NASA CR-152084

(NASA-CR-152084) BENEFIT-COST EVALUATION OF AN INTRA-REGIONAL AIR SERVICE IN THE BAY AREA Technical Report, 1 Jan. - 31 Dec. 1977 (Washington Univ.) 285 p HC A13/MF A01 CSCL 05C G3/03

N78-19082

Unclas 08625

BENEFIT-COST EVALUATION OF AN INTRA-REGIONAL AIR SERVICE IN THE BAY AREA

Dr. Lonnie E. Haefner

December 28, 1977

NASA Grant NSG-2170
Period of January 1, 1977 - December 31, 1977

Department of Civil Engineering
Washington University
St. Louis, Missouri

for

AMES RESEARCH CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

285

NOTICE

BENEFIT-COST EVALUATION OF AN INTRA-REGIONAL AIR SERVICE IN THE BAY AREA

NASA Grant NSG-2170
Period of January 1, 1977 - December 31, 1977

Department of Civil Engineering
Washington University
St. Louis, Missouri 63130

December 28, 1977

Dr. Lonnie E. Haefner
Principal Investigator

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

LIST OF FIGURES

LIST OF FIGURES
(continued)

LIST OF TABLES

LIST OF TABLES
(continued)

LIST OF TABLES
(continued)

LIST OF TABLES
(continued)

LIST OF TABLES
(continued)

LIST OF TABLES
(continued)

CHAPTER I

INTRODUCTION - STUDY DESIGN

CHAPTER I

INTRODUCTION - STUDY DESIGN

Introduction - Review of Study Design

This report summarizes the work completed during the period January 1, 1977 through December 31, 1977 on NASA Grant No. NSG-2170 "Benefit-Cost Evaluation of an Intra-Regional Air Service in the Bay Area." As previously stated in the Summary Progress report of January 3, 1977, the objective of the research is to execute an analysis of benefits and costs that would result from an intra-regional air service operation in the San Francisco Bay Area.[1] A simplified study methodology of the research effort is illustrated in Figure 1. Essentially, the study utilizes an iterative statistical decision model to evaluate combinations of commuter airport sites and surface transportation facilities in conjunction with service by a given commuter aircraft type in light of Bay Area regional growth alternatives and peak and off-peak regional travel patterns. The model evaluates such transportation options with respect to criteria of airline profitability, public acceptance, and public and private non-user costs. In so doing, it incorporates information on modal split, peak and off-peak use of the air commuter fleet, terminal and airport costs, development costs and uses of land in proximity to the airport sites, regional population shifts, and induced zonal shifts in travel demand. The model is multimodal in its analytic capability, and performs exhaustive sensitivity analysis.

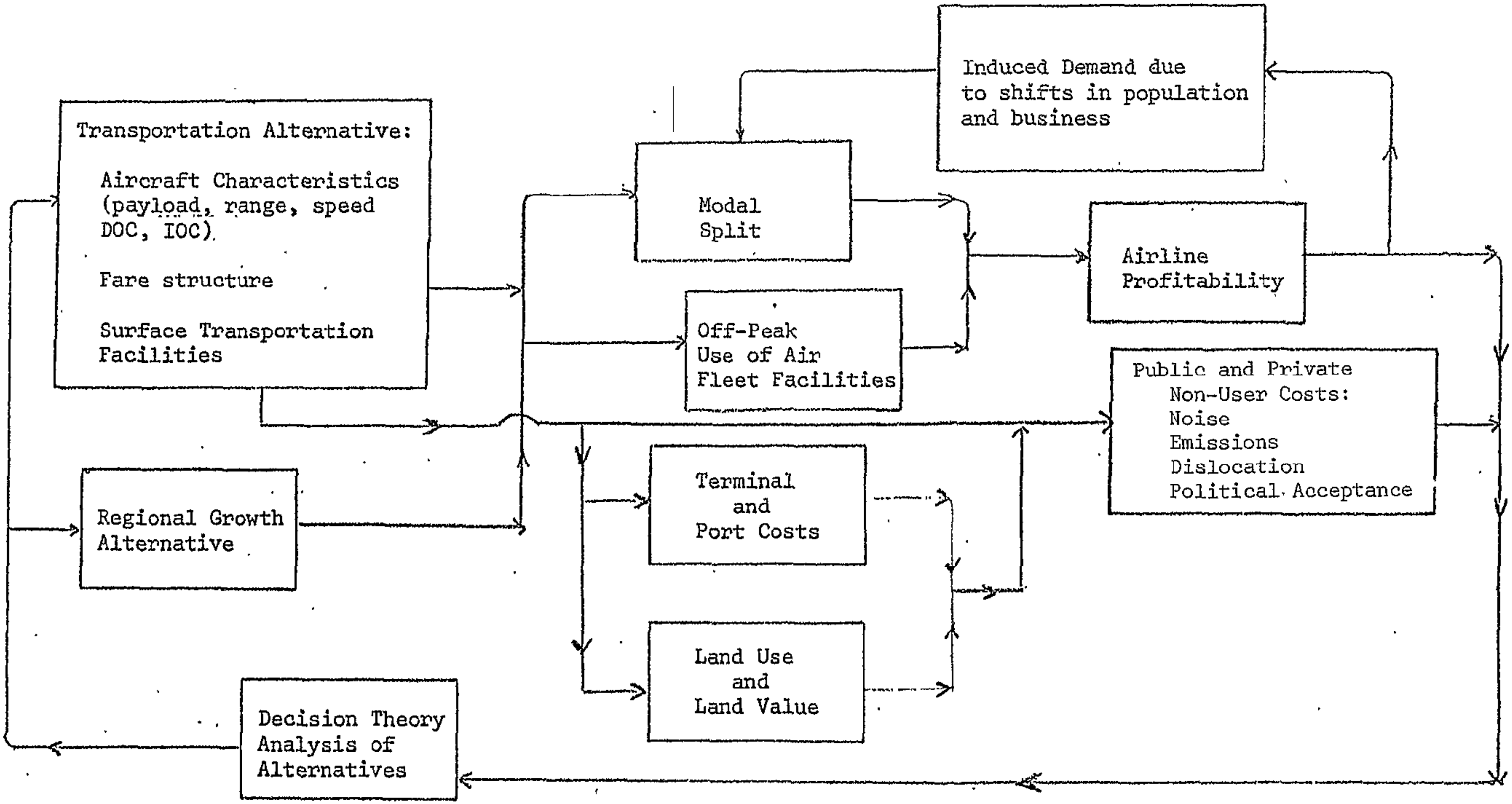
Objectives of Research

Several specific objectives were accomplished during the research period. They include:

1.) The development of a more refined evaluation of regional commuter air alternatives, using completely updated land use forecasts and

Figure 1

STUDY METHODOLOGY OF THE RESEARCH EFFORT



travel projection modelling output, which were made available after January 1, 1977. This refined data insures accurate and realistic model calibration, exhaustive sensitivity analysis, and a more meaningful interpretation of the model results.

2.) The testing of evaluation techniques previously developed at the level of locating, siting, and operation of individual air commuter terminals.[2] In addition, cost, environmental, and socio-economic analyses of the specific placement of air commuter terminal sites, plane and fleet size, and scheduling within the alternative policies previously developed were undertaken.[3]

3.) The development of a study format for assessing citizen reaction to the presence of air commuter facilities and their consequences, through the assessment of public acceptance of noise and the construction of citizen participation preference processes in the evaluation scenarios.

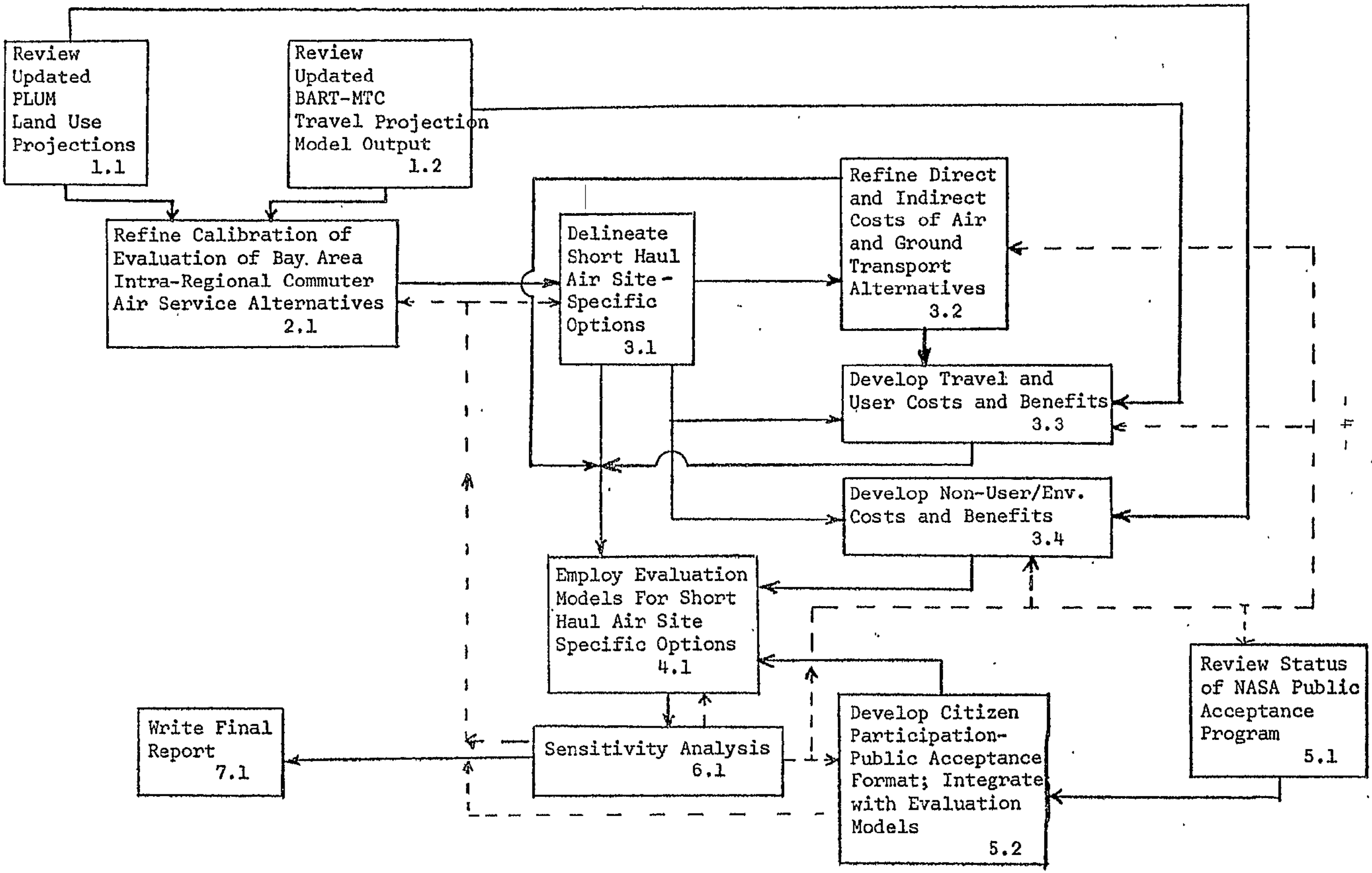
4.) The assessment in a real world case study situation of the validity of the evaluation models and structures used in the study of regional air commuter facilities problems, and conclusions as to the ultimate transferability and generalization of these techniques to other regions and situations.

