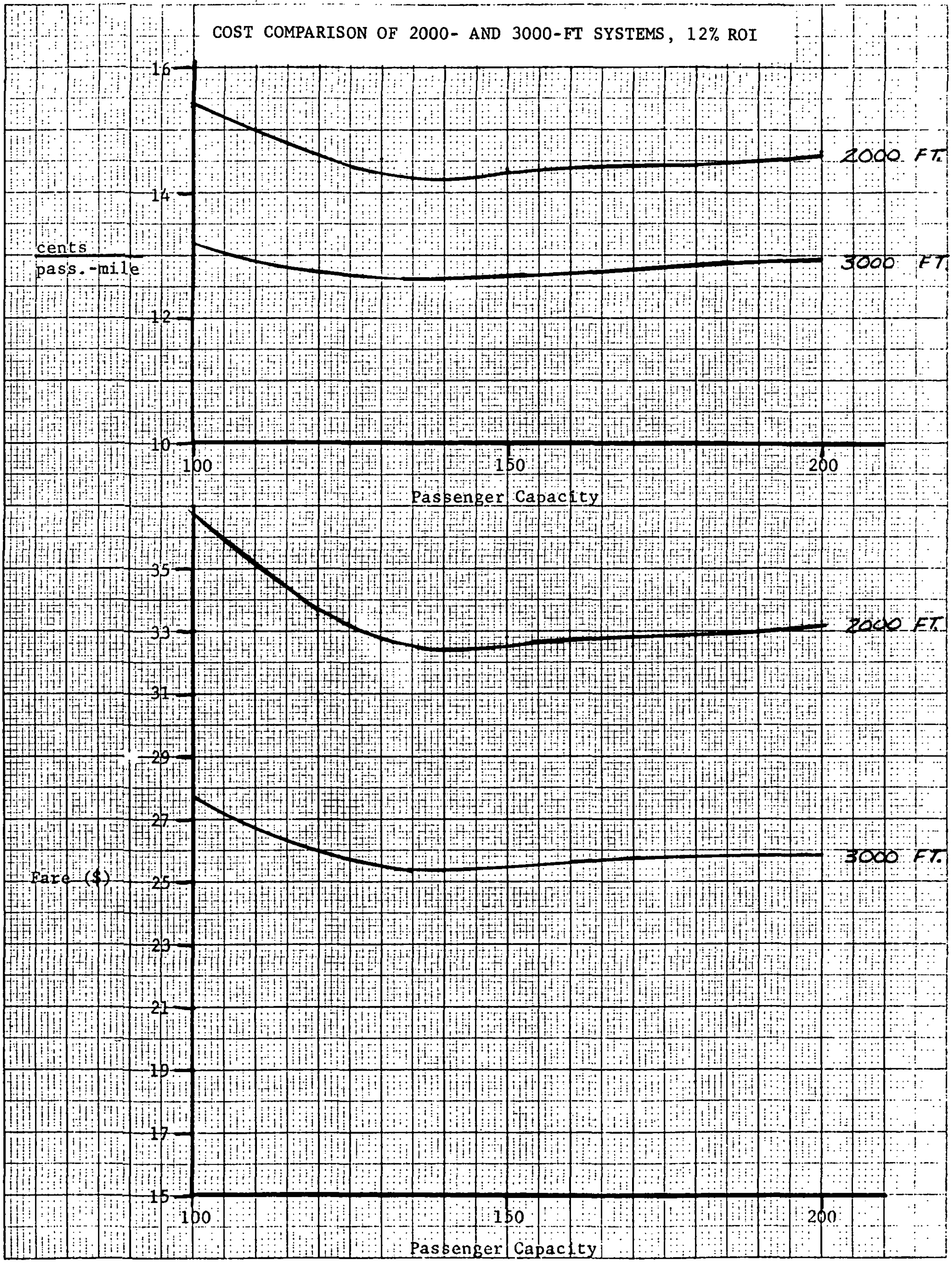

COST COMPARISON OF 2000- AND 3000-FT SYSTEMS, 12% ROI
16
14
12
10
cents
pass.-mile
100
150
200
Passenger Capacity
2000 FT.
3000 FT.
35
33
31
29
27
25
23
21
19
17
15
Fare ($)
100
150
200
Passenger Capacity
2000 FT.
3000 FT.

Figure IV-3

2000' System (140 Passenger Capacity)

TOTAL DEPARTURES	192	79	28	34	22	29
192	Origin Dest.	CBD	SCS	SJE	HAY	BUC
51	LBH	(1) 21	(2) 7	(3) 9	(4) 6	(5) 8
28	VNS	(6) 12	(7) 4	(8) 5	(9) 3	(10) 4
84	CBD	(11) 33	(12) 13	(13) 15	(14) 10	(15) 13
29	SMA	(16) 13	(17) 4	(18) 5	(19) 3	(20) 4

3000' System (140 Passenger Capacity)

TOTAL DEPARTURES	249	82	22	44	51	50
249	Origin Dest.	SFO	PAO	SJE	HAY	BUC
69	LBH	(1) 22	(2) 7	(3) 12	(4) 14	(5) 14
30	ELM	(6) 10	(7) 3	(8) 5	(9) 6	(10) 6
27	VNS	(11) 9	(12) 2	(13) 5	(14) 6	(15) 5
23	BUR	(16) 9	(17) 0	(18) 4	(19) 5	(20) 5
100	SMA	(21) 32	(22) 10	(23) 18	(24) 20	(25) 20

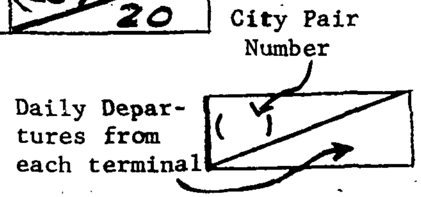


Table IV-5

Computer Program City Pair Identification and
Number of Daily Departures for Optimum Aircraft Size, 12% ROI

2000' System (140 Passenger Capacity)

TOTAL ONE-WAY AIR TRIPS	33497	14137	4896	5792	3565	5085
	Origin / Dest.	CBD	SCS	SJE	HAY	BUC
8973	LBH	(1) 3727	(2) 1248	(3) 1580	(4) 988	(5) 1430
4627	VNS	(6) 2158	(7) 681	(8) 803	(9) 377	(10) 608
14994	CBD	(11) 6009	(12) 2328	(13) 2602	(14) 1730	(15) 2325
4881	SMA	(16) 2243	(17) 639	(18) 807	(19) 470	(20) 722

3000' System (140 Passenger Capacity)

TOTAL ONE-WAY AIR TRIPS	43558	14429	3757	7711	8992	8898
	Origin / Dest.	SFO	PAO	SJE	HAY	BUC
12179	LBH	(1) 3874	(2) 1216	(3) 2132	(4) 2434	(5) 2523
5162	ELM	(6) 1726	(7) 378	(8) 912	(9) 1095	(10) 1051
4610	VNS	(11) 1637	(12) 339	(13) 793	(14) 938	(15) 903
3910	BUR	(16) 1479	(17) 0	(18) 701	(19) 914	(20) 816
17926	SMA	(21) 5713	(22) 1824	(23) 3173	(24) 3611	(25) 3605

Table IV-6

1985 Air Demand for Optimum Aircraft Size

Final 2000-ft and 3000-ft Systems (9 and 10 Air Terminals, resp.)

Daily One-Way Trips, 12% ROI

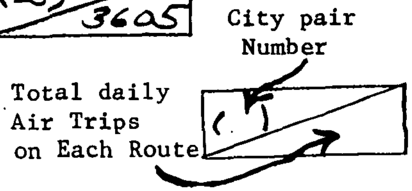


Table IV-7

TOTAL SYSTEM RESULTS - 8% & Zero ROI

Aircraft Capacity N \ ROI	¢/PASS-MI 8	¢/PASS-MI 0	NO. A/C SYSTEM 8	NO. A/C SYSTEM 0	AVG. $AIR/TRIP 8	AVG. $AIR/TRIP 0	AVG. $FARE 8	AVG. $FARE 0	TRIPS/DAY 8	TRIPS/DAY 0	RTS. DROPPED* 8	RTS. DROPPED* 0
2000-FT. SYSTEM												
100	13.31	11.05	72.7	103.0	47.03	39.00	29.89	22.25	39687	56919	—	—
110	12.93	10.79	70.9	97.9	45.69	38.09	28.53	21.30	42240	59247	—	—
120	12.70	10.65	67.0	92.4	44.90	37.58	27.65	20.74	43557	60468	—	—
130	12.54	10.52	63.2	86.6	44.29	37.13	26.97	20.21	44587	61625	—	—
140	12.49	10.44	59.8	81.7	44.12	36.83	26.69	19.85	45243	62575	—	—
150	12.49	10.35	56.3	76.2	44.11	36.54	26.61	19.47	45686	63087	—	—
160	12.47	10.34	52.6	72.2	44.10	36.52	26.48	19.39	45214	63169	—	—
170	12.54	10.29	49.1	67.4	44.35	36.31	26.58	19.08	44748	63310	—	—
180	12.51	10.32	45.9	64.6	44.24	36.42	26.32	19.12	44680	63333	—	—
190	12.58	10.26	43.8	62.0	44.50	36.21	26.53	18.85	44260	63810	—	—
200	12.51	10.25	41.0	59.3	44.25	36.20	26.08	18.77	44196	63996	—	—
3000-FT. SYSTEM												
100	12.02	10.50	88.0	110.8	41.86	36.56	23.93	18.92	48796	62025	—	—
110	11.83	10.33	83.9	105.3	41.22	35.95	23.23	18.28	50477	63746	—	—
120	11.72	10.22	79.5	98.0	40.81	35.58	22.75	17.81	51810	64538	—	—
130	11.59	10.10	74.0	90.7	40.35	35.14	22.19	17.27	52784	65675	—	—
140	11.54	10.06	69.4	85.9	40.18	35.02	21.91	17.09	53087	65958	—	—
150	11.51	10.03	64.8	80.4	40.12	34.90	21.72	16.86	52894	66308	—	—
160	11.53	9.99	61.2	75.3	40.16	34.79	21.66	16.65	52759	66540	—	—
170	11.58	10.01	57.3	71.7	40.35	34.84	21.70	16.62	52734	66565	—	—
180	11.59	10.01	53.7	67.6	40.41	34.85	21.68	16.53	51859	66286	17	—
190	11.56	9.97	49.6	64.8	40.33	34.73	21.51	16.35	51289	66781	17	—
200	11.54	9.97	48.2	61.6	40.25	34.71	21.36	16.24	51935	66724	12,17	—

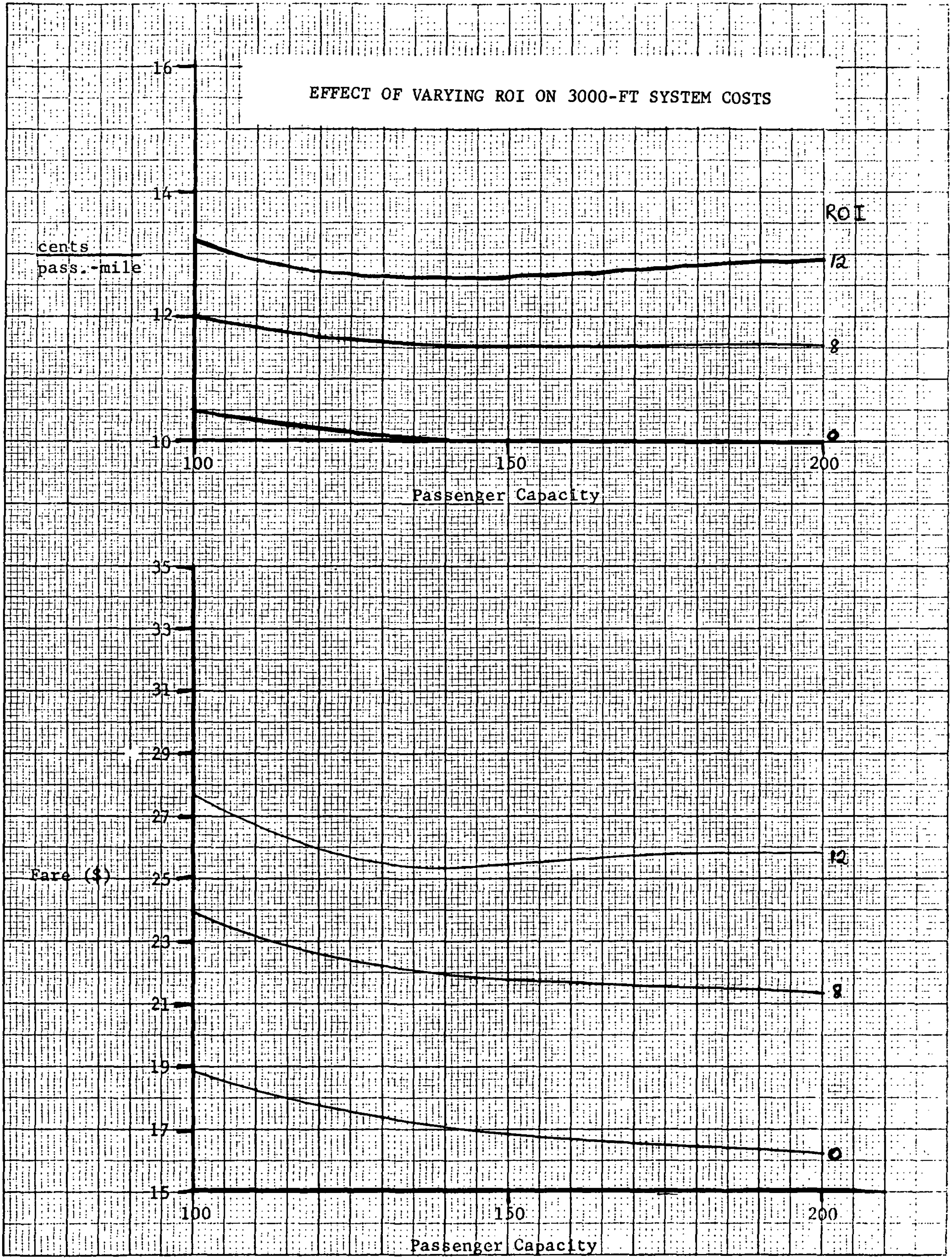

EFFECT OF VARYING ROI ON 3000-FT SYSTEM COSTS
16
14
12
10
cents
pass.-mile
ROI
12
8
0
100
150
200
Passenger Capacity
35
33
31
29
27
25
23
21
19
17
15
Fare ($)
12
8
0
100
150
200
Passenger Capacity