Detailed Research Work Plan

The detailed work plan for processing the above research objectives is shown in Figure 2. It consisted of seven phases, with some phases having component tasks within them. Phase 1 had two component tasks, related to incorporation of the revised PLUM land use forecasts and the refined MTC

FIGURE 2

DETAILED WORK PLAN



travel deamnd projections. Task 1.1 collected and reviewed the latest PLUM land use forecasts for 20 years hence; likewise, Task 1.2 collected and reviewed the refined BART-MTC ground transport travel demand model output recently completed at MTC. Phase 2 consisted of one Task 2.1, which incorporated refined inputs into the statistical decision model structure formulated in the previous grant effort,[4] and revised the evaluation and related sensitivity analysis, noting alternations in optimal policies for regional air commuter transportation alternatives.

The above phases yielded a framework of accuracy and relevance for processing the remaining research phases. Phase 3 consisted of four component tasks. Task 3.1 delineated site specific options for locating commuter air terminals which accomplished a variety of regional growth and planning objectives, and compatibly linked them with the regional ground transportation alternatives. Three generic types of sites were considered within the envelope of policies studied:

1.) Fringe regional sites offering opportunities for regional expansion and viable interconnection into other regions.

2.) Specific CBD core sites, particularly as they related to VTOL/STOL and interlinkage of core related transportation interchanges; for example, the Bay Ferry Service and downtown BART service.

3.) Critical loci of regional travel interchange on the BART System, and specific BART-bus station interchanges i.e. the Fremont Station, Southern Pacific commuter termini, etc.

Tasks 3.2 and 3.3 modified historical and previously gathered direct, indirect, and user travel costs and benefits, in order to properly develop cost scenarios for the carrier, the user, and the site operation for the above site location alternatives studied. Task 3.4 developed reasonably rigorous site non-user and environmental analyses, as inputs to the forthcoming evaluation tasks and citizen-participation/citizen-acceptance study formats. The previously developed regional information, in conjunction with detailed site mapping and analysis, yielded a catalogue of impacts with respect to:

Noise, including NEF contours

Impact on mobile source Air Quality

Localized impact on surrounding land values, economic base and value added and the relationship of such to PLUM growth states

Altered patterns of energy consumption and the relationship to region wide energy consumption

Phase 4 consisted of one task, Task 4.1, which employed the developed statistical decision theory model at a site specific level in the city of Fremont, California. Incorporation of the above user and non-user information yielded a site evaluation for Fremont which fit the optimal policy of regional air commuting previously formulated.

Phase 5, developed interactively with other phases, and used to modify the evaluation structure, dealt with citizen participation in the evaluation of facility location and design. There were two component tasks within it. Task 5.1, in conjunction with NASA-Ames, other associated researchers, and literature searches developed in NAS2-8324, reviewed the status of public acceptance programs for short haul commuter aircraft and airport site selection in metropolitan areas. Task 5.2 developed an appropriate citizen participation-public acceptance study design, incorporating information in Chapter 5 of NASA CR-137771, and dealt with the problem in a modified public works analysis format. This format was then incorporated into the evaluation Task 4.1, reflected in Fremont and the modification of alternatives in task 2.1, resulting in a variety of modified policy and site-alternatives, state space modification, and/or different weights used in the environmental value matrices, all reflecting citizen viewpoints, value structure, and regional political implications of implementing different sets of alternatives.

Phase 6 had the Task 6.1 of continual sensitivity analysis over parameters deemed appropriate at that juncture of the study. Based on findings during the research effort, continual alteration in state probabilities, monetary costs, environmental consequences, site locations, fleet alternatives, and citizen value weighting were studied. Appropriate feedback, re-analysis, and interpretation of the above were executed with respect to activities in Tasks 2.1, 3.1, 3.2, 3.3, 3.4, and the evaluation model and citizen acceptance-participation study design in 4.1, 5.1, and 5.2, respectively.

Given completion of the sensitivity analysis in Task 6.1, the final phase, (Phase 7) consisting of Task 7.1, was the development of this final report, yielding a written narative of the twelve months of study activity. The thrust of the report documented herein is to illustrate the capability of the model appropriately structured for application in the Bay Area. The synthesis of the above into the following final written report includes appropriate written, graphical, and computer software documentation.

Overview of Final Report Structure

As was stated in the beginning of this chapter, the objective of the research is to develop an evaluation model of benefits and costs that would result from an intra-regional air commuter system in the San Francisco Bay Area. The analysis and evaluation of such an air transportation system was undertaken by using a Markovian Decision Model, discussed in Chapter II, which used three growth states output from the PLUM model (Projective Land Use Model), discussed in Chapter III, to form the Markovian State Space. Subsequently, in Chapters IV thru VIII, appropriate analysis of regional travel demand modelling, the air commuter alternatives, impact analysis, and growth state transition probability matrices are developed and discussed. Chapter IX discusses the site specific evaluation methodology employed at Fremont, California. Finally, Chapter X, discusses the conclusions derived from the research with respect to inter-regional air service in the San Francisco Bay Region over the coming 20 years, the validity and transferability of such evaluation modelling approaches, and potential areas for further research.

Footnotes

[1]Benefit-Cost Evaluation of an Intra-Regional Air Service in the Bay Area, NASA Grant NSG-2170, Period of July 1, 1976 - December 31, 1976, January 3, 1977, Dr. Lonnie E. Haefner, Principal Investigator, Washington University.

[2]A State-of-the-Art Review of Transportation Systems Evaluation Techniques Relevant to Air Transportation Volume I, Contract No. NAS2-8324, Dr. Lonnie E. Haefner, Principal Investigator, Washington University, August 1975.

[3]Ibid.

[4]op. cit.

CHAPTER II

OVERVIEW OF EVALUATION MODELLING APPRAOCH

CHAPTER II

OVERVIEW OF EVALUATION MODELLING APPROACH

Brief Review of Relevant Markovian Decision Theory Structure

This chapter reviews the significant elements of the evaluation modelling structure. The analysis and evaluation of the benefits and costs that will result from intra-regional air service operation in the San Francisco Bay Area can be undertaken by a Markovian Decision Theory approach. This approach involves the formulation of a state space, delineation of transportation alternatives, state transition probabilities, and reward matrices for the system under study as illustrated in Figure 3.

In an analysis of an existing or proposed system from a Markovian framework, the basic concern lies with the trajectory of the process, i.e. the sequence of system states, rather than in the time interval between successive states (although this sequence of time intervals can also be considered a random variable). More directly, a system can be described in terms of its state transitions given discrete time intervals. The state variable descriptors, such as land use, population, and economic forecasts, themselves capture the dynamics of the system.

The basic assumption of a Markov process lies in its relationship between the successive states of the system. The composition of the states used in this research project are further developed and elaborated on in Chapter III. The notation for the formulation of the state space is:

$s(n)$ state at time interval n, $n = 1, 2, \ldots$

$i, j, k, \ldots m$ any sequence of states $1, 2, \ldots N$.

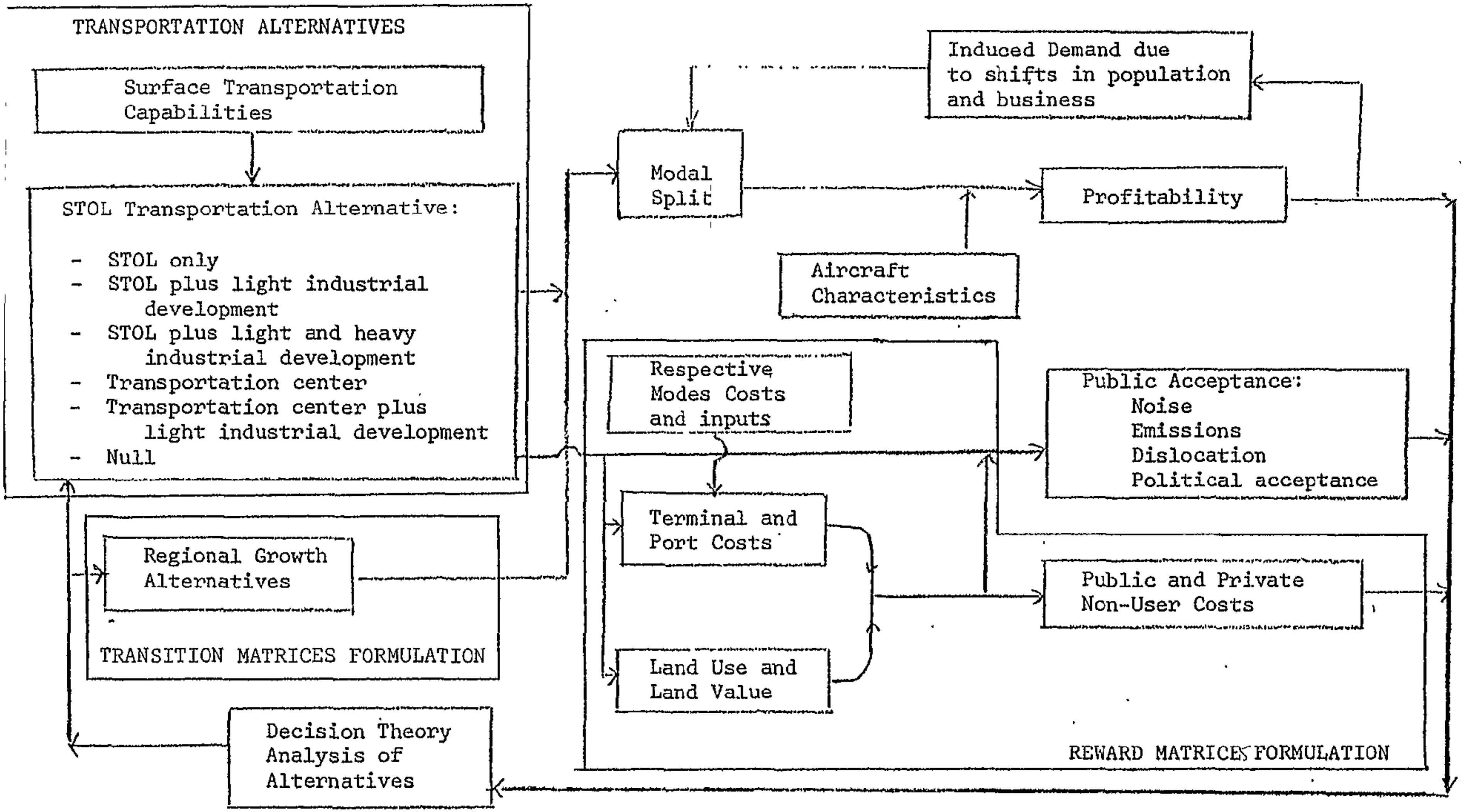
The actual Markovian assumption has the following formulation:

$$P\{s(n+1) = j \mid s(n) = i, s(n-1) = k, \ldots s(0)=m\} = P\{s(n+1)=j \mid s(n)=i\}$$

where P is a probability measure.

FIGURE 3

MARKOVIAN DECISION THEORY MODELLING STRUCTURE



The Markovian property is equivalent to the conditional probability of any future "event," given any past "event." In addition, the future state of the system is independent of the past events and depends upon only the present state of the process.[1] In essence, the system's being in state j at time n + 1 has only to do with the previous state i, and not all previous states of the system from time zero. For the postulated Markov Process previously defined, a significant assumption concerns the ergodic property. This property asserts that the final long run steady state probabilities are independent of the initial starting state.

The next step in the modelling formulation is the development of k alternatives for future regional air commuter activity. These k alternatives are formulated in conjunction with different assumptions affecting the region under study. These assumptions may relate to the potential for transportation service in the region, as well as the locale of possible sites available. These are discussed in detail in Chapter V.

The state transition probabilities, which are developed in Chapter VII, are the probabilities P_{ij} of a system in state i going to state j in the next time interval. Several assumptions are made with respect to the transition probabilities, in order to maintain accuracy, and remove some of the modelling complexity. These are: 1.) There is a finite set of states 1, 2, . . .N of the system which may be occupied at any time. 2.) The time interval spacing is assumed to be constant. 3.) The p_{ij} measures are independent of time and therefore do not change with time.

There are two constraints on the probability measures:
First, for all i, j,

$$0 \leq p_{ij} \leq 1.$$

Second, the probabilities are normalized,

$$\sum_{j=1}^{N} p_{ij} = 1 \qquad i = 1, 2, . . . N.$$

As a result, the matrix of the transition probabilities, N x N, is referred to as a stationary matrix.

The stochastic inputs for this evaluation methodology consist of the single step transition probabilities for the Markov process. The determination of these probabilities are critical to the analysis, and reflect professional evaluation of the land use and transportation issues in the Bay area.

In studying the dynamics of a transportation system, our concern is with the future state of the system given its present state. The matrix of the transition probabilities, developed completely in Chapter VII, P_{ij}, is composed of the probabilities of the system (the region's land use and socio-economic patterns), currently in state i, moving to state j (the same or different land use or socio-economic patterns) in the next transition. The transition time period will be a time span which allows the land use and socio-economic patterns to develop recognizable shifts representing regional growth implications. In addition, for each transportation alternative there is a P_{ij} matrix which is a stochastic matrix. This results in:

$$P^k = P^k_{ij}$$

where k equals the number of transportation alternatives under study, and i and j correspond to the different growth states. This property reflects the inherent degree of association of changes of regional growth patterns by virtue of employment of particular types of transportation investment, and demonstrates the classic land use transportation feedback mechanism. The values in the P_{ij} matrix reflect historical and researched knowledge of the effect a particular transportation alternative has on land use and socio-economic patterns, as well as prevailing and likely future trends in regional growth patterns.

The remaining component of the evaluation structure is the reward matrix, R^k_{ij} reflecting gains to the system of a state transition from i to j when alternative k is employed. The transition reward matrices are formulated on the basis of the regional value added due to the state-transition, and the cost of the appropriate transportation alternative, and/or the related environmental impact of the transportation alternative. The formulation of the reward matrices is developed in detail in Chapters VI through VIII. The matrix of rewards generated by the Markov process is a random variable with the same probabilistic relations of the Markov process. Thus, there are k matrices of transition probabilities, each referred to as P^k, and k reward matrices, R^k, each associated with the k^{th} alternative.

The relative total expected reward or relation value, $v_i(n)$ is the expected total earnings or gain of the next n transitions, given the system is initially in state i. The mathematical relation is as follows, where the terms have been previously explained,

$$
\begin{aligned}
v_i(n) &= \sum_{j=1}^{N} p_{ij} \left(r_{ij} + v_j(n-1)\right) \qquad i = 1, 2, \ldots N \\
&= q_i + \sum_{j=1}^{N} p_{ij}\, v_j\, (n-1)
\end{aligned}
$$

where

$$q_i = \sum_{j=1}^{N} p_{ij}\, r_{ij}$$

is the expected immediate reward for state i.

The above equation on q_i is manipulated through a simultaneous equation solution approach, termed the Policy Iteration Technique, which uses a Markovian solution to find:

$$K^* = \max_k \{q_i^k + \sum_{j=1}^{n} P_{ij}^k V_j\}$$

where

q_i^k = the expected reward from the next stage transition, given the starting growth state i, for transportation alternative k,

P_{ij}^k = single step transition probabilities, growth state i to growth state j, for transportation alternative k,

V_j = relative total expected reward or relative value accruing to the system under the previous policy,

N = the maximum number of states

For each state i, the alternative, k*, is found which maximizes the test quantity and is the optimal alternative for that particular state. A composite of these k* for each state of the system is termed the optimal decision or policy vector

$$d^* = \begin{bmatrix} k_1^* \\ k_2^* \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ k_n^* \end{bmatrix}$$

which delineates a complete strategy for all possible states of the system.

The test quantity k^* represents the selection criteria by which one alternative is considered optimal in relation to the other transportation alternatives for each land use-socio-economic system state. Symbolically, this maximized test quantity for each transition represents the alternative to be selected for each state, based on a set of rewards and values relative to all alternatives. As such, this test quantity is not an absolute measure of benefits for the selected transportation alternatives, but rather a means of relative ordering of their worth, given the stochastic properties of the entire system. For complete coverage of the mathematics, see Howard[2] and/or Appendix A .

Markovian Decision Theory is a highly relevant tool in emerging transportation systems evaluation research. It allows an optimum seeking approach to be pursued in light of the inherent uncertainty of the real world process, and in the environments, termed states, under which the decisions may be obtained.

Past historical studies, or experimentation, may allow the probability distributions of the states and their transitions to be built, along with cataloging the rewards with respect to the impacts of an alternative on a particular state. If one reads the above closely, it is apparent this method closely simulates the real-world process of placing transportation system alternatives in an uncertain set of environments, and probilistically accruing several societal, environmental and user impacts each with associated costs, gains, and the propensities for altering the state structure. Chapter III will begin this process by describing and structuring the state space from appropriate population, land use and socio-economic data and computational forecasts in the Bay Region.