Figure IV-4

VARIATION OF DAILY AIR DEMAND WITH AIRCRAFT SIZE, ALL TEN SYSTEMS

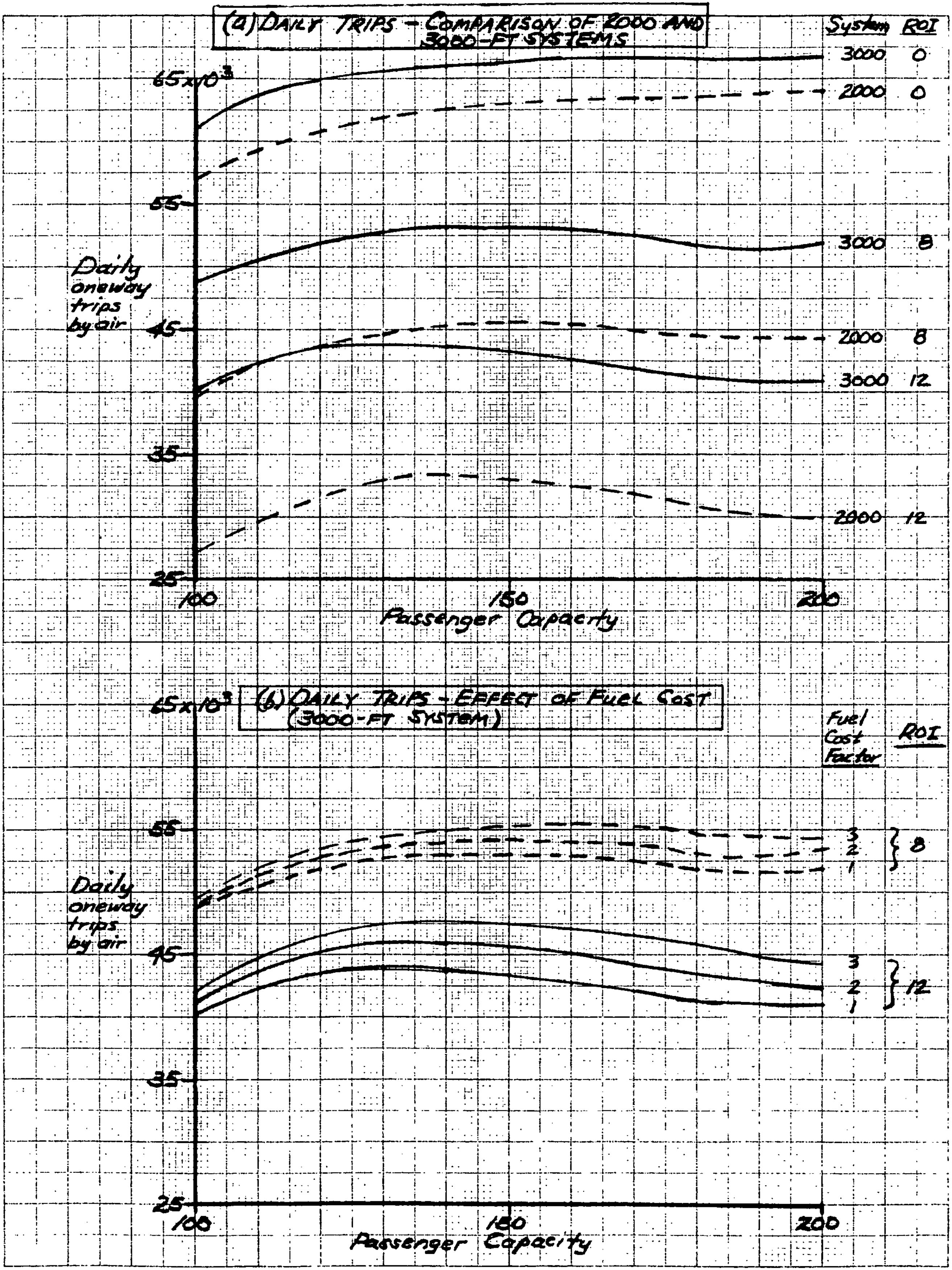
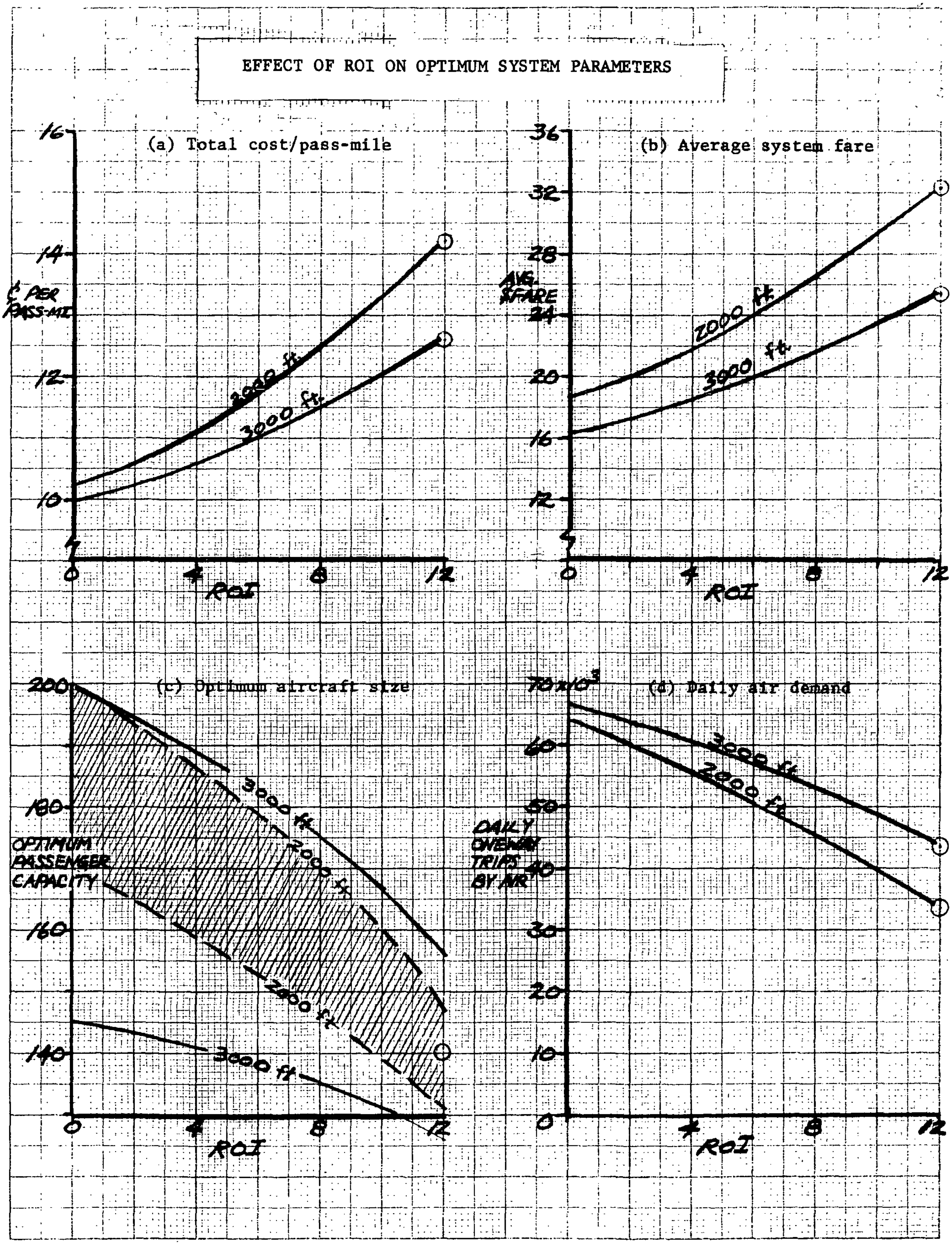


Figure IV-5


EFFECT OF ROI ON OPTIMUM SYSTEM PARAMETERS

(a) Total cost/pass-mile

(b) Average system fare

(c) Optimum aircraft size

(d) Daily air demand

Figure IV-6

Table IV-8

TOTAL SYSTEM RESULTS - 8 & 12 % ROI
INCREASED FUEL COSTS - 3000-FT SYSTEM

ROI / N Aircraft Capacity	¢/PASS-MI		NO. A/C SYSTEM		AVG. $AIR/TRIP		AVG. $FARE		TRIPS/DAY		RTS. DROPPED	
	8	12	8	12	8	12	8	12	8	12	8	12
2 x FUEL COST												
100	12.71	13.79	89.1	74.7	44.24	48.07	25.90	29.45	48831	40951	—	—
110	12.41	13.44	85.2	72.0	43.20	46.83	24.80	28.17	51270	43433	—	—
120	12.22	13.22	80.2	69.0	42.54	46.07	24.07	27.34	52805	45176	—	—
130	12.11	13.09	75.4	64.4	42.18	45.61	23.60	26.77	53482	45932	—	—
140	12.07	13.12	71.0	60.3	42.01	45.73	23.34	26.72	53987	45914	—	—
150	12.00	13.07	65.8	55.3	41.77	45.58	22.95	26.48	54235	45204	—	17
160	12.07	13.12	62.1	51.8	42.02	45.73	23.11	26.50	53957	45135	—	17
170	12.04	13.18	58.2	48.2	41.93	45.98	22.88	26.67	53904	44067	—	12,17
180	12.11	13.26	55.0	45.0	42.19	46.28	23.11	26.83	52866	43460	17	12,17
190	12.10	13.32	51.6	41.6	42.16	46.51	22.95	26.90	52748	42914	17	7,12,17
200	12.01	13.40	49.7	39.3	41.88	46.80	22.57	27.05	53456	41784	17	7,12,17
3 x FUEL COST												
100	13.29	14.43	90.0	77.4	46.26	50.27	27.48	31.28	49476	42052	—	—
110	12.98	13.98	85.9	74.0	45.18	48.67	26.35	29.61	51932	44824	—	—
120	12.68	13.80	81.7	69.6	44.11	48.06	25.21	28.90	54292	45593	—	—
130	12.60	13.57	76.0	67.1	43.88	47.26	24.86	28.03	54302	47574	—	—
140	12.54	13.56	71.5	62.3	43.64	47.24	24.53	27.88	54969	47658	—	—
150	12.56	13.61	67.8	58.4	43.74	47.40	24.54	27.92	55123	47439	—	—
160	12.45	13.60	64.4	53.9	43.36	47.39	24.08	27.79	55504	47023	—	17
170	12.51	13.65	59.3	50.4	43.54	47.60	24.07	27.85	55127	46516	—	17
180	12.57	13.66	55.9	46.5	43.77	47.67	24.23	27.84	54719	45879	—	12,17
190	12.52	13.80	53.8	43.6	43.59	48.19	23.54	28.24	55095	44305	—	7,12,17
200	12.54	13.73	50.4	41.1	43.70	47.90	23.98	27.83	54220	44333	17	7,12,17

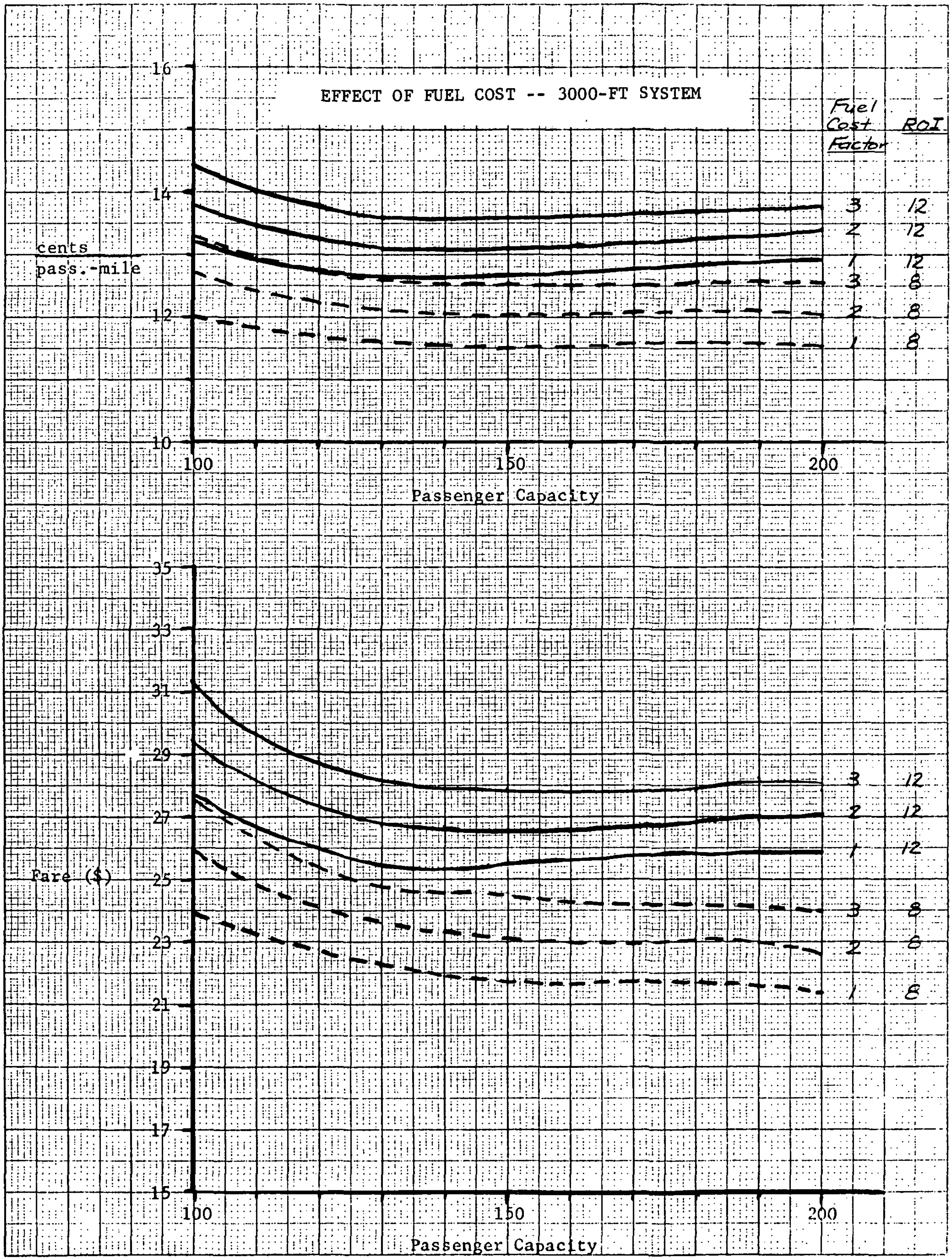

EFFECT OF FUEL COST -- 3000-FT SYSTEM
cents
pass.-mile
16
14
12
10
100
150
200
Passenger Capacity
Fuel Cost Factor
ROI
3 12
2 12
1 12
3 8
2 8
1 8
Fare ($)
35
33
31
29
27
25
23
21
19
17
15
100
150
200
Passenger Capacity
3 12
2 12
1 12
3 8
2 8
1 8

Figure IV-7

EFFECT OF FUEL COST ON OPTIMUM SYSTEM PARAMETERS -- 3000-FT SYSTEM

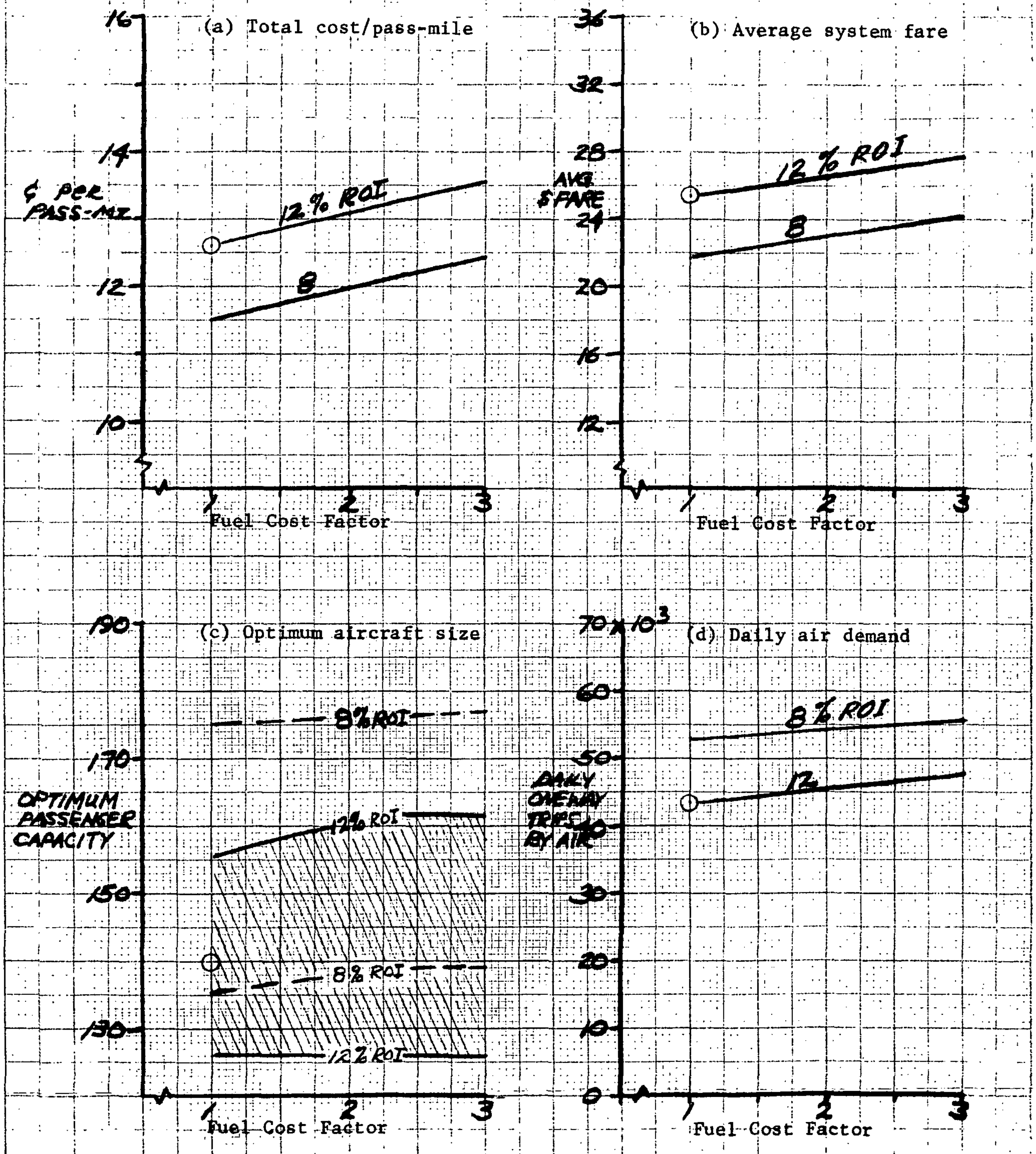


Figure IV-8

Table IV-9

Definition of Optimum Aircraft Size and Corresponding Parameters based on Minimum Cost per Passenger Mile

System	Optimum Aircraft Capacity*	Cents/Passenger Mile	Average Fare	No. Daily Trips
2000/12	140	14.21	$32.38	33,497
2000/8	160	12.47	$26.48	45,214
2000/0	200**	10.25	$18.77	63,996
3000/12	140	12.61	$25.40	43,558
3000/8	150	11.51	$21.72	52,894
3000/0	190	9.97	$16.35	66,781
3000/12/2x	150	13.07	$26.48	45,204
3000/8/2x	150	12.00	$22.95	54,235
3000/12/3x	140	13.56	$27.88	47,658
3000/8/3x	160	12.45	$24.08	55,504

* Optimum size selected based on lowest cents/passenger mile. In some cases, this does not correspond with maximum number of daily trips

** Note: Aircraft Capacity of 200 was largest size checked

References

1. Systems Analysis and Research Corporation, "Bay Area Study of Aviation Requirements - Aviation Forecast," May 1970.

2. McDonnell Douglas Corporation (Douglas Aircraft Company), "STOL System Feasibility Study," PR71-STOL-9286-1, April 19, 1971

3. Douglas Aircraft Company, "Study of Quiet Turbofan STOL Aircraft for Short Haul Transportation," MDC J4382, May 2, 1973.

4. Landrum and Brown, "Survey of Los Angeles International Airport Scheduled Air Passenger Market," 1967.

5. E. G. Stout and L. A. Vaughn, "The Economics of Short-Short Haul," Astronautics and Aeronautics, December, 1971.

COMMUNITY IMPACT AND ACCEPTANCE OF SUBURBAN STOL/RTOL AIRPORTS

Introduction

"Community Acceptance Analysis" describes a variety of methods used to anticipate whether a transportation proposal will receive a favorable or hostile reaction at the municipal level. The common denominator of community acceptance analyses is the use of questionnaire and interview methods to determine whether the adverse environmental impacts of a transportation project outweigh its benefits in the eyes of community residents.

Community acceptance analysis provides the leaven of political realism necessary for evaluating the feasibility of transportation system concepts originated at the federal, state or regional level. It provides a means of avoiding jurisdictional confrontation and lengthy court actions by encouraging community leaders to consider the merits and demerits of a transportation project before it enters the planning and funding pipeline. This is accomplished by conducting a first-cut environmental impact assessment and then discussing the results with community opinion leaders before detailed project planning is initiated. The procedure allows community leaders to assess the desirability of a project before a modal administration or private operator commits to project implementation.

The Community Acceptability of Airport Development-Methodology

The community acceptance method presented here was developed in the context of a specific goal: determining the political feasibility of converting five general aviation airports in the San Francisco Bay Area for use by a commercial airline serving the Bay Area-Los Angeles Corridor.

The community impact of two aircraft types was examined and the acceptability of those impacts discussed with a cross section of community opinion leaders who would be likely to play an active role in a community controversy involving the issues of economic development and environmental quality. The two aircraft considered were:

STOL(1): a quiet turbofan aircraft which carries 100 to 150 passengers and is capable of using 2000 foot runways;

RTOL(1): a less expensive quiet turbofan aircraft designed to use 3000 foot runways and carry 100 to 150 passengers. In terms of the ground area affected, RTOL aircraft are slightly noisier than the faster-climbing STOL mode.

The differences in these aircraft types is small compared to the larger question of whether commercial service should be permitted in these airports.

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(1) As noted earlier, the STOL (short take-off and landing) label will be applied to the 2000 foot runway aircraft and the RTOL (reduced take-off and landing) label used for the 3000 foot case as a matter of convenience. There is no clear boundary between STOL and RTOL.

The research goal was to systematically predict whether the implementation of either aircraft system is politically feasible and to identify community concerns which must be accomodated in order to maximize airport benefits. The research question can be stated as follows:

> Will local communities support expansion of their general aviation airports as part of a regional airport system which rationally allocates commercial air travel demand among airports located conveniently close to major economic and residential centers?

The implications of the research question are clearer when we ask: Will five Bay Area communities tolerate the adverse environmental impacts of increased airport operations in order to stimulate economic development and increase air travel convenience?

The airports considered were:

> Palo Alto Municipal Airport, a general aviation facility which could be developed to divert 1.4 million air passengers annually from increasingly crowded San Francisco International airport and San Jose Municipal Airport.
>
> Hayward Air Terminal, a general aviation facility that would divert 3.0 million air commuters from Oakland Metropolitan Airport.
>
> Gnoss Field, a general aviation facility in Marin County, that would divert 1.2 million passengers from San Francisco International Airport.
>
> Buchanan Field, a general aviation facility in Concord, that would service Contra Costa County and divert 3.0 million passengers from Oakland Metropolitan Airport.
>
> San Carlos Municipal Airport, a mid-Peninsula general aviation facility that would divert 1.8 million commuters from San Francisco International Airport.

An airport site near San Francisco's Central Business District was also considered. The currently unimproved CBD site would divert 5.2 million passengers from San Francisco International Airport. The CBD site would require land acquisition, the demolition of a limited number of existing structures and the development of terminal facilities -- a considerably larger investment than would be required to improve the five sites with pre-existing general aviation facilities.

The community acceptance method developed here represents a considerable departure from the "salesmanship" approach which has typified the community acceptance methods prevalent in the aircraft industry.