Footnotes

[1] Operations Research by Frederick S. Hillier and Gerald J. Lieberman, Holden-Day, Inc. 1974.

[2] Howard, Ronald A., Dynamic Programming and Markov Processes, M.I.T. Press, Cambridge, Mass., 1960.

CHAPTER III

FUTURE GROWTH PROJECTIONS

CHAPTER III

FUTURE GROWTH PROJECTIONS

Review of Computations and Profile of Future Growth Projections

This chapter will discuss the future growth projections for the San Francisco Bay Area with respect to long run planning objectives and the associated land use, population, and economic forecasts of relevance to the research effort, and the structuring of computational models discussed in this report. The PLUM (Projective Land Use Model) model[1] was used by the Association of Bay Area Governments and the Metropolitan Transportation Commission to develop forecasts for the metropolitan area. Such model output has been used by the research team to structure the Markovian state space of the research evaluation models.

The PLUM Model is designed to yield projections of future zonal distribution of population, employment and urban land use within a region. The model is based on two fundamental concepts which were derived from the Lowry Model. The first concept involves a distinction between "basic" and "local serving" employment. The second concept involves the notion of an allocation function. The model iterates to a single forecast for the year desired based on a balancing between the projected location of the basic employment, the distribution of the local-serving employment, and the set of households associated with both employment categories. The output of the PLUM model is a set of projections of employment, population, and land use per zone of the region under study for a given target year. This model and its associated output on future growth states was used by the Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC) in a joint study conducted in 1976-1977 and adopted by the ABAG Regional Planning Committee on March 2, 1977.

For the purposes of this report, this output will be referenced as the "PLUM" Series 3 projections."[2] These Series 3 projections are the third set in a series of projections produced jointly by ABAG and MTC since the original PLUM Series 1 study in 1970. The Series 3 projections reflect modelling improvements, additional technical and policy considerations, refined land use and employment data, and information on future transportation systems in the region not possessed in the Series 1 and 2 data. The projections are also based on a more comprehensive review of regional planning issues developed during the succeeding stages in the PLUM modelling process. They project such growth and distribution of population, employment, housing, and land use for the nine county San Francisco Bay Region through the year 2000. The assumptions that underlie the Series 3 projections include:[3]

1. At the regional level, alternative sets of plausible assumptions are made regarding national and regional demographic and economic trends.
2. At the subregional level, the projections reflect the current operating policies of local service-providing and regulatory agencies whether or not they are expressed in the general plans of cities and counties.
3. Transportation assumptions about highway and transit facilities are based on the Metropolitan Transportation Commission's regional transportation plan.
4. The projections assume that no major wars or natural disasters will occur during the projection period.

5. Development of new technologies is not considered in the projections.
6. The projections do not include environmental and energy policies which may be incorporated in the future.

Figure 4 shows the San Francisco Bay Area Region which is composed of the nine counties of Sonoma, Marin, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo and San Francisco. Formally, the Plum Series 3 output produces two growth projections for this region. These are labeled as Base Case 1 and Base Case 2 and representing different assumptions about overall population growth in the region, and the geographic distribution of basic employment. (See Appendices B and C for Base Case data)

The development and use of base case projections is an important part of the current planning process at ABAG.[4] The objective of the base case formulation is to provide an analytically viable framework in which to identify the results of policy actions in terms of possible future problems. As a result, if the base cases are representative of the operating policies of the region, then they will most likely predict where the region will be in future years. The base case projections thus provide a starting point from which problems may be identified and the effects of various policies on these problems can be examined.[5]

In order to retain consistency in the formulation and refinement of the Markovian decision model developed in this research with that arrived at in the NASA Study NSG-2170[6] a third case, Base Case 3 was added to the set of PLUM output states. Base Case 3 was arrived at by taking the average of Base Case 1 and Base Case 2. The main features of each growth state

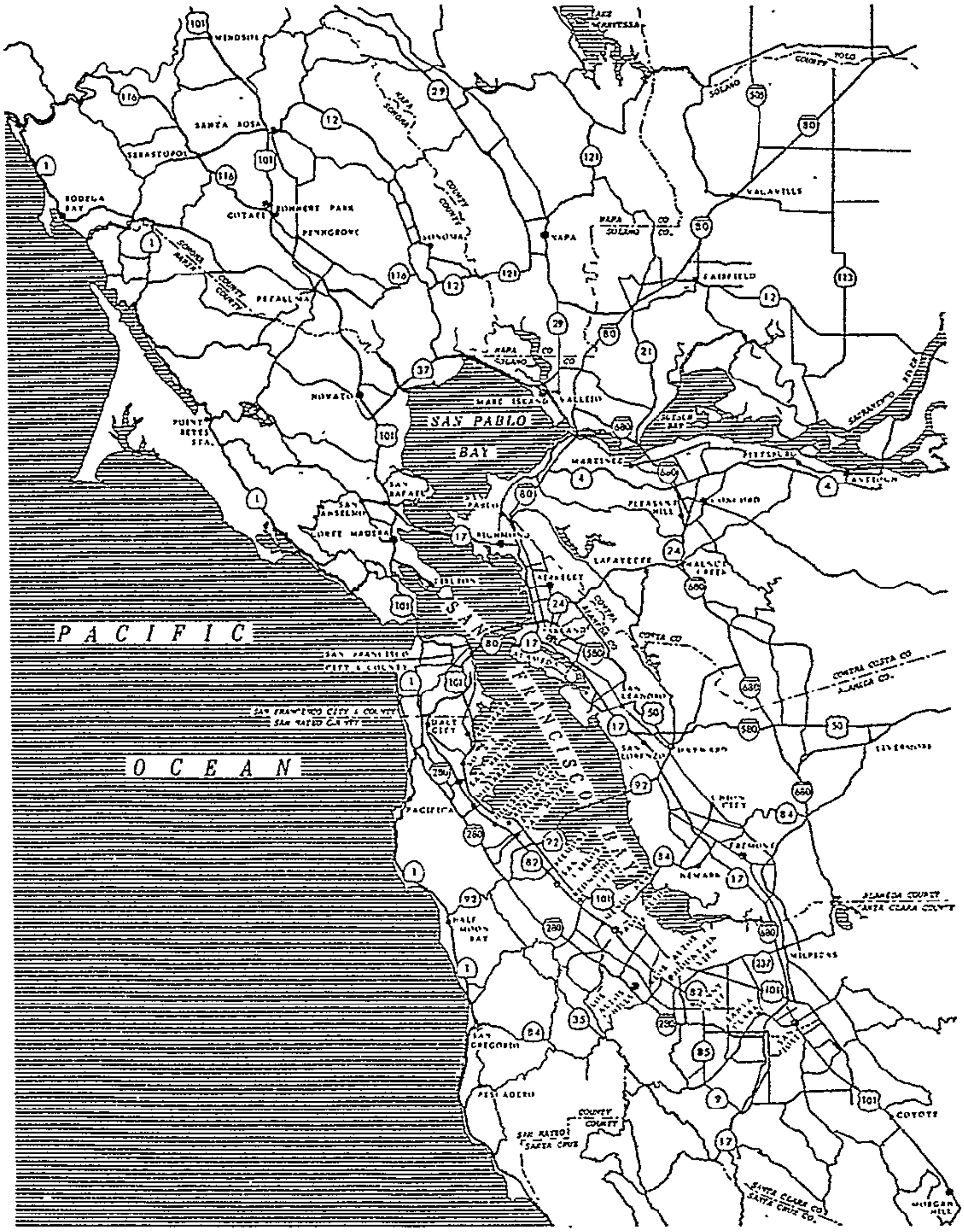


Figure 4

SAN FRANCISCO BAY AREA REGION [7]

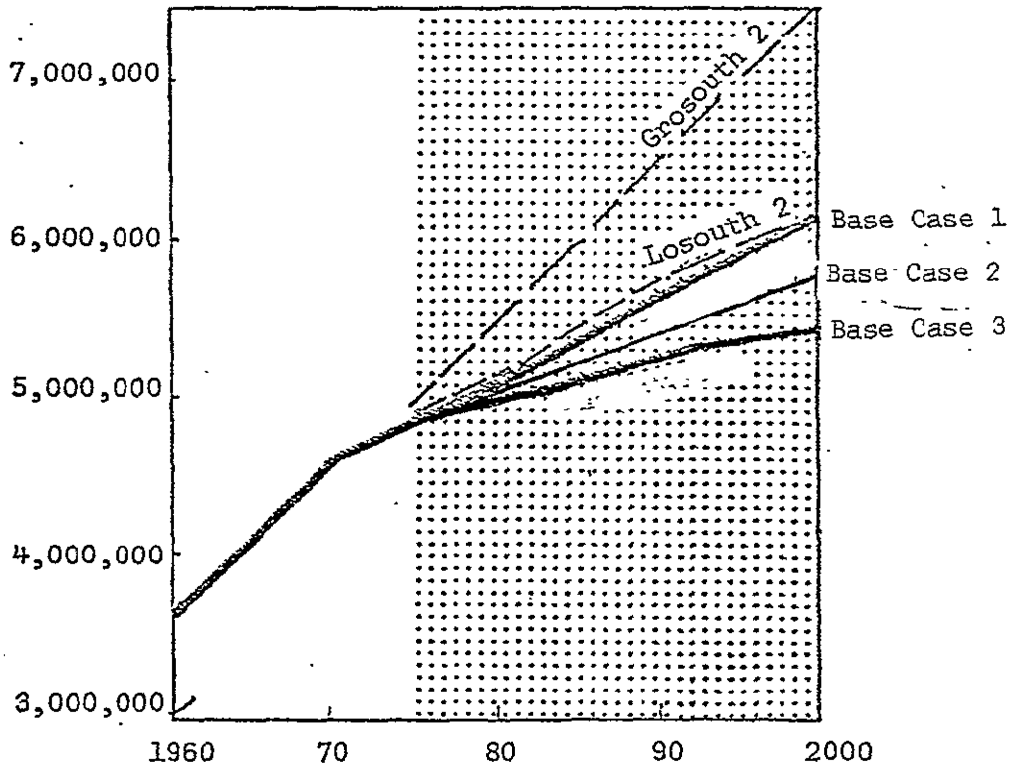
appear in Figures 5 through 7, and are further elaborated on in the text below. Table 1 represents a comparison of PLUM Series 2 data which was used in the early study (NSG-2170[8]) and the PLUM Series 3 data used in this research endeavor.