Method Problems in Industry Studies of Community Acceptance

The techniques used by the aircraft industry for community acceptance analysis provide a useful catalogue of method problems which can be avoided by more systematic design. Three specific problems have flawed industry studies of community acceptance:

1. Underestimation of adverse environmental impacts. In some cases adverse impacts have been dismissed on the basis of unrealistically optimistic assumptions. The concept that NEF (noise exposure forecast) values of 30 or less are suitable for residential zones is one such example. In other cases, the full range of community impacts has not been assessed. And in yet other cases, adverse environmental impacts have been presented in euphemistic or obscure technical jargon which neutralizes their controversiality. The result is that community opinion leaders have been asked to assess their community's reaction without a full understanding of the scope and magnitude of airport impacts and without a full appreciation of controversies which might arise downstream in the community decision-making process.

2. Biased sampling procedures. Some industry analyses of community reaction to airport development have sampled the opinions of airport managers and chamber of commerce officials and then presented their views as a representative sample of community opinion. These studies have made no effort to determine whether these aviation enthusiasts actually are representative spokesmen for community goals. It is likely, in fact, that their estimate of community goals and priorities is neither accurate nor representative -- particularly in communities where conflict between the advocates of urban growth and environmental quality has not crystalized into discernable political factions with predictable responses to development proposals.

3. Faulty analytical procedures. In some industry studies, field interviews have been conducted without first establishing formal decision criteria as to what community reaction constitutes "acceptance" or "rejection." The failure to establish explicit decision criteria allows post hoc rationalizations about the feasibility of airport implementation biased by the interviewer's enthusiasm for the development proposal. A closely related problem is the failure to develop analytical methods for arriving at meaningful conclusions when community factions disagree on the feasibility or desirability of airport development. Clearly, strongly expressed opinions both for and against airport development cannot be averaged to produce a composite neutral attitude.

In order to arrive at a more systematic method for anticipating community reaction to an airport development proposal we must answer six questions:

1. What are the community impacts of airport development?
2. What is the magnitude of those community impacts?
3. What political jurisdiction or jurisdictions make up "the community?"
4. Who speaks for "the community," thus defined?
5. What assessments of airport disadvantages and desirability constitutes "community acceptance" or, conversely, "community rejection?"
6. What way of describing airport impacts will give community leaders a full understanding of the merits and demerits of airport development and a realistic basis for making judgements about its controversiality and desirability?

Many community acceptance studies have produced "results" without explicitly addressing these questions. Studies which have not developed explicit decision criteria for dealing with such questions must be considered unreliable -- and most likely biased toward the conclusions which the research team hoped to reach in each community. It should be emphasized that explicit decision criteria do not eliminate the bias of the researcher; they do provide a check against gross and unintended bias introduced by unconscious decisions and a meaningful basis for independent evaluation of the results and conclusions.

An eight-stage research procedure was developed in light of the questions posed above. The research team:

1. Defined "The Community" as the municipal jurisdiction with primary responsibility for airport development decisions.
2. Developed explicit operational definitions for "community acceptance" appropriate to interviews with community opinion leaders.
3. Queried local officials in order to identify the "most influential" opinion leaders in each community.
4. Queried local officials to determine whether economic development or environmental preservation has higher community priority.
5. Developed a checklist of environmental, social and economic impacts that could potentially result from airport construction and aircraft operations.
6. Projected the magnitude of those impacts in the light of findings from empirical studies of airport impact in similar communities across the nation.
7. Informed community opinion leaders of the full range of airport impacts in a language which did not mask or neutralize the potential controversiality of airport development.
8. Sought their assessment of how their community would react to the airport development proposal.

The specific operations involved in each of the eight phases of the research effort and the results for each community are discussed below.

Phase One: Defining "The Community"

Defining what population constitutes "the community" is a significant decision-point in community acceptance analysis. The sampling frame used in any opinion research effort serves to define the meaning of the results and the conclusions that can be drawn from them.

Three different populations might reasonably be defined as "the community" for the purpose of anticipating "community" reaction to an airport development proposal:

1. The population in the airport's market area;
2. The population in the area severely impacted by aircraft noise or some other adverse impact factor;
3. The population of the municipal jurisdiction which has primary responsibility for airport development decisions.

Within each of these groups, one might also consider several different sampling strategies:

1. Interviews with random individuals;
2. Interviews with public officials;
3. Interviews with individuals who, on the basis of past political behavior, would be likely to play an active role in a future airport controversy.

The dilemma of sample population was resolved by considering the decision-making process that leads to airport development. The minimum condition -- the sine qua non -- of STOL or RTOLport implementation is local government approval for airport expansion. Without city council approval, municipal airports cannot be expanded to accomodate commercial turbofan operations.

In most cities, airport development and expansion has resulted from the efforts of business leadership working in cooperation with airport and airline management. Elected officials have responded to the initiative of business leadership in pursuing airport development more often than they have taken the initiative themselves.

This suggests that the enthusiasm of local business leadership is a necessary condition for municipal approval of airport development.

Enthusiastic support for airport expansion from business leaders is not, however, a guarantee that a city will welcome STOL or RTOLport development. The political clout of conservation groups is becoming an increasingly significant factor in the outcome of airport development and expansion decisions at the municipal level.

For the past decade, community politics in the Bay Area have been dominated by the debate over urban growth -- how to promote economic development; how to contain urban sprawl; how to balance the tax base of bedroom suburbs; how to halt the flight of middle income families from the center city; how to preserve the last remants of urban open space while attracting new industry and jobs; how to relieve traffic congestion and reduce air pollution.

Public works policy -- including airport development -- has been a central issue in the debate between the proponents of environmental quality and economic development. The San Francisco "Freeway Revolt;" the electoral defeat of the "Southern Crossing" Bridge; the Save Our Bay fight against a Shoreline Freeway; the continuing controversy over the California Water Project; the defeat of a 42-million passenger Southbay "Superport" -- each campaign focused on public works policy and each found conservation groups and organized business interests at loggerheads.

The organizations presenting testimony at a recent airport policy hearing in San Jose is illustrative of the groups which have dominated the civic debate over airport expansion:

- The San Jose Chamber of Commerce
- The Southern Pacific Land Company
- The San Jose Junior Chamber of Commerce
- The Chamber's Industrial Recruitment Committee
- The Chamber's Tourism and Convention Committee
- The Sierra Club
- The Committee for Green Foothills
- The Save Our Valley Action Committee
- The County Medical Society Environmental Health Committee
- The United New Conservationists
- The Bay Area Council, and
- The League of Women Voters.

If past history is any indication, the leaders of the combatants in a community airport controversy will be conservationist groups and business interests; elected officials will play an arbitrative role in development decisions.

Thus it seems reasonable to define the sample population as public officials, influential business leaders and environmental organizations in the municipal jurisdiction with primary responsibility for airport development decisions. These are the opinion leaders who would be most likely to play a decisive role in determining the outcome of an airport development controversy.

It must be emphasized that <u>approval</u> at the municipal level does not insure the political feasibility of either STOL or RTOLport development. Community acceptance, thus defined, by no means insures that a STOL or RTOL system will receive approval from jurisdictions at the county, regional or federal level. Municipal approval of airport development is a necessary but not sufficient condition of system implementation. In the Bay Area, agencies with formal jurisdictional powers include:

1. The Metropolitan Transportation Commission, the regional transportation planning agency charged with allocating passenger demand among the region's airports.

2. The Federal Aviation Administration, the federal agency charged with resolving airspace conflicts and administering the environmental protection provisions of the 1970 Airport Development Act.

3. Airport Land Use Commissions, County agencies charged with minimizing land use incompatibility between airports and surrounding urban uses.

4. The State Department of Aeronautics, the state agency charged with enforcing aircraft noise standards.

5. The Environmental Protection Agency, the federal watchdog agency which administers the National Environmental Policy Act of 1969.

Nor does municipal enthusiasm imply the approval of other political actors with considerable influence but without formal decision powers. These include:

1. The administrators of metropolitan hub airports;

2. Airlines currently serving the Los Angeles-San Francisco corridor from hub airports;

3. Private pilots who would share municipal facilities with STOL or RTOL aircraft;

4. Neighboring communities impacted by airport noise, air pollution emissions, and traffic congestion.

Even with favorable community reaction these groups remain a potential political and jurisdictional constraint to airport development. Another constraint is political inertia. The problem of inertia is aggravated by the fact that there is no regional or state agency with the jusisdictional powers appropriate to the implementation of a regional airport system. Nor is there an adequate mechanism for coordination between regional airport planning efforts in the Bay Area and Los Angeles.

A full investigation of system feasibility in light of the constraints imposed by this sizeable list of political and jurisdictional hurdles is beyond the scope of this research. This study is focused on the minimum condition of STOL/RTOL feasibility -- the reaction of citizens in the municipal jurisdiction charged with primary responsibility for planning and airport expansion.

Thus, "the community" is defined here as one political jurisdiction -- an area which is likely to be smaller than both the market area of the proposed airport and the geographic area which would be impacted by the environmental and economic effects of airport development.

Phase Two: "Community Acceptance" -- Concept Development

As we have indicated, conservation activists and business leaders are likely to disagree on the merits of airport development, while elected city officials play an arbitrative role between the two interest groups.

This presents a situation in which the economic needs of the particular community and the political influence of airport proponents are more likely to predict airport decisions than a systematic costing of airport impacts -- positive and negative. For this reason, the reaction of community opinion leaders to the STOL/RTOLport proposal -- their assessment of its desirability and political feasibility -- provides a handle for assessing its "acceptability."

Current airport development controversies in the Bay Area suggest that a relevant sample of community opinion leaders should include:

- The most influential spokesman for downtown businessmen
- The most influential spokesman for the construction industry
- The most influential spokesman for major industrial employers
- The manager of the existing general aviation airport
- The city council member whose voting record indicates the most consistent pattern of support for economic development
- The city council member whose voting record indicates the most consistent pattern of support for environmental preservation
- The most influential spokesman for environmental organizations
- The most influential spokesman for homeowners and property taxpayers.

The outcome of airport controversies across the nation indicates that development or expansion is most likely to occur where it commands the united support of a community's economic leadership. On the other hand, airport development has been stymied where severe environmental impact activates the opposition of influential environmental organizations.

This analysis of airport decision-making at the community level suggests that:

1. STOL/RTOLport development would have a <u>very high likelihood of community acceptance</u> where conservationists feel the majority of community residents would support airport development.
2. On the other hand, STOL/RTOLport development would have a <u>very low likelihood of community acceptance</u> where economic leaders feel the majority of community residents would oppose airport development.

Thus, the perceptions of the most likely airport proponents and opponents provide the end-points of a scale rating the likelihood of community acceptance. Where those who would be most likely to favor and benefit from airport expansion feel it is infeasible, it <u>is</u> very likely to be infeasible. The converse holds true for likely airport opponents -- hence the scale end points.

The mid-point in the scale of acceptance probability is the case in which business and conservation leaders disagree on how their community would react to an airport development proposal.

In communities where conservationists and business leaders disagree on the likelihood of acceptance, their impressions must be checked against data which indicates how the community has resolved similar growth controversies in the past. The questionnaire data used to weight the perceptions of business and environmental leaders will be discussed in Phase Four.

At this point, however, we can present the five-point scale used in the research and the decision criteria used in estimating the likelihood of STOL/RTOLport acceptance:

CRITERIA FOR RATING THE LIKELIHOOD OF STOLPORT ACCEPTANCE

Rating	Criteria
Acceptance Highly Likely	Environmentalists feel majority voters would support STOLport development if a referendum were held.
Acceptance Likely	Business leadership feel majority would support; Environmentalists feel majority would oppose; questionnaire data emphasizes employment and tax base concerns
Acceptance Marginal	Conflicting perceptions of majority response; no clear supremacy of environmental or employment concerns.
Acceptance Unlikely	Business leadership feels majority would support; environmentalists feel majority would oppose; questionnaire indicates priority for environmental concerns.
Acceptance Highly Unlikely	Business leadership feels majority would oppose STOLport development if a referendum were held.

Two aspects of this rating system require further emphasis. First, the criteria for rating the likelihood of community acceptance are not scaled in terms of the costs and benefits of the airport's impact on its host community. Rather, it is scaled in terms of how community opinion leaders perceive the goals of the majority of their community's voters with respect to the airport's impacts. Thus, the perceived balance of airport costs and benefits are only one aspect of a scaling system which can also reflect judgements about the importance of environmental quality and the political influence of environmental activists.

The second aspect of the rating system which deserves explicit mention is the fact that the balancing of the merits and demerits of STOL/RTOLport development is left to community leaders. Every effort is made to insure that the attitudes of research team members do not influence the community's judgment of its own best interest.

We can now discuss the procedures used to identify "the most influential spokesman" for economic development and environmental quality and the methods used to profile community preference in the growth/environment debate.

Phase Three: The Identification of Community Opinion Leaders

Questionnaire methods were used to identify the "most influential spokesman" for the transportation goals of the business community and environmental organizations. In each of the five communities, city council members, the planning and public works director and the city manager were queried by mail and asked to nominate the most influential spokesmen for the transportation goals of various interest groups.

The person who received the most "nominations" in each category was selected for a later interview.

The approach to the identification of community influentials will be recognized as a sophistication of the "reputational technique" used by Floyd Hunter. Two departures from Hunter's technique merit explicit note:

1. There is no assumption that the community is run by a power structure or power elite; a number of interest groups are proposed as potentially influential.

2. There is no assumption that the persons identified are power brokers in any general sense; the questionnaire deals explicitly with people who are influential in the area of transportation policy.

The mail questionnaire is shown in Figure V-1.

Phase Four: Identifying Community Priorities in the Economic Growth/Environmental Preservation Debate

In order to validate the opinions offered by community leaders speaking for special interests, the questionnaire administered to public officials also ascertained a ranking of community concerns. These policy concerns formed two constellations -- one which indicated priority for environmental preservation, the other giving priority to economic development goals. The questionnaire asked each council member, the city manager and the planning and public works director to rank the importance local citizens would give each of the following questions about a transportation project:

- How much local employment will it provide?
- Will it improve the position of local business?
- Will it contribute to the attraction of industrial and commercial tax base?

Figure V-1

A. Your Name: ______________________ Your City: ______________________

B. As the regional plan for transit, highways and airports is developed by the Metropolitan Transportation Commission, which of the following questions about the local impact of transportation do you feel your community would want planners to answer first? Please rank the five MOST IMPORTANT questions starting with "1" as MOST IMPORTANT. (If you wish to continue ranking beyond five please do so; it would be helpful.)

( ) How much will it cost local taxpayers?

( ) How much local employment will it provide?

( ) Will it improve the position of local business?

( ) Will it contribute to the attraction of industrial and commercial tax base?

( ) Will it help contain urban sprawl?

( ) Will it encourage highrise development?

( ) Will it relieve or increase air pollution?

( ) Will it relieve or increase noise pollution?

( ) Will it contribute to community aesthetics?

( ) Will it provide for the special needs of low-income families?

( ) Will it provide for the special needs of the elderly?

( ) Will it relieve highway and freeway congestion?

( ) Will it relieve airport congestion?

( ) Will it reduce or increase traffic in residential neighborhoods?

( ) Will it displace housing?

( ) Will it displace parks or open space?

PLEASE CONTINUE TO THE NEXT PAGE.

C. Who do you feel is the most influential spokesman in your community for the transportation priorities of the following groups? (Please suggest an organization if no particular individual comes to mind. Indicate "not relevant" if a group does not play a role in shaping opinion in your community.)

Conservationists and environmentalists:

________________________________ ________________________________
name affiliation

Downtown business leaders:

________________________________ ________________________________
name affiliation

Major industrial employers:

________________________________ ________________________________
name affiliation

Property taxpayers:

________________________________ ________________________________
name affiliation

Low-income families:

________________________________ ________________________________
name affiliation

The elderly:

________________________________ ________________________________
name affiliation

Real estate developers:

________________________________ ________________________________
name affiliation

Commuters:

________________________________ ________________________________
name affiliation

The building and construction trades:

________________________________ ________________________________
name affiliation

THANK YOU VERY MUCH FOR YOUR COOPERATION.

- Will it reduce or increase local taxes?
- Will it relieve or increase air pollution?
- Will it relieve or increase noise pollution?
- Will it displace parks or open space?
- Will it help contain urban sprawl?

The rankings provided by each official were summed to create a profile of community priorities in the growth/environment debate. The profile was used later in assessing the reliability of the more detailed judgements made by community opinion leaders in the interview situation.

Phase Five: Identifying the Community Impacts of Airport Development

In order that community opinion leaders may make an informed judgement about the desirability and political feasibility of airport development, they must be fully informed of the community impacts of STOL and RTOL operations. This requires making a first cut analysis of the environmental, social and economic effects of airport development and presenting the impacts in language which can be understood by political leaders as well as technical experts.

In order to identify the full range of airport impacts on community life, the research team examined a large number of environmental impact statements, consultant reports and planning matrices. This investigation produced an inventory of airport impacts which provided a checklist of effects that were examined in each community. The checklist is presented as a impact assessment matrix in Figure V-2.

Figure V-2

Airport Impact Matrix

IMPACT FACTORS:

COMMUNITY RESOURCES:	Air Quality	Water Quality	Wildlife Habitat	Parks and Open Space Recreation Areas	Agricultural Open Space	Residential Neighborhoods	Schools	Commercial Uses	Hospitals, Libraries	Industrial Uses	Local Streets	Freeways	Local Economy
Flight Operations													
Aircraft Fueling													
Engine Run-up													
Ground Traffic													
Airport Construction													
Access Construction													
Airport Employment and Payroll													
Airport-Induced Employment and Payroll													
Airport Purchases													
Airport Taxes													
Airport-Induced Development													

Using the matrix, it was possible to identify the impacts that will provide the pro and con arguments in a controversy over airport development. The beneficial impacts of airport development include:

1. Air travel convenience
2. New employment opportunity
3. New income and payroll
4. New tax base
5. Airport revenues

The adverse effects of airport construction and operation include:

1. Noise pollution
2. Air pollution
3. Ground traffic
4. Displacement or disruption due to construction
5. Increased population pressure.

The matrix was subsequently used to inventory community conditions and to make certain that significant site-specific impacts, not listed above, were not ignored inadvertently.

Phase Six: Determining the Magnitude of Airport Impacts in Each Community

The characteristics of STOL and RTOL aircraft, the number of passengers and aircraft operations anticipated, and pre-existing community conditions are all significant factors in determining the magnitude of the airport's impact on its host community. Air pollution provides a convenient example: the volume of air pollution generated by airport development will vary as a function of aircraft performance and passenger volumes, but the severity of air pollution impact will also depend on topography, weather conditions and pre-existing levels of air pollution. Similarly, the size of an airport's workforce and payroll will vary with aircraft type and passenger volume, but the magnitude of economic benefit to the community will also depend on the ability of the local economy to retain and recycle this infusion of new income.

Thus, the magnitude of impact will vary from airport to airport even if the aircraft type and the number of operations are the same from community to community.

Most communities have developed an extensive data base describing community conditions -- land use, air pollution levels, economic characteristics, etc. These indicators of local conditions allow us to predict the community impact of an airport using impacts measured empirically in similar communities elsewhere. The projection of airport impacts on the basis of previous empirical research allows the determination of airport costs and benefits with reasonable accuracy.

It is felt that the resulting assessments of impact magnitude are sufficiently precise to allow community leaders to make political judgements about their community's reaction to airport impacts. This presumption is based on the expectation that airport controversies will be determined by the relative importance political leaders attach to jobs and traffic congestion, for example, and not by quibbles over whether new jobs will number 100 or 124. Whether traffic on Main Street would be increased by 10% or 12.4% is not likely to significantly alter opinions about the desirability of airport development.

In attempting to quantify the magnitude of airport impacts, particular emphasis was placed on evaluation criteria which have meaning in day-to-day experience. Noise levels expressed in Decibles or EPNdB, for example, do not provide a meaningful political vocabulary; the number of people who would be sufficiently annoyed by aircraft noise to complain to authorities is a politically meaningful concept -- and one which can be balanced against the number of people who would benefit from new airport employment. Whenever possible, airport impacts were quantified in the politically negotiable vocabulary of common experience and human behavior.

As we have indicated, the community impact of airport development will vary in magnitude from airport to airport depending on both the volume of air travel allocated to each airport in the system and pre-existing conditions in the airport's host community. For this reason, the detailed discussion of site-specific impacts will be postponed until we have discussed the data gathering procedures for each impact factor.

<u>The economic benefits of airport development</u>: Airport development stimulates economic growth in the market area where it is located. Airport employment, payroll and purchases, like a pebble dropped in still water, generate successive ripples of economic activity -- new residential and commercial construction, new local purchases, secondary employment, new sales and property tax revenues, each generating income which is partially reinvested in and cycled through the region's economy.

The primary economic impacts of airport development include:

1. Employment by airlines, businesses located at the airport and government agencies
2. Employment in the construction of airport facilities
3. Exogenous investments in airport construction
4. Visitor expenditures
5. Airport tax payments.

The secondary impacts of airport development include:

1. The stimulation of airport-related commercial activity, such as the hotel/motel business
2. The stimulation of residential housing demand and residential construction.

The tertiary impacts of airport development include:

1. The income and employment multiplier which results from the recycling of new payroll through the community's economy

2. Additions to the community's residential and commercial tax base and sales tax revenues.

The first step in projecting the magnitude of an airport's primary impact on its market area is to determine the level of exogenous investment -- the size of the pebble. To accomplish this, we must estimate the size of the airport work force, its payroll, the dollar volume of local purchases, tax payments made by the airport, and the dollar value of visitor expenditures.

The work force at a STOL or RTOLport will include airline terminal personnel, ground crews, government personnel, and concessionaires in numbers proportionate to passenger volume. The type of service offered by a STOL or RTOL commuter airline will closely ressemble that of Pacific Southwest Airlines, a commuter airline which currently employs one worker for each 2458 passengers, including maintenance workers and executive staff. When non-airline personnel are included in the STOL/RTOLport work force and airline maintenance workers excluded, the number employed is likely to be similar to the number employed at commuter airports where PSA is the major air carrier -- airports such as San Jose and Sacramento. Assuming no freight or maintenance operations, the employee to passenger ratio should be similar then to the current employment/passenger ratios at Sacramento Airport (1:3208 annual passengers) or San Jose Municipal Airport (1:2619 annual passengers). Using an average of the San Jose and Sacramento cases, we can project STOL/RTOLport employment as:

$$\frac{\text{Number of passengers annually}}{2900}$$

Based on surveys conducted in San Jose and Los Angeles, it can be assumed that the average airport employee receives a salary of $12,000 with take-home pay around $10,000.

The total airport payroll is thus closely approximated by the expression:

$$\frac{(\$10{,}000)(\text{Annual Passengers})}{2900}$$

Local purchases can also be projected with reference to the San Jose case where Bechtel Corporation estimated local expenditures for goods and services at $4.6 million for an airport serving close to two million passengers annually. Thus total airport expenditures for goods and services purchased locally can be closely approximated by the expression:

$$(\$2.50)(\text{Number of passengers annually})$$

Using the San Jose case to estimate local expenditures by non-resident air travelers, we arrive at the expression:

$$\text{Visitor \$'s} = (\$5)(\text{Annual passengers})$$

Similarly, the airport's contribution to local tax revenues can be projected using the expression:

$$(\$.5)(\text{Annual passengers})$$

The expressions above provide the base entries necessary for determining the secondary and tertiary impacts of airport development, in combination with income and employment multipliers appropriate to each airport site. An income multiplier is an empirically derived number which indicates the cumulative annual value of each new dollar of outside investment after it has been recycled and respent in the local economy. Similarly, an employment multiplier indicates the employment that will be induced in related sectors of the local economy by increased employment in the export sector of the economy.

Discussions with economists in the Bay Area indicated that an employment multiplier between 2.1 and 3.0 is appropriate to the San Francisco Bay Area. Because the STOL/RTOL system contemplated is predominantly suburban, the lower end estimate is used here. Thus, the following expression can be used to project the total employment increment due to airport development:

$$\frac{(2.1)(\text{Annual passengers})}{2900}$$

The same economists indicated that the total induced income can be projected on the basis of the following expressions:

For Santa Clara County:

(Visitor Expenditures + Airport Taxes + Airport Payroll + Airport Purchases)(2.25)

For San Francisco and San Mateo Counties:

(Visitor Expenditures + Airport Taxes + Airport Payroll + Airport Purchases)(2.1)

For Alameda, Contra Costa and Marin Counties:

(Visitor Expenditures + Airport Taxes + Airport Payroll + Airport Purchases)(2.0)

The total land acreage necessary to accomodate airport induced population growth and commercial employment has been derived from the detailed land use projections of the Regional Airport Systems Study. The urban acreage required to accomodate induced growth near each airport is projected by the following expression:

Residential acreage = (.14)(Total employment)

Commercial acreage = (.015)(Total employment)

Thus, the primary economic impacts of airport development were projected in relationship to passenger volumes on the basis of empirical data collected in other communities. Secondary and tertiary impacts were projected on the basis of the primary impact estimates. The projected economic impact of STOL/RTOLport development for each suburban airport is shown in Table V-1.

Land Development and Population Pressure - An Economic Disbenefit: While new employment and payroll are an economic asset to a community, they are simultaneously a burden to the carrying capacity of the natural environment. New population leads, in turn, to new residential development, and this in turn to diminished open space reserves, increased air and water pollution, and so forth through the litany of environmental concerns associated with the process of urbanization.

Two of these adverse impacts of urbanization were isolated for qualitative analysis:

1. Whether land scarcity in the airport environs would create pressure for the conversion of low-to-moderate income neighborhoods to apartment densities -- a controversial issue in many Bay Area communities;
2. Whether the income level of airport employees was considered with the housing market near the airport or whether extended commuting would be required of the airport work force -- another controversial issue in the Bay Area often refered to as the "jobs-to-housing ratio."

Qualitative statements about land scarcity and job-to-housing ratio were made after examining land development projections made during the Bay Area Transportation Study using a Projective Land Use Model.

Noise Pollution: The noise annoyance associated with jet aircraft virtually assures that airport development will become a controversial local issue. EPNdB contours for both the 2000 and 3000-ft runway aircraft were mapped for each airport using noise footprints supplied by McDonnell-Douglas Aircraft.