The PLUM Series 3 Study projects a regional 1990 population ranging from 5.6 million in Base Case 1 to 5.2 million in Base Case 2 with an intermediate value of 5.4 million in Base Case 3, which compares to a 1975 population of 4.8 million. The year 2000 population ranges from a high of 6.1 million for Base Case 1 to a low of 5.4 million for Base Case 2. The 1990 occupied housing units range from 2.36 million in Base Case 1 to 2.34 million in Base Case 2, which shows a growth rate faster than either population or labor force. The 1990 labor force for the region is estimated to grow at a faster rate than total population, ranging from a high of 2.65 million to a low of 2.56 million in Base Case 1 and 2, respectively.[9]

Appendix C contains the PLUM Series 3 data for total population and housing. After examining this data, it becomes apparent that Santa Clara County will show the highest growth with respect to population and housing. Next is Contra Costa County, followed by Alameda, Solano and Sonoma which also represent counties with high growth rates. The counties of Napa, Marin, and San Mateo show slow growth rates with respect to population. San Francisco will continue to lose in population, but will increase in jobs which will result in more work trips.

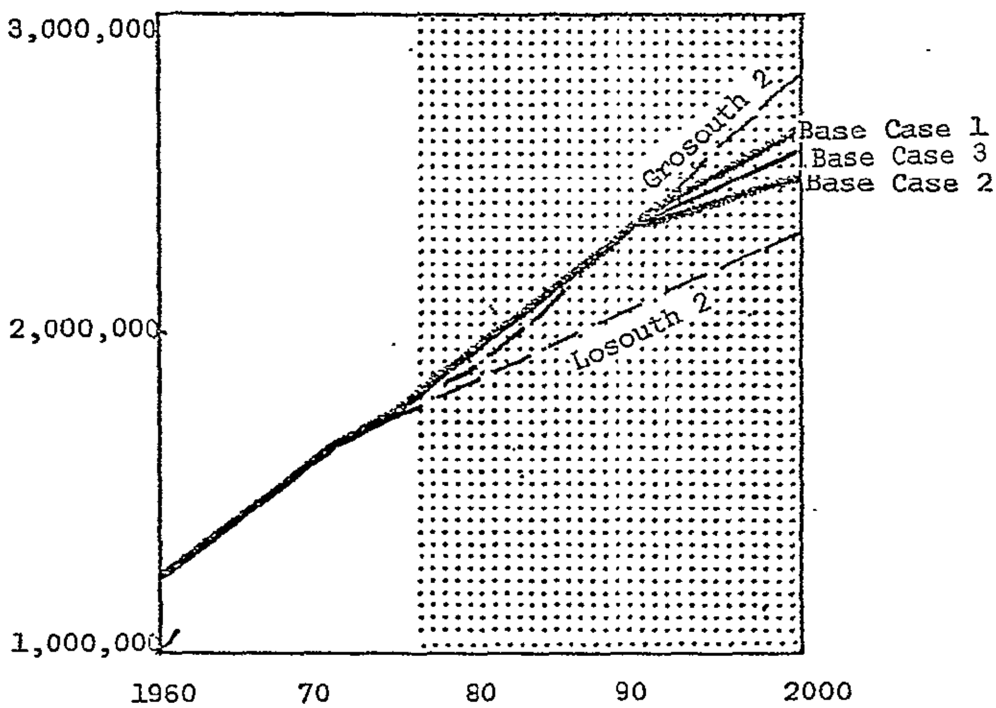
For the region in its entirety, the northern counties of Solano and Sonoma exhibit the fastest growth with respect to housing followed by the Central and then the Southern Counties. The relative rate of growth in

PLUM Series 3 Study Data[10]



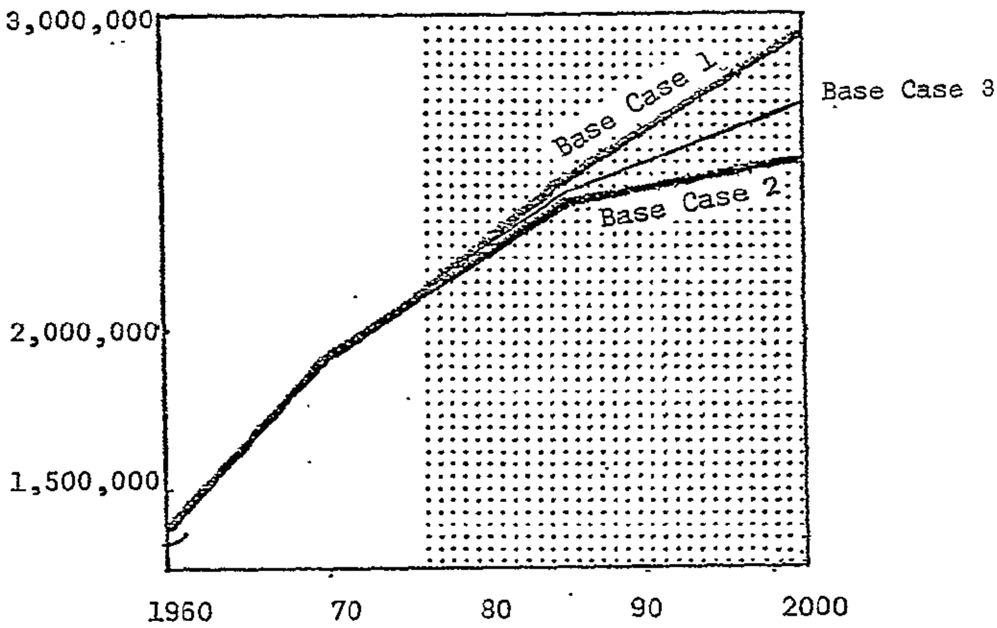
Population: Comparison of Base Cases with Series 2

FIGURE 5



Occupied Housing Units: Comparison of Base Cases with Series 2

FIGURE 6



Projected Regional Employment Growth

FIGURE 7

TABLE 1

A COMPARISON OF REGIONAL PROJECTIONS:[11]
SERIES 2 AND SERIES 3 DATA
(All Data in 1000s)

Projection	Alternative	Year	Population	Occupied Housing Units	Labor Force
Estimate*		1975	4829.2	1768.2	2122.2
Series 3	Base Case 1	1990	5621.9	2363.9	2652.8
	Base Case 2	1990	5283.7	2342.7	2561.6
	Base Case 3	1990	5452.8	2353.3	2607.2
Series 2	Grosouth	1990	6556.7	2370.0	2674.9
	Losouth	1990	5773.4	2112.2	2428.6
	Gronorth	1990	6557.0	2374.9	2675.2
Series 3	Base Case 1	2000	6149.0	2657.8	2953.8
	Base Case 2	2000	5418.6	2506.6	2653.2
	Base Case 3	2000	5783.8	2582.2	2803.5
Series 2	Grosouth	2000	7545.8	2842.9	3229.0
	Losouth	2000	6205.2	2336.7	2743.5
	Gronorth	2000	7546.8	2833.8	3230.1

* Estimate by California Department of Finance (DOF)

Solano County in jobs will not be great, resulting in longer work trips for the residents of this county. Conversely, Santa Clara County will experience a larger projected increase in jobs than in housing, resulting in an increasing number of work trips into the county.

State Space Formulation

As stated previously, one of the principal advantages of the Markovian evaluation methodology is its capability to review various transportation alternatives in light of land use-growth state changes. This allows the execution of a search for the optimal transportation policy under uncertainty. The computational search format is initially developed by structuring the PLUM Series 3 projections to correspond to growth states in the Markovian model. Such a corresponding structure appears in Table 2. Using the notation discussed in Chapter II, the state space exists as S(n), with n = 1, 2, and 3. In this case S(1) corresponds to the states for year 1975, S(2) corresponds to the states for year 1990, and S(3) corresponds to the states for year 2000. The formal states are:

State 1 = Base Case 1

State 2 = Base Case 2

State 3 = Base Case 3

The above set of states are a finite number of mutually exclusive categories which reflect how the system could appear at some point in time. Using this state formulation, the reward matrix and other components of the evaluation computations can be developed in Chapter VI. The forthcoming discussion in Chapters IV and V will address travel demand concerns, and delineation of intra-regional air commuter transportation policy alternatives.

TABLE 2

GROWTH STATES
(all data in 1000's)

S(n)		1975			1990			2000		
Growth States		Population	Occupied Housing	Labor Force	Population	Occupied Housing	Labor Force	Population	Occupied Housing	Labor Force
1	Base Case 1	4829.2	1768.2	2122.2	5621.9	2363.9	2652.8	6149.0	2657.8	2953.8
2	Base Case 2	4829.2	1768.2	2122.2	5283.7	2342.7	2561.6	5418.6	2506.6	2653.2
3	Base Case 3	4829.2	1768.2	2122.2	5452.8	2353.3	2607.2	5783.8	2582.2	2803.5

Footnotes

[1] Computer Programs for Urban Transportation Planning, PLANPAC/BACKPAC, General Information April 1977, U.S. Department of Transportation, Federal Highway Administration.

[2] Summary Report, Provisional Series 3 Projections: Population, Housing, Employment, and Land Uses, San Francisco Bay Region, March 2, 1977, Association of Bay Area Governments, Metropolitan Transportation Commission.

[3] Ibid.

[4] Discussion Paper for Series 3 Base Case Projections, In house paper, Association of Bay Area Governments, January 14, 1976, Stan Hoffman.

[5] Ibid.

[6] Benefit-Cost Evaluation of an Intra-Regional Air Service in the Bay Area, NASA Grant NSG-2170, Period of July 1, 1976 - December 31, 1976, Dr. Lonnie E. Haefner, Principal Investigator, Washington University, January 3, 1977.

[7] Map from Effects of a V/STOL Commuter Transportation System on Road Congestion in the San Francisco Bay Area, by T. F. Kirkwood, October 1972, R-1075-NASA.

[8] Summary Report, Provisional Series 3 Projections: Population, Housing, Employment, and Land Uses, San Francisco Bay Region, March 2, 1977, Association of Bay Area Governments, Metropolitation Transportation Commission.

[9] Benefit-Cost Evaluation of an Intra-Regional Air Service in the Bay Area, NASA Grant NSG-2170, period of July 1, 1976 - December 31, 1976, Dr. Lonnie E. Haefner, Principal Investigator, Washington University, January 3, 1977.

[10] Ibid.

[11] Ibid.

CHAPTER IV

DEMAND MODELLING

CHAPTER IV

DEMAND MODELLING

Overview of Demand Analysis Components

The estimation of person-trip travel demand for a new technology such as STOL requires a slightly different perspective than a travel demand analysis for more traditional modes. In the case study conducted on the San Francisco Bay Area, it was necessary to estimate those existing trips which could be attracted to the air mode. In this chapter discussion will focus on the data bases, estimation of STOL air travel demand, and a preliminary statement with respect to sites served by such a system.

The demand analysis is divided into two major parts. The first part concerns demand for airport feeder service. Airport feeder service is defined as the transport of residents and non-residents from various locations to one of the three regional air carrier airports or vice versa, (i.e., San Francisco International, Oakland International, and San Jose Municipal). The second part of the demand analysis addresses intra-regional daily commuting. As the previous sentence suggests, this concerns the journey-to-work for persons making reasonably long commuter trips.

Preliminary Site Selection

Early in the research, a set of sixteen potential STOL service points were identified in consultation with NASA personnel.[1] As illustrated in Figure 8, these sites are geographically distributed over the entire Bay Area. They include existing general aviation fields, the existing air carrier airports, and several new STOL sites (e.g. Transbay Terminal). The rationale for reviewing sites prior to the demand analysis is that existing

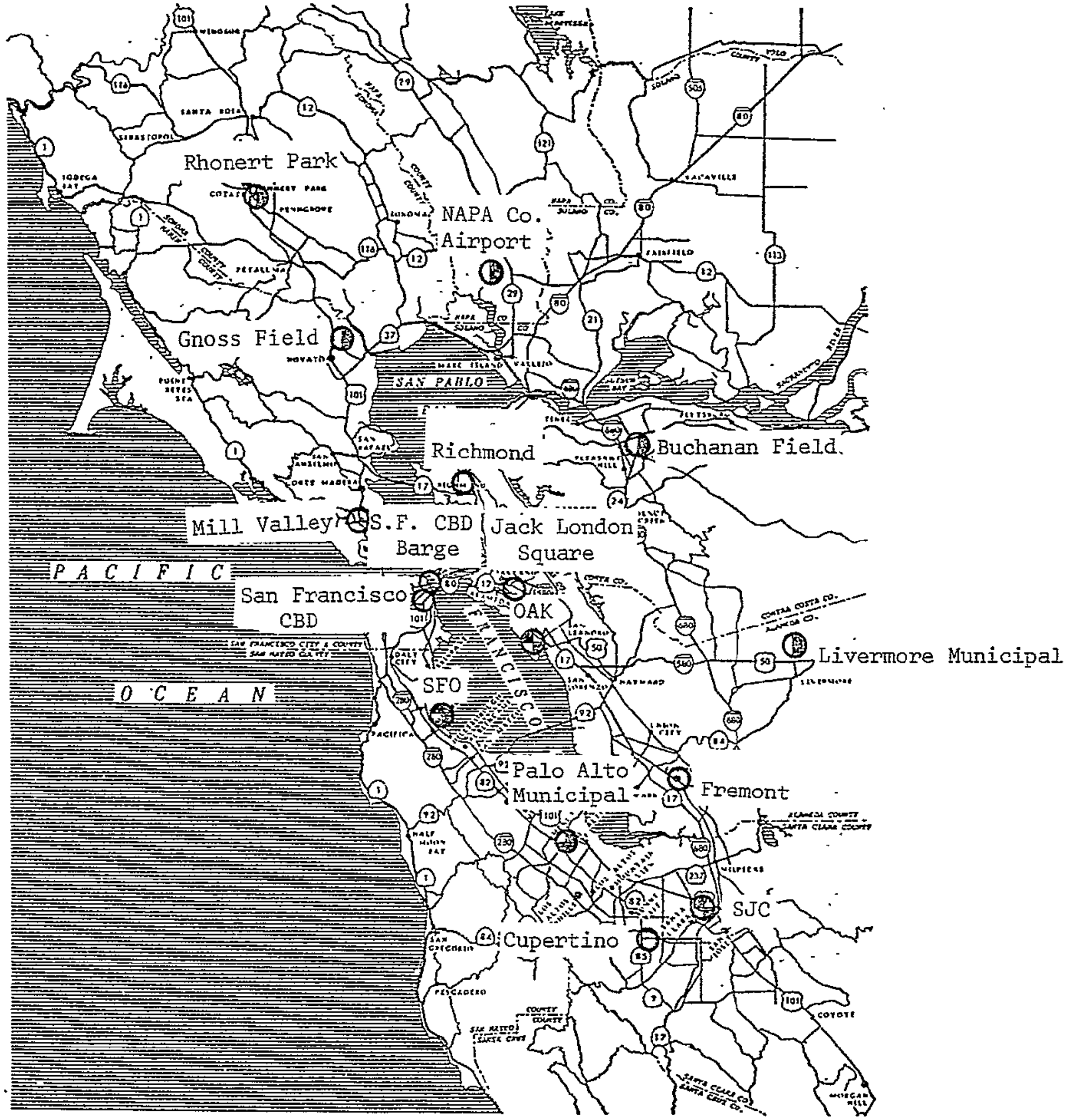


FIGURE 8

ORIGINAL SITES FOR DEMAND ANALYSIS

Major Airports

General Aviation Fields

New Sites

facilities should be used as much as possible in order to reduce the costs and impacts of the air commuter system. The demand analysis eventually eliminated four sites from consideration due to insufficient travel demand. The minimum demand level acceptable is that which would allow two flights each day between a particular origin-destination pair at a load ratio of .5. [2] The following sections cover the detailed methodologies used to estimate airport feeder and air commuter travel demand, concluding with a discussion of the quantitative results of the demand analysis.

Airport Feeder Demand Estimation Methodology

The Airport Feeder Demand Methodology was developed to estimate the number of person-trips that would use STOL from various sites to reach air carrier airports. The process employed is illustrated in Figure 9. The initial step obtained the number of passengers originating or terminating at each of the air carrier airports. This was developed from the 1974 Civil Aeronautics Board Origin-Destination Survey. [3] The next step was to apportion this air travel demand to different final origins and destinations in the Bay Area. The Air Passenger Survey of 1975, facilitated a review of the distribution of air passenger origins and destinations within the Bay Area by county. [4] The percent of air passengers from a particular air carrier airport to a particular county was multiplied by the number of originating and terminating passengers at that airport, yielding the raw passenger volumes by airport by county, as shown in Table 3.