These EPNdB contours were translated into Noise Exposure Forecast (NEF) contours which adjust the noise level measurements for the number of aircraft operations, the mix of aircraft, and the frequency of flights in evening hours when noise intrusion would be most annoying. NEF values are based on an empirical formula which recognizes that noise annoyance is a function of the frequency of noise intrusion, the loudness of each noise event and the ambience of background noise (day or night).

A study conducted by TRACOR, Inc. for NASA related NEF zones to the amount of noise annoyance which people experience while watching television, relaxing outdoors, talking on the telephone, conversing face-to-face, reading, etc. The

Table V-1
The Economic Impacts of Airport Expansion

	PALO ALTO	SAN CARLOS	HAYWARD		BUCHANAN	
	3000'	2000'	2000'	3000'	2000'	3000'
Annual Air Passengers	1,540,000	2,200,000	1,800,000	2,840,000	2,400,000	2,630,000
Airport Employees	530	760	625	980	830	910
Airport Payroll ($)	5,300,000	7,610,000	6,240,000	9,800,000	8,330,000	9,080,000
Local Purchases ($)	3,840,000	5,500,000	4,500,000	7,050,000	6,033,000	6,580,000
Visitor Spending ($)	7,700,000	11,000,000	9,050,000	14,200,000	12,070,000	13,170,000
Local Tax Revenue ($)	770,000	1,100,000	905,000	1,400,000	1,207,000	1,320,000
Total Employment	1,100	1,600	1,300	2,050	1,750	1,900
Total New Income ($)	35,206,000	53,080,000	41,430,000	64,905,000	55,000,000	60,000,000
Residential Acres	160	225	180	290	245	270
Commercial Acres	20	25	20	30	25	30

TRACOR study surveyed and determined the number of people who were annoyed, and the number who complained about noise nuisance in different NEF bands surrounding each of seven airports.

Using census tract block data, a land use inventory, and a superimposed noise footprint calibrated to NEF values, the research team was able to apply the TRACOR estimates and arrive at a prediction of the number of people who would be annoyed by the noise from aircraft operations at each airport examined.

In addition, it was felt that people living in areas that would be bounded by NEF contours exceeding certain levels as a result of the new commercial aircraft operations were entitled to compensation for the disbenefit they suffer. Tables III-10 and III-11 show the schedule of monthly payments assumed for each NEF region. These values multiplied by the number of residences affected created an equivalent monthly charge against the airport that had to be added to the total infrastructure cost as discussed in the infrastructure section.

For a detailed discussion of acoustics, noise measurement, the mapping process and noise levels for each airport community, see Appendix E.

Air Pollution: Aircraft operations, engine run-up, fuel handling and ground traffic contribute to the air pollution associated with airport operations. The severity of the pollution problem caused by airport development varies with pre-existing pollution levels, topography, weather conditions and the sensitivity of nearby populations (with elderly or hospitalized persons being most susceptible to health effects).

The volume of hydrocarbons, nitrogen oxides, sulfur oxides, particulates and carbon monoxide that would be emited during each airport activity was estimated on the basis on previous empirical studies.

1. Emissions resulting from each take-off and landing cycle were estimated as 1/2 the emissions from a current source with known volumes, the DC-10. The halving of the DC-10 data accounts for technological improvements in aircraft designed 10 years later.
2. Emissions from fuel handling and engine rev-up were estimated on the basis of a study of pollution at San Francisco Airport and corrected for the number of flight operations projected for each airport examined.
3. Automotive emissions were estimated on the basis of projected traffic volume and emission estimates supplied by the Bay Area Air Pollution Control District.
4. Emission estimates for 1985-level general aviation activity were also supplied by the BAAPCD.

The collective impact of these airport related emissions on contaminant concentrations in the airport vicinity were then estimated for each community. Meteorological detail and results are presented in Table III-3.

In describing the airport's impact on air quality to community leaders, pollution volumes were expressed in terms of an equivalent -- vehicle miles on a local freeway exposed to the same meteorological conditions and with an orientation similar to the flight path that aircraft would use. Daily airport pollution volumes were expressed in terms of the freeway traffic analogy.

Ground Traffic Congestion: Air pollution is one aspect of ground traffic which is likely to cause community concern. Increasing freeway congestion, through-traffic in residential neighborhoods, and the inhibition of both pedestrian and vehicular cross-traffic in airport areas are further concerns.

Ground traffic volumes observed at existing commercial airports were used to project airport access needs and traffic volumes. The traffic volumes recorded at existing airports were adjusted to reflect projected STOL/RTOLport passenger volumes and corrected to exclude traffic generated by airport freight operations.

An inventory of street patterns and existing highway capacities was made to determine necessary roadway improvements and the volume of through traffic that might impact neighborhood streets.

The Environmental Impacts of Airport Construction: The adverse impacts of airport construction are likely to be ephemeral, but even short-term impacts are capable of causing community controversy. The magnitude of construction impacts are site-specific, but a checklist of questions can be presented at this time:

1. Will construction displace general aviation activities? If yes, for how long?

2. Will construction displace or disrupt surrounding land uses? If yes, how many acres of each land use?

3. Will construction involve extensive topographical alteration? If yes, with what effect, aesthetic or ecological?

4. Will construction create significant air, water, or noise pollution? If yes, how severe are any long-term effects?

5. Will construction involve bayfill? If yes, how many acres?

6. Will construction effect the water table or the foundation stability of adjacent land?

7. Will geologic instability require precautionary engineering techniques?

8. Will construction activities or the completed construction limit access to or use of surrounding areas?

9. Will construction activities require the disposal of wastes or other spoils? If yes, how will they be disposed of?

Phase Seven: Presenting the Airport Proposal for Community Discussion

Community leaders must be informed of the airport's impact on their community before they can make an intelligent judgement about whether airport development would be desirable or whether it would be too controversial to implement.

The technical jargon of engineering consultants is not useful for this purpose. The fraternal language of economists, noise consultants and engineers masks controversial impacts in the arcane vocabulary of "technologese." This semantic neutralization of controversial impacts can lead community leaders to a distorted perception of both the concerns at issue and the intensity of community reaction to them. Technical jargon is also inappropriate because it is likely to intimidate or confuse political leaders. The judgements made by political leaders will be more reliable if they feel they can make an important contribution by participating knowledgeably in the research effort.

Thus, for community leaders to make informed judgements about the desirability and feasibility of airport expansion, the costs and benefits of airport expansion, and the costs and benefits of development must be described in a language which uses the political vocabulary of the community without distorting the conclusions drawn from systematic impact assessment.

This can be accomplished by describing the impacts of airport development in terms of everyday activities that would be enhanced or disrupted. An appropriate language for data presentation can be determined by anticipating the kind of questions that an intelligent but unspecialized policy-maker might ask:

How many people could expect new jobs as the result of airport development?

How many people would be disturbed by aircraft noise while relaxing in their back yards?

How much air pollution is X pounds/operation in terms of a familiar equivalent, say, the pollution currently generated by cars on a nearby freeway?

Anticipating this kind of question allows the presentation of impact magnitudes in a language and format which facilitates political judgements about the trade-offs between costs and benefits; whether, for example, employment for "X" people counterbalances the noise annoyance that will be experienced by "Y" people?

This approach simultaneously allows local leaders to assess the distribution of costs and benefits associated with airport development; whether the benefits will be enjoyed broadly while disbenefits are limited to a small population, or vice versa.

In order to communicate the costs and benefits of airport development to municipal leaders, a ten-page brochure was developed using a political vocabulary suggested by the questions above. Impact evaluation criteria and the language of the brochure were chosen in order to make airport impacts intelligible to community leaders with a level of technical expertise similar to that displayed in public testimony before the Regional Airport Systems Study Commission.

A sample of the brochures which resulted can be found in Appendix H.

In each community, the brochure was mailed to and reviewed by community leaders before conducting interviews to determine the feasibility and desirability of STOL/RTOLport development.

Phase Eight: The Format of Interviews with Community Influentials

Political influentials are not comfortable with the highly structured, closed-ended interview methods used by public pollsters. Personal interviews with political elites must be sufficiently informal to establish a rapport between the interviewer and the interviewee; yet they must also be sufficiently structured to insure the comparability of data collected in interviews with different people and to prevent the intrusion of interviewer bias. The first requirement rules out a formal questionnaire; the second mandates some questions which are carefully formulated prior to the first interview and repeated in succeeding interviews.

These conflicting requirements mandate a loosely structured interview process, guided but not confined by a formal interview schedule. The loose structure of this kind of interviewing procedure capitalizes on the expertise of the interviewee and allows the interviewer to pursue significant points raised during the interview.

Several common questions were asked in each interview:

1. If voters in __________ had this information and were asked to vote on airport development, how do you think the vote would split?
    - 1a. What factor would be most important in deciding the vote?
2. Can you think of any group in __________ that would actively work for airport development?
    - 2a. What would they be most enthusiastic about?
3. Are there any groups that would vehemently oppose airport development?
    - 3a. What would they be most opposed to?
4. Has __________ dealt with any similar development issues recently?
    - 4a. How were they resolved?
    - 4b. Would airport development be more or less controversial than (the case(s) mentioned)?
5. Would you be able to support airport development?

In order to encourage frank and open discussion, it was emphasized that STOL/RTOLport development is "a new concept in aviation," and not an immediate decision which the community will face. It was also emphasized that the community impact assessment presented in the brochure was not a formal Environmental Impact Statement and that no formal engineering studies are being conducted.

Despite these sanctions for open discussion, it was found that community influentials were reluctant to take a personal position on STOL/RTOLport development -- even "in concept." On the other hand, there was no reluctance to discuss the political response which an airport development proposal would encounter at the community level. These frank discussions of the community's political atmosphere, current priorities and future directions provide a reasonably systematic assessment of the community acceptability of the STOL and RTOL concepts.

Several caveats are necessary before we turn to an examination of the research results.

Caveats about Using and Generalizing the Results

The most obvious limitation of a community acceptance analysis based on interview data is its time dependence: community leaders are asked to react NOW to an airport development that would not occur until 1985. To the extent that community values and conditions remain stable, and, to the extent that immediate land use decisions by current influentials are necessary to limit adverse airport impacts, the results of a community acceptance analysis today can be used as a guide to civic reaction in the future.

Another limitation of the community acceptance analysis method developed here is its scope: The method does not consider the full range of political actors necessary for implementation of the STOL or RTOL concepts. The method used here only examines reaction at the municipal level -- a necessary but not sufficient condition of system development.

The most important limitation on the validity of the results is imposed by potential inaccuracy in the perceptions of community leaders interviewed. Careful design involving interviews with community leaders representing a spectrum of viewpoints can partially -- but only partially -- correct for ill-considered views expressed in small-sample interview research.

One last caveat must be emphasized: The results of this study cannot be generalized to other STOL or RTOL markets. The study indicates that the most important factors in community reaction to airport development are local conditions and community values, not incremental improvements in the performance characteristics of a particular turbofan aircraft. The results reported here cannot be projected to other STOL or RTOL corridors without intensive investigation of local conditions.

Sources of Error in the Projection of Impact

In projecting the noise, air pollution, ground traffic and economic growth that would result from 1985 STOL and RTOL operations, the investigators relied heavily on previous research to supply data which, because of budget constraints, could not be gathered in the field. The reliability of the findings reported here are thus conditioned by the accuracy of previous research.

There are inevitably some errors that result because the findings of previous research in other communities were extrapolated and adjusted to fit local conditions in STOL-system communities. The judgments and assumptions made in the process of extrapolating previous studies are noted in the text.

Error also originates from the use of preliminary travel demand estimates to project flight operations and passenger volumes. On the basis of aggregate California corridor traffic volumes, for example, 65 daily operating cycles were predicted for Palo Alto in 1985. This estimate was revised to 37 cycles on the basis of second-cut demand projections. The final Palo Alto estimate based on computer analysis results is lower still--22 cycles per day in 1985.

Palo Alto noise level projections were based on the 65 cycle estimate. The result is an over-estimation of noise exposure level equivalent to almost 5 EPNdB in Palo Alto -- the case of maximum error.

The second-cut estimate of cycles per day was used in projecting economic benefits, traffic congestion and air pollution tonnage. In Palo Alto -- again, the case with the largest discrepancy between final and second-cut projections of traffic volume -- the result is a margin of error approaching 40 percent.

It is felt that the errors in the true value of community impact do not invalidate community reactions solicited on the basis of the preliminary demand estimates. Two factors support this judgment. First, both economic benefits and environmental disbenefits were inflated proportionally; thus the relative balance or trade-off between costs and benefits retains its integrity. Second, opinion leaders reacted to the STOL concept as a policy problem and a dilemma in goal conflict. In the interview situation, opinion leaders did not show the technician's concern for project detail, but rather viewed STOL introduction as a political issue. Thus, it can be concluded that the absolute magnitude of community impact is less important in determining community reaction than the relative balance between costs and benefits and project's consistency with community goals.

A final source of error is imposed by the large number of unknowns which confound projection to 1985. Community conditions in 1985 -- a significant factor in the impact equation -- elude definitive prediction. Major shifts in land use zoning, a significant downturn in economic conditions, quantum advances in noise suppression technology -- any of these or other unforeseen factors could invalidate the conclusions reached in this time-bound analysis of community impact and community acceptance.