The next computation factors the passengers volumes by an income constraint similar to Eastwood modal split model. [5] It is estimated that 60% of all passengers had incomes in excess of $15,000 annually. [6] This figure

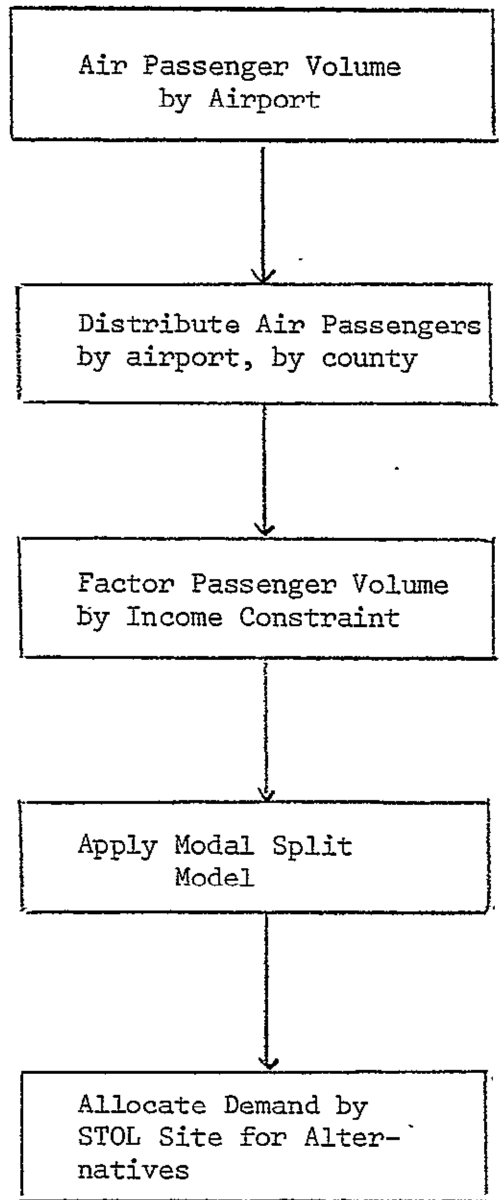


FIGURE 9

AIRPORT FEEDER DEMAND ESTIMATION PROCESS

TABLE 3

AIR CARRIER PASSENGERS ENPLANED IN

THE SAN FRANCISCO BAY AREA, 1974

COUNTY	SFO	SJC	OAK	TOTAL
ALAMEDA	661485	32948	283790	978223
CONTRA COSTA	327108	0	111154	438262
MARIN	392529	0	2035	394564
NAPA	43614	0	2035	45649
SAN FRANCISCO	2965780	0	2035	2967815
SAN MATEO	1388392	21965	0	1410357
SANTA CLARA	872288	296942	0	1169230
SOLANO	159919	0	2035	161954
SONOMA	174457	0	2035	176492
OUTSIDE	283493	54913	2035	340441
TOTAL	7269065	406768	407154	8082987

FY1974 ACTUAL FIGURES

was multiplied by the raw volume to yield a volume for the modal split analysis with the accompanying assumption being that all passengers with incomes in excess of $15,000 annually will be considered as potential air users by the modal split analysis. In excess of 80% of all air passengers use auto as the mode of access.[7] Given that STOL will only attempt to capture those passengers with relatively long airport access trips and higher incomes, its major competitor is the auto mode access.

Subsequently, the air feeder service passengers are allocated to the STOL facilities in each county. Since the number of facilities in each county is different in different air transportation policy alternatives, the following rule was adopted: If only one STOL facility existed in the county, it would receive all passengers who would use STOL. If there were two or more STOL facilities in the county, each would receive an equal share. These assumptions do not adequately account for future shifts in travel demand as non-residential land use ultimately develops around STOL facilities, yielding capability to forecast changes in air feeder demand over time based on land use stimuli for trip making. However, given the stability of present demand data available for the feeder demand estimation portion of the methodology, it was felt accurate to employ such operating rules. Obviously, future operating rules for fractions of demand allocation can be altered as the air passenger survey data base is calibrated into the future.

Air Commuter Demand Estimation Methodology

The air commuter demand estimation component dealt with daily home-based work trips. The primary data source for the analysis was the 1970 Census Urban Transportation Planning Package Commuter Matrix for the

Metropolitan Transportation Commission 440 Zone System. The demand estimation methodology is illustrated in Figure 10. The commuter matrix provides daily home-based work trips between each zone and every other zone in the region. Associated with each STOL service point is a cluster of zones which realistically constitute the site's "demand shed." This demand shed is that set of zones in the vicinity of the STOL site from which the STOL passengers would likely originate from. Operationally, it was assumed that: a) persons would travel no more than 10 miles to get to a STOL site and b) the STOL trip would need to be equivalent to a 30 mile auto trip to be worthy of consideration as a mode choice. Using the above two criteria, zones around each site were selected and the person trips using auto were partitioned into candidate trip volumes for further analysis.

Using the raw demand generated above, an income factor was applied. Again, only those persons earning in excess of $15,000 annually were considered as potential STOL travelers. The trip volumes resulting from this partition are now ready for detailed modal split analysis computation, discussed below.

Modal Split Analysis

The objective of the modal split analysis was to computationally determine the percentage of the candidate group of travellers who would be attracted to using STOL. The modal split model used was of the logit form,[8] where:

$$\Pr(M = 1|ij) = \frac{e^{f(x)} \cdot a}{1 + e^{f(x)} \ a},$$

where $\Pr(M = 1|ij)$ is the probability of choosing mode 1 given a trip from i to j, and f(x) is a stimulus function, and a is a scale factor = .25.

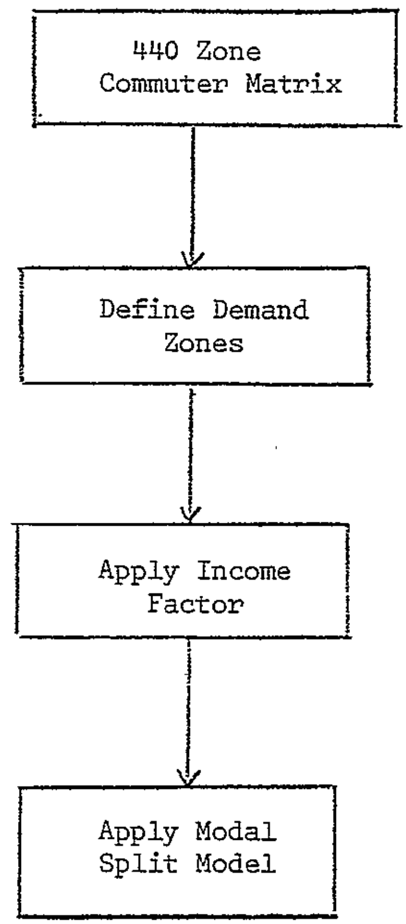


FIGURE 10

AIR COMMUTER DEMAND METHODOLOGY

The stimulus function used is based on differences in travel time and travel cost between air and auto. Using an implied value of time of \$.20/minute travel costs are converted into equivilent minutes of time.[9] Travel time for auto is computed as follows:[10]

$T_a = (D_f/V_f)60 + 5(B) + 5$ where:

D_f is the freeway distance,

V_f is the freeway average speed = 50 MPH,

B is the number of bridges crossed,

and 5 minutes is allowed for egress at the trips end

Travel time for air is as follows:

$T_s = (D_f/V_f)\ 60 + W_i + B_t + T_e$ where:

D_f is the freeway distance to the STOL port,

V_f is the average freeway speed = 50 MPH,

W_i is the ingress waiting time = 5 minutes

B_t is the block time, and

T_e is the egress time from the STOL port to the destination = 5 minutes.

Distance to the freeway is not considered in either case since it was felt to be nearly identical for both auto and air. Distances were measured from the centroid of the county to the nearest STOL facility.

Travel costs for auto were as follows:

$C_a = O_pD_a + P + B$ where

O_p is the per mile perceived operating cost = \$.06/mile,[11]

D_a is the total distance,

P is parking cost as shown in Table 4-B, if used, and

B is the bridge toll, if used = .50.

TABLE 4

TYPICAL CBD PARKING COSTS PER DAY[12]

Location	Cost
San Francisco	\$.75
Oakland	.50
San Jose	.25

Travel cost for air was calculated as below:

C_s = \$.06 D_a + Fare + C_e where:

D_a is total driving access distance,

C_e is cost of transit egress = \$.25, and

Fare = \$2.00 + \$.10(D) where

D is air distance in miles.[13]

Using the above formula for travel time and travel cost, and the \$.20/minute value of time, the equivalent minutes of travel were computed between relevant trip origins and destinations. Modal split percentages for STOL Ports served appear in Appendix E. These percentages tend to be highly in favor of STOL use, because only trips in excess of 30 air miles are under consideration. Appendix F exhibits the figures for equivalent minutes of travel for the modal split calculations.

Results of Demand Analysis

As indicated earlier in this section, 16 sites were originally selected for analysis, illustrated in a preliminary manner in Table 5. Detailed analysis of alternatives and their component sites exists in Chapter V. Quantitative results of the demand analysis developed in this chapter are shown in Table 6 for Alternatives I and III and in Table 7 for Alternative IV. The comprehensive demand results for all 12 relevant alternative sites, origin zones and destination zones are available in Appendix G, separated by air feeder and air commuter component.

These tables show several noteworthy results: First, the sites in the North Bay area provide a significant number of trips to the Oakland and San Francisco CBD areas. In addition, the San Francisco International Airport is a focus of significant demand. As expected, these volumes include mostly airport feeder demand. Three of the South Bay Area sites (San Jose Municipal, Cupertino, and Palo Alto Municipal) failed to produce sufficient demand and were dropped from further consideration. Reasons for this result primarily from San Jose Municipal's position as a local serving air carrier airport for the airport feeder demand, and the relatively close proximity of work and residence for persons living in the South Bay Area. Similar reasons could be cited for the failure of the Richmond CBD site to be included. Its longest distance commuter patterns are well under 30 miles in trip length.

Chapter V will delineate and examine the resulting air commuter alternatives and component sites in detail, prior to evaluation and site specific computation in Chapters VI through IX.