A Final Caveat: The Central Ethical Dilemma of Community Acceptance Analysis

A community's enthusiasm for airport development does not necessarily indicate that an airport's adverse impacts are minimal or that the site is optimally located. Rather, community acceptance indicates that, in the viewpoint of community leaders, the benefits of airport development excede its costs.

Thus, community acceptance analysis can produce anomalous findings: enthusiastic support for an airport with severely adverse environmental impacts; vehement opposition to an airport with minimal adverse impact. The seeming contradiction is explained by the fact that: a community with a faltering economy and an unbalanced tax base is forced to compromise environmental goals in order to stimulate economic development; conversely, a community with a healthy economy and tax base has the luxury of picking and choosing between alternative development strategies.

This anomaly is the central ethical dilemma of community acceptance analysis. In communities where necessity is the mother of environmental degradation, particular caution should be used in interpreting community acceptance as a measure of optimal system configuration.

Bay Area Community Acceptance Results

A Brief Summary of Community Reaction

Intensive interviews with civic leaders in three Bay Area communities -- Concord, Hayward and Palo Alto -- indicate that community reaction to the STOL concept is sufficiently negative to make the development of a full system of suburban STOLports extremely unlikely.

The controversiality of the STOL concept indicates that it is highly unlikely that STOLports could be developed in a rational regionwide configuration which minimizes airport access time -- the primary economic incentive for introducing STOL or RTOL aircraft in the Bay Area. The most important element determining the reception which STOL/RTOL service receives seems to be the current travel time from each community to major hub airports in the Bay Area. Reaction to STOL is most favorable in Concord, the city most distant from the nearest metropolitan airport -- this in spite of the fact that environmental impacts are the most adverse at the Concord site.

Although the intensity of reaction varied from community to community, a number of consistent themes emerged from the interviews with community leaders:

1. The introduction of commercial STOL service would be extremely controversial; the chances of approval by local leaders are sufficiently slim that potential STOL proponents would prefer to avoid the long and bitter controversy they are certain would ensue.

2. Communities in the Bay Area are reluctant to compound environmental problems unless there is an over-riding social need; incremental gains in passenger convenience and the economic benefits of STOLport development are not viewed as "over-riding social needs."

3. General aviation airports provide a valuable service; the scale of STOL/RTOL operations using 100 to 150 passenger aircraft is out of keeping with the level of general aviation activity projected for 1985.

4. The STOL concept is too much too late; street capacities, free zones and airspace capacities have been designed with general aviation aircraft in mind; it is too late to unravel the patterns of urban development that surround suburban airports.

5. STOL does not have a readily identifiable political constituency. The number of people who would benefit from shorter airport commutes is not sufficiently large or concentrated to overcome the predicted vehement opposition of organized environmental groups and ad hoc groups of adversely affected homeowners.

6. Except in the case of Concord, the number of potential STOL supporters is reduced by the availability of inexpensive and frequent air service at San Jose, Oakland and San Francisco airports.

Interpreting the Community Interview Results

The reaction to the STOL/RTOLport concept in each community focused on different factors with the common thread of reaction reported above. Thus, the reaction reported above cannot be reported as a general indictment of the STOL concept although it suggests that a multi-site suburban STOLport system is, at this time, nothing less than a political albatross.

The negative reaction of the three suburban communities to a quantum increase in aviation activity does not negate the acceptance potential of STOL/RTOL aircraft in other settings:

1. STOL would significantly reduce noise levels at San Jose Municipal airport; the environmental organizations that have brought San Jose airport expansion to a standstill indicate strong support for the STOL/RTOL concept.

2. Hamilton Air Force Base and other large military airfields can be explored as potential STOL sites.

3. Rapidly urbanizing areas on the metropolitan periphery such as Santa Rosa can be explored as potential STOL markets.

The negative reaction of all three of the suburban communities studied does suggest the wisdom of caution in projecting the market for STOL/RTOL aircraft. This conclusion is buttressed by the characteristics of the three communities which reacted negatively to the STOL concept: they are, in effect, a cross section of the metropolitan subcenters in the Bay Area.

Palo Alto is the major employment center of the mid-Peninsula. With an extremely high assessed valuation per capita, Palo Alto is in a position to pick and choose between proposals for future development. The city has opted to retain its suburban residential character while becoming a model of accomplishment in the area of open space preservation. Palo Alto's industrial tax base and the revenues derived from its municipally owned utility system are also allowing the city to assume a leadership role in the provision of low and moderate income housing.

The density of future development is a major political issue in Palo Alto. In this context, it is not surprising that Palo Alto is disinterested in assuming the burden of providing housing for a major new moderate income employer, i.e., a commercial airport operation.

The reluctance of Hayward, an employment exporter, is surprising. In terms of the Bay Area average, Hayward has a low assessed valuation per capita and a limited employment base. The deterioration of Hayward's downtown area, the limited revenues available for education and municipal services, depressed residential areas -- all suggested that Hayward would welcome an infusion of new income and tax base.

This was not found to be the case. Business leaders in Hayward feel that the city's tax and employment base can be improved without incurring the social and environmental costs of airport development. They count on residential development to the south -- in Fremont and Newark -- to boost Hayward's attractiveness to clean industries seeking industrial park locations close to a skilled suburban work force.

Concord is a rapidly developing community on the Bay Area's urban periphery. The future character of Concord is extremely uncertain; the city's development displays two conflicting trends -- development as a bedroom community for Oakland-bound commuters and simultaneously, as a major employment sub-center with region-serving shopping centers and industrial parks.

The debate between economic growth and environmental quality is becoming a major theme in the Diablo Valley illustrated by organized opposition to freeway extensions, the further proliferation of oil refining operations, and further apartment density development.

The desire to stage its rapid growth and to control air pollution makes Concord reluctant to compound the development stimulus of BART with the new stimulus of airport development. On the other hand, the lengthy commute from Concord to Oakland Airport makes a strong argument for direct STOL service from Buchanan Field to Los Angeles. The business proponents of balanced development in Concord are enthusiastic about the convenience benefits of STOL but they are less than confident about its political feasibility.

As Concord develops into a major employment sub-center, STOLport development might become politically feasible. At present, this feasibility must be rated marginal.

Thus, community leaders in three Bay Area cities, each in different stages of the urbanization cycle, are not convinced that the benefits of STOLport development can match its costs or that STOL systems represent a politically viable technology. These findings are a mandate for considerable caution in projecting the marketability of STOL and RTOL aircraft.

Interview Findings -- A Tale of Three Cities

As the sketches above indicate, Concord, Hayward and Palo Alto display markedly different community profiles. It is therefore not surprising that the political styles in the three communities are equally diverse. The differences in political goals and political styles is underlined by findings which might confound the systems analyst or the advocate of formal decision theory: the reaction to the STOLport is most negative in Palo Alto where adverse impacts are the least severe; the reaction to the STOLport is least negative in Concord where the adverse impacts are the most severe. This result is not surprising to the social scientist who expects the nuance of each particular situation to play as significant a role in political decisions -- often overshadowing so-called "objective criteria."

The situational nuances which establish the decision-making parameters in each community are best illustrated with direct quotations from the field interviews in each community.

PALO ALTO

Interviews in Palo Alto were conducted with the County Airport administrator, the leading spokesman for downtown Palo Alto businessmen, and the city's most prominant real estate developer.

The reaction of the airport administrator: "If it's economically feasible, it makes sense to pursue it . . . but I doubt very seriously that it could pass" either the voters or the city council.

The reaction of the spokesman for Downtown Palo Alto, Inc.: "I think it would go over like a lead balloon . . . It would be a waste of everybody's time to even make a presentation. The current city council members consider themselves the mothers and fathers of environmental issues."

And the realtor's reaction: "The majority in Palo Alto doesn't want anything that will increase traffic, noise, or density unless there is an overriding social need. The convenience of San Jose airport nullifies that social need argument . . . Pro-growth people might feel that it would be nice to have but they're not going to knock themselves out to get it."

The airport administrator estimated that Palo Alto voters would defeat an airport bond issue by a 60-40 election margin. "There would be a hue and cry," he said, "from the 6000 member County Airman's Association," from Palo Alto's well-organized environmental groups, and from the City Council. He noted that increasing the number of tie-downs for general aviation aircraft is a controversial issue in Palo Alto because of the potential for conflict between the use of the Baylands as a wildlife refuge and as an aircraft clear zone. "It is standard operating procedure at the existing airport to locate and bury seagulls that collide with aircraft," he added, "before the other side finds them."

On a more technical note, the airport manager noted the problems of airspace conflict, extremely unstable subsurface soil conditions, and conflict between general aviation and commercial activities given the airport's limited land area. Expanding the airport's land area, he argued, is politically infeasible because it would intrude on recreation land that is "defended like like apple pie and motherhood."

The downtown business leader estimated a more sizeable negative vote in a STOLport referendum: 66 percent opposed. The referendum would focus on:

-- the aggravation of Palo Alto's jobs-to-housing ratio
-- the loss of bayland recreation areas
-- traffic congestion
-- increased development pressure.

Palo Alto, the downtown leader noted, is the headquarters city for organized environmental groups in the mid-Peninsula: the Sierra Club, the Committee for Green Foothills, the Mid-Peninsula Conservation Center, Ecology Action and a well-organized residentialist association. As a result, airport expansion "would be political suicide." The airport administrator was more blunt: "It took nerve to put your name on that proposal."

The realtor, a veteran of several referenda on development proposals, was more pragmatic. Airport expansion would fail in a municipal election, he argued, unless there was an exceptionally large turnout. "There is a solid 'no' (growth) vote in Palo Alto that gets to the polls. If you can turn out more than the usual 10,000 voters it has a chance." But he added that a STOLport would not find a ready constituency in Palo Alto. The number of people who can conveniently use nearby San Jose airport "would reduce the number of people in the so-called 'establishment' that would go out and fight for it." His conclusion: 60 percent opposed, if the city council approved a ballot measure -- a doubtful proposition.

The political portrait of Palo Alto which emerges from interviews, questionnaire analysis and the analysis of voting returns in recent municipal elections suggests that STOLport implementation would be highly unlikely. This combination of measures indicates that:

-- Palo Alto's City Council is dominated by a coalition of residentialists and environmentalists who place low priority on further economic development.

-- The preservation of open-space and the city's low-density residential character have high community priority.

-- The city headquarters the best-organized environmental organizations in the Bay Region.

-- There is no grievance with the existing level of commercial air service in the California Corridor; consequently, there is no identifiable group or organization within Palo Alto to promote the STOL concept.

-- New employment is viewed as a disbenefit, a confounding factor in the city's efforts to balance its job-housing ratio and to combat traffic congestion.

It must be concluded that STOLport development in Palo Alto is highly unlikely.

HAYWARD

Interviews in Hayward were conducted with the Airport Manager, the Chairman of the Downtown Advisory Board, and the Industrial Development director of the local Chamber of Commerce.

The Airport Manager's reaction: "I don't think you'd get enough support to get it out of the city council chambers . . . Our goal is set; we're here; we're bound by our master plan. We're not really in competition with Oakland; we're a third-tier airport."

The downtown business leader: "I don't see the need for it. Oakland Airport is not being fully utilized. A STOLport would be superfluous when you have a major metropolitan airport 10 miles down the road."

The Chamber of Commerce spokesman: "This airport complements other airports in the Bay Area; what you're talking about is really contrary to any plan we've ever had. I doubt that it would serve the community's interest."

The Hayward airport manager argued that STOLport development would be infeasible in terms of the size of the airport and the scale of STOL operations:

-- city streets could not bear the additional traffic burden;
-- noise levels would be unacceptable to nearby residents;
-- airspace is prohibitively limited given the location of Oakland Airport;
-- general aviation and Air National Guard activities would suffer inconvenience.

The airport manager also argued that STOL is politically infeasible, anticipating opposition from the Federal Aviation Administration, Oakland Airport, the Association of Bay Area Governments and homeowner associations in Hayward and neighboring San Lorenzo. "As long as we stay within the general aviation framework we're all right;" he argued, "If we change the goals, we can count on opposition from environmentalists and homeowners." The opposition, he said, would be sufficiently stiff to produce a 70 percent vote against STOLport development.

The downtown business leader estimated that a STOLport ballot measure would be "defeated by a fairly good margin:" perhaps three to two. STOL would generate more resistance than support in Hayward, he argued, on the grounds of noise, air pollution and the fears based on safety hazards and air space conflicts. The convenience of Oakland airport, he said, would make it difficult to locate a group that would spearhead STOLport development.

The Chamber's industrial recruiter offered the same judgment: a STOLport proposal would be defeated at the polls with a 60 percent vote against. He predicted that Hayward's city council would oppose the project -- precluding a test by ballot.

The Chamber spokesman noted that industrial clients have located in the airport industrial park with the understanding that the airport would be developed according to a strict master plan. "I don't think we'd be fair to all the firms that have purchased land," he said, "if we change the rules now." Noting that the airport's projected development is almost complete, he said, a change in direction would "really rock the boat." Traffic congestion, he added, would be a severe disbenefit to the firms located in the airport industrial park.

The political portrait of Hayward which emerges from the interviews and questionnaire analysis suggests that community acceptance of STOLport implementation would be highly unlikely. This combination of measures indicates that:

-- The Hayward City Council is favorable to planned economic development but the STOL proposal comes too late to be consistent with established objectives for the city's future growth.

-- Hayward wants economic development -- new jobs, new tax base and downtown renewal -- but it views light industrial development as the environmentally and politically sensible means to that end.

-- There is no grievance with existing service and therefore no apparent motivation for provoking an extremely heated controversy.

-- Traffic congestion is a major problem in Hayward which the airport would aggravate, confounding industrial recruitment and downtown rehabilitation.

-- Nearby residents are already concerned about noise problems; a STOL proposal would be threatening to the maintenance of current airport activities because of the political opposition it would provoke.

CONCORD

Interviews in Corcord were conducted with the Assistant Airport Manager, the Director of the Chamber of Commerce, the Assistant Director of the Contra Costa County (Industrial) Development Association and the County Supervisor in whose district the County airport is located.

The interviews in Concord were the only case in which civic and business leaders were sufficiently enthused with the STOL concept to give serious consideration to the political strategy necessary to move from the concept stage toward STOLport implementation. This markedly different reaction is reflected in the comments which follow, indicating an up-hill battle toward a controversial but desirable objective.

The most detailed discussion of political strategies for STOLport implementation was provided by the spokesman for the County Development Association. This is his assessment:

1. The key to STOLport implementation is Supervisor Warren Boggess; the supervisor could effectively veto STOLport development.
2. The STOLport would probably fail in a countywide bond election; financing should be accomplished through a joint powers agreement or non-profit corporation rather than voter approved bonds.
3. The STOLport would have to make every possible concession to environmental concerns; lack of environmentalist opposition would be important for successful implementation.
4. Opposition from environmental organizations -- the Sierra Club, The Stop Smog Committee and the Conservation League, would be vocal but its effectiveness would be blunted by disorganization.
5. Regardless of noise suppression, there would be substantial opposition from affected homeowners; an airline would have to anticipate maximum delays and a court action despite good faith efforts to mitigate adverse impacts.
6. Labor unions -- the Central Labor Council, the Construction Trades and the Teamsters -- would be a politically potent ally of STOLport development, motivated by job opportunity.
7. Organized taxpayers associations would probably be favorable; rank and file taxpayers living closer to Oakland Airport would probably be opposed.
8. The Concord Chamber of Commerce would support the STOLport provided the city got a slice of the tax benefits from the airport -- a problem since the airport is located on unincorporated county land. Conventions would be a major salespoint with the local Chamber.

9. The Department of Public Works and the Planning Commission might well support the project; support from the County Planning staff would be contingent on stringent environmental impact restrictions.

10. Private pilots would probably oppose large-scale commercial operations; how well organized and how influential they are would be a key question.

11. Homeowners associations in Pleasant Hill, Pacheco and Concord might well oppose STOLport development. They are not currently mobilized and the telling factor in their future mobilization would be politicians in search of a constituency.

12. Office holders in Pleasant Hill would probably oppose STOLport development; they are concerned with the amenities of suburban living.

13. An extremely well-financed, well-organized campaign would be necessary; even then the STOLport would be difficult to market to the general electorate; the best prospect is a campaign leading to direct action by the Board of Supervisors -- and that depends on the reaction of Supervisor Boggess.

The Assistant Airport Manager's view: STOL would be a major benefit to Diablo Valley residents who must travel almost an hour to the nearest metropolitan airport; but STOL implementation would be sufficiently controversial that it would probably not gain approval from the Board of Supervisors.

The Chamber spokesman: "STOL is a saleable item," but "there aren't any people who come to mind who are foremost airport boosters who would step forward and push this thing through." The major salespoint for a STOLport would be, according to the Chamber director, the increasing highway congestion between Diablo Valley and Oakland. He concurred that there would be heated opposition from Pleasant Hill, environmental organizations and the some 300 residents who complain about current noise levels at the airport.

Each of the community leaders interviewed indicated that Contra Costa County Supervisor Warren Boggess occupies a position which uniquely allows him to exercise a controlling voice in decisions affecting Buchanan Field. The Supervisor is a pilot, the owner of a fixed base operation at Buchanan Field, the former Chairman of the Regional Airports Systems Study Commission, and the representative of the supervisorial district in which the airport is located. The Contra Costa County Board of Supervisors quite naturally defers to Boggess' judgment in matters relating to aviation.

Supervisor Boggess expressed the following view: "I honestly feel that in terms of the surrounding urban development, Buchanan Field is past the point that it could be doctored up to have high frequency STOL service."

"I don't want to appear to be totally negative;" he added, "Before I make any judgment I would want to expose the STOLport idea to a public hearing process and let the public react to it."

Boggess predicted that "community reaction would be instantaneous," and that the proposal would be extremely controversial. He predicted heated opposition from Pleasant Hill, Concord homeowner associations and environmental organizations which he characterized as "quite well organized." He said the results of a bond election would be "touch and go," with a narrow majority in his Fourth Supervisorial District probably voting against the proposal.

Support for the proposal, Boggess said, would come from the Chamber of Commerce and "Chamber of Commerce types" as well as politically influential organized labor.

Boggess noted that residential areas of Pleasant Hill are already sensitive to noise intrusion resulting from overflights by general aviation aircraft. For this reason, "It is very important for Buchanan Field to maintain a low profile. To increase activity at Buchanan Field, Hayward or San Carlos is undoubtedly going to cause controversy. It might be sufficient to escalate existing feelings into a situation in which people come to think of the airport as a bad neighbor." The STOL proposal, he said, would "eliminate the airport's nice low profile and call more and more attention to it."

The Supervisor also noted two technical factors that had not been considered during the Stanford study:

1. Travel time from the Diablo Valley to Oakland Airport will be significantly reduced if and when freeway connections in Oakland are completed (the Grove-Shafter Extension) and when BART extends the full distance from Concord to Oakland Airport.

2. Variable wind conditions at Buchanan Field would necessitate occasional southerly take-offs with resultingly greater noise impact over residential areas.

Boggess suggested that STOL proponents should work with a County Supervisor's committee which is currently working to identify a location for a new airport in Contra Costa County east of Antioch. Site selection, clear zone planning and land use controls for the new airport he said might then be developed with STOL in mind.

The interviews with Boggess and economic leaders in the Diablo Valley suggest that community approval for a STOLport would be a "touch and go proposition." As Boggess put it: "The glamour age is over; people are no longer impressed with the glamour of aviation. It would have to justify itself on its merits." We must therefore conclude that even in Concord -- the community most receptive to the STOL concept, the community acceptability of STOLport development must be rated "marginal."

Summary

Interviews with community opinion leaders in three Bay Area communities indicate that the adverse impacts of STOL, much less RTOL aircraft, would be extremely controversial.

These civic leaders emphatically recognize the importance and desirability of convenient air travel. But they are equally emphatic in thinking that modest improvements in air travel convenience do not justify community disruption. It seems clear that, in the view of the opinion leaders interviewed, the conversion of general aviation airports to commercial STOL use falls within this latter category -- an added convenience that does not justify community disruption.

Thus, in the three Bay Area communities studied, it appears that STOL is too much proposed too late. We must conclude that the likelihood of STOLport acceptance in Concord is "marginal" and "highly unlikely" in both Hayward and Palo Alto.

References

1. The Bechtel Corporation, "Environmental, Social and Economic Impact of the Proposed 1972-77 Capital Improvement Program for the San Jose Municipal Airport," November, 1972.

2. Waldo and Edwards, Consultants, "The Economic Impact of Los Angeles International Airport on Its Market Area," Los Angeles Department of Airports, November, 1971.

3. Tiebout, Charles M., The Community Economic Base Study, Washington, D. C., 1963.

4. Association of Bay Area Governments, Economic and Spatial Impact of Alternative Airport Locations, Regional Airport Systems Study, ABAG, July 1971, Two Volumes.

BIBLIOGRAPHY

A Selected Bibliography of Published Materials Relating to the Evaluation of the Community Acceptability of Transportation Projects

(1) Richard S. Bolan, "Community Decision Behavior: The Culture of Planning," Journal of American Institute of Planners (September 1969), Vol. 35, No. 5.

(2) Sean Damer, "Public Participation in Planning: A Review," Town Planning Review (July 1971), Vol. 42, No. 3.

(3) Edwin N. Thomas, "Strategies for the Evaluation of Alternative *Transportation Plans," Progress Report Number 96, 1970, Highway* Research Board.

(4) Gordon J. Fielding, "Transport Impact Research: Problems of Location Decisions at the Community Level," The (Western) Regional Science Association Annals (December 1970), Vol. 4, No. 2.

(5) Gordon J. Fielding, "Structuring Citizen Involvement in Freeway Planning," 1972, Highway Research Board Annual Meeting.

(6) Robert H. Friis, "Transportation Objectives, Criteria and Standards," (November, 1971), Technical Paper, Denver Joint Regional Planning Program.

(7) "Social, Economic and Environmental Factors of Transportation," Highway Research Record No. 356, Highway Research Board. 20 reports including:

Erwin A. France, "Effects of Citizen Participation in Governmental Decision-Making."

Melvin M. Webber, "Alternative Styles for Citizen Participation in Transport Planning."

Paul Weiner, "Nonuser Effects in Highway Planning."

Hans Bleiker, J. H. Suhrbier and M. L. Manheim, "Community Interaction as an Integral Part of the Highway Decision-making Process."

Frank C. Colcord, Jr., "Transportation and the Political Culture,"

Joseph O. Mason and Charles T. Moore, "Development of Guides for Community Acceptance of Highway Location, Development and Construction."

(8) "Citizen Participation and Community Values," Highway Research Record No. 380, Highway Research Board. Five reports, including:

K. M. Travis and S. C. Plog, "Community Involvement in Transportation Planning: A New Approach."

Ki Sub Pack, "Achieving Positive Community Participation in the Freeway Planning Process."

Gordon J. Fielding, "Structuring Citizen Involvement in Freeway Planning," pp. 23-36.

Marvin L. Manheim and John H. Suhrbier, "Community Values: A Strategy for Project Planning."

(9) "Transportation and Community Values," Highway Research Record No. 305, (1969), Highway Research Board. Includes:

A. B. Bishop, Clark Oglesby, et.al., "Community Attitudes Toward Freeway Planning Procedures."

Martin Wachs, "Basic Approaches to the Measurement of Community Values."

(10) "Community Values as Affected by Transportation," Highway Research Board, 42nd Annual Meeting, January, 1965.

(11) Highway Research Board, "Decision Theories in Transportation Planning," Special Report 108, 1970, Highway Research Board.

(12) Thomas Hillegrass, "Community Decision Structure and Urban Planning Process," (March 1970), ASCE Journal of Urban Planning and Development.

(13) B. G. Hutchinson, "Structuring Urban Transportation Planning Decisions: Available Social Science Constructs," Environment and Planning (1970), Vol No. 3.

(14) Kirkland C. Mead et.al., "Basic Issues in Incorporating Community and Environmental Factors in the Transport System Planning Process," Proceedings of Transportation Research Forum, Vol. 12, 1971.

(15) Marvin L. Manheim, "Community Values in Highway Location and Design," Report No. 71-4, September 1971, Urban Systems Laboratory, M.I.T.

(16) Judith V. May, "Citizen Participation: A Review of the Literature," Committee of Planning Librarians, Exchange Bibliography No. 210/211.

(17) William Ockert and Charles E. Pacton, "A Strategy for Evaluating A Regional Highway-Transit Network," (1968), Regional Planning Council, Baltimore.

(18) Milo C. Pierce, "Participation in Decision-making: A Selected Bibliography."

(19) Proceedings of the Joint ASCE-ASME Transportation Engineering Conference, July, 1971.

D. G. Harvey, "Measurement of Community Values in Transportation Network Evaluation."

Gerald M. Sturman, "The Engineer, His Client and Impact Analysis."

(20) A. R. Prest, "Cost-Benefit Analysis: A Survey," Economic Journal (1965), Vol. 75

(21) Charles C. Schimpeler, "A Decision TheoreticApproach to Ranking Community Goals and Evaluating Alternative Plans," (1967), Purdue University, Joint Highway Research Project.

(22) Wilbur Smith & Associates and TRW Systems Group, California Transportation Evaluation Project (1971), Procedural Guide; Final Report; Summary Report. Prepared for the State of California Business and Transportation Agency.

(23) J. C. Sorenson, "Identification of Social Costs and Benefits in Urban Transportation," Systems Analysis of Urban Transportation (1968), Vol. 3, Prepared for HUD by General Research Corp.

(24) E. N. Thomas and Y. L. Schofer, "Criteria for Evaluating Transportation Plans," Highway Research Board, National Cooperative Highway Research Program, Report No. 96.

(25) W. L. Wheaton and M. F. Wheaton, "Identifying the Public Interest: Values and Goals," in Ernest Erber, Urban Planning in Transition, Grossman, 1970.