TABLE 5

INTRA-REGIONAL AIR SERVICE ANALYSIS SITES

Alternative I - Low STOL

1. Mill Valley U.S. 101 Causeway near Strawberry Point
2. Rhonert Park - Cotati at U.S. 101 and CA 116
3. NAPA Co. Airport - south of NAPA
4. Buchanan Field - at Concord
5. Livermore Municipal - west of Livermore
6. Oakland International (OAK)
7. San Francisco International (SFO)

Alternative II - Status Quo

Alternative III - Medium STOL

All sites included in Alternative I and

1. Fremont
2. San Francisco CBD - Transbay Terminal
3. Oakland - Jack London Square

Alternative IV - High STOL

All sites included in Alternative III and

1. Gnoss Field - Novato
2. S.F. CBD - World Trade Center - Barge

	Mill Valle	Gnoss	Rhonert Pa	Napa Co.	Buchanan	Richmond	Jack Londo	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trad	Trans Bay
Mill Valley			523	43			91							797		
Gnoss																
Rhonert Park	523													284		28
Napa Co.	43						49	23	23					335		
Buchanan								89	56					589		91
Richmond																
Jack London														317		
Oak				23	89					27				288		
Fremont														341		20
Livermore								27						267		
Cupertino																
Palo Alto																
SFO	797		284	335	589			535		514						
World Trade																
Trans Bay																

Alternative III

Alternative I

Alternatives I and III

TABLE 6
TOTAL DEMAND -
AIR FEEDER + AIR COMMUTER

	Mill Valley	Gnoss	Rhonert Par	Napa Co.	Buchanan	Richmond	Jack London	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trade	Trans Bay	
Mill Valley																	
Gnoss																	
Rhonert Park	523																
Napa Co.	43																
Buchanan																	
Richmond																	
Jack London	91	31		49													
Oak				23	89												
Fremont				23	56												
Livermore								27									
SJC																	
Cupertino																	
Palo Alto																	
SFO	481	375	284	335	589		317	288	341	267							
World Trade					213												
Trans Bay			28		91				20								

Alternative IV

TABLE 7
TOTAL DEMAND -
AIR FEEDER + AIR COMMUTER

Alternative IV

Footnotes

[1]Correspondence with Mr. Mark Waters, NASA-Ames of June 21, 1977.

[2]Approximation from "A Study of Commuter Airline Economics," Summerfield and Associates.

[3]"Origin-Destination Survey of Airline Passenger Traffic," Civil Aeronautics Board, First Quarter, 1975.

[4]"Air Passenger Survey, August 1975," Metropolitan Transportation Commission.

[5]"Operational Evaluation of a Regional Air Transportation System for the San Francisco Bay Area," Stephen Eastwood, Geoffrey Gosling, Mark Waters, September, 1976.

[6]Ibid.

[7]Ibid.

[8]Ibid.

[9]Ibid.

[10]Ibid.

[11]Ibid.

[12]"Immediate Travel Impacts of Transbay BART," Metropolitan Transportation Commission, March, 1975.

[13]op. cit.

CHAPTER V

DEVELOPMENT OF AIR COMMUTER TRANSPORTATION ALTERNATIVES

CHAPTER V

DEVELOPMENT OF AIR COMMUTER TRANSPORTATION ALTERNATIVES

Development of Alternatives

Subsequent to the travel demand analysis of Chapter IV, several final alternative policies for Future Regional Air Commuter Development were formulated in conjunction with certain relevant assumptions concerning the study site. These assumptions are:

1. There is some potential for inter-regional service in addition to travel between San Francisco, Oakland, and San Jose airports. For example, inter-regional service to the possible additional airports of Sacramento, Stockton, Fresno, Monterey, Lake Tahoe, etc.
2. Airport feeder service to Oakland and San Francisco airports are realistic possibilities.
3. Intra-regional air commuting to the San Francisco central business district and to the Oakland central business district from Marin, Solano, Sonoma, Napa, Contra Costa, Alameda, and San Mateo Counties are distinct possibilities.
4. In arriving at costs of a particular air commuter transportation alternative, an estimate can be attained through the synthesis of costs associated with annual maintenance costs, annual terminal costs, aircraft annual recovery costs, direct operating costs of the STOL craft and costs associated with the construction or renovation of airports for STOL aircraft.

Description of the Air Commuter Transportation Alternatives

The air commuter transportation alternatives developed in this research range from the status quo to a high intensity STOL alternative. The following pages contain a narrative description of the alternatives in conjunction with a graphic representation in Figures 11 through 14.

Alternative I - Air Feeder and General Aviation

Major Airports - OAK (Oakland)
SFO (San Francisco)

General Aviation Fields - Rhonert Park
Napa County Airport
Buchanan Field
Livermore Municipal

New Sites - Mill Valley

This alternative, illustrated in Figure 11, incorporates airport feeder services from general aviation fields which include Rhonert Park, Napa County Airport, Buchanan field and Livermore Municipal Airport. In addition, a new site would be constructed in the Mill Valley area near the U.S. 101 Causeway and Strawberry Point. The above five feeder sites would offer connecting STOL flights to San Francisco, and Oakland airports. This alternative relies heavily on existing airports, requiring new site construction at only one location.

Alternative II - Status Quo

Major Airports - Oakland International
San Francisco International
San Jose Municipal

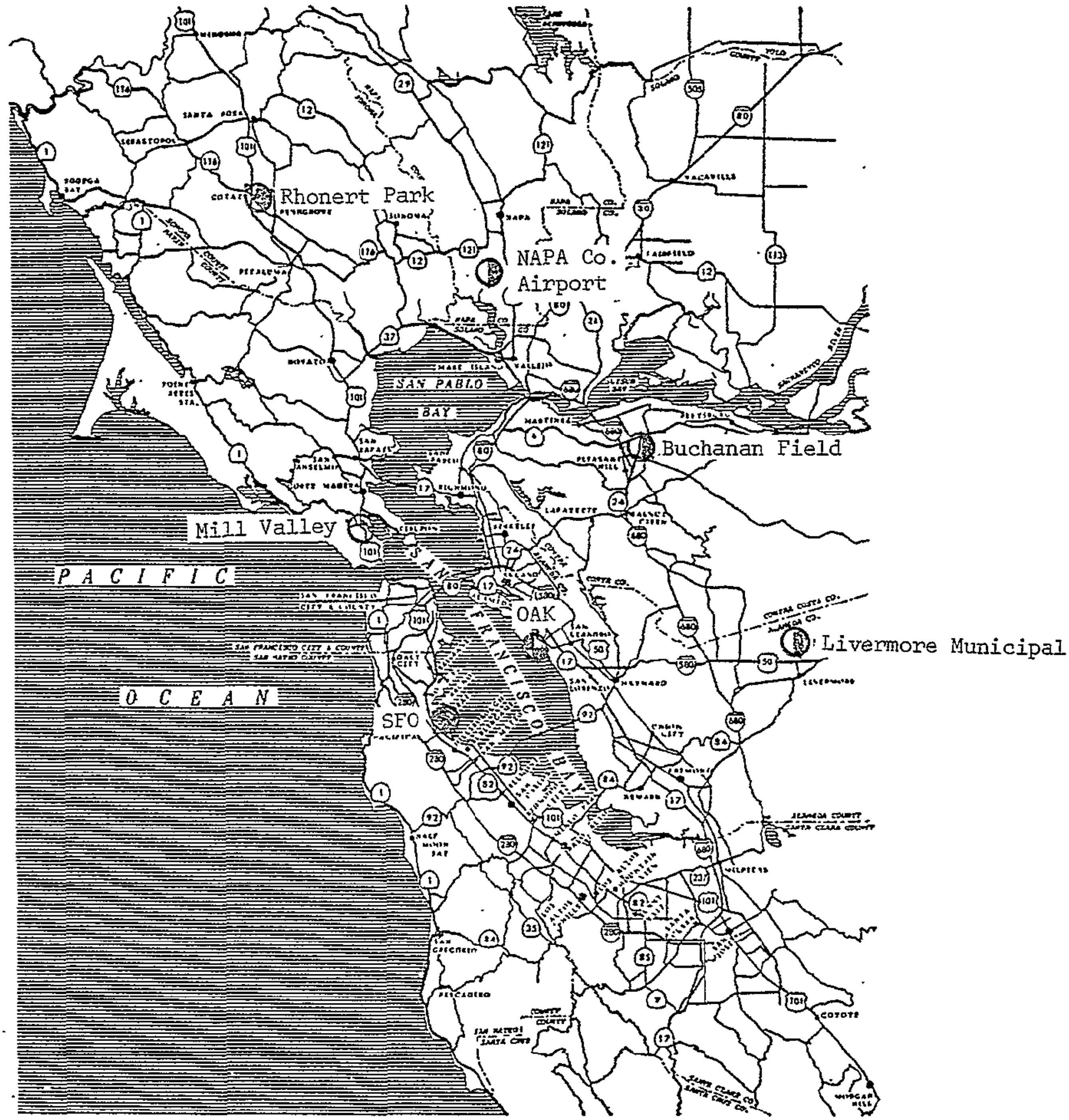


FIGURE 11

ALTERNATIVE I: AIR FEEDER AND GENERAL AVIATION

Major Airports

General Aviation Fields

New Sites

General Aviation Fields - Gnoss Field

Napa County Airport

Buchanan Field

Livermore Municipal

Palo Alto Municipal

This alternative, illustrated in Figure 12, essentially portrays the current conditions of limited and/or non-existent air commuter and air feeder services to San Francisco, San Jose and Oakland Airports.

Alternative III - Low STOL

Major Airports - Oakland International

San Francisco International

General Aviation Fields - Rhonert Park

Napa County Airport

Buchanan Field

Livermore Municipal

New Sites - Mill Valley

San Francisco CBD - Transbay Terminal

Fremont

Oakland - Jack London Square

This alternative, illustrated in Figure 13, includes all of the sites considered in Alternative I as well as new sites at Fremont, Oakland and new Central Business District STOL operations in downtown San Francisco near the Transbay Terminal (See Figure 13).[1] As in Alternative I, the eight feeder sites would offer connecting STOL flights to San Francisco and Oakland airports. This alternative relies more heavily on newly developed STOL ports throughout the region.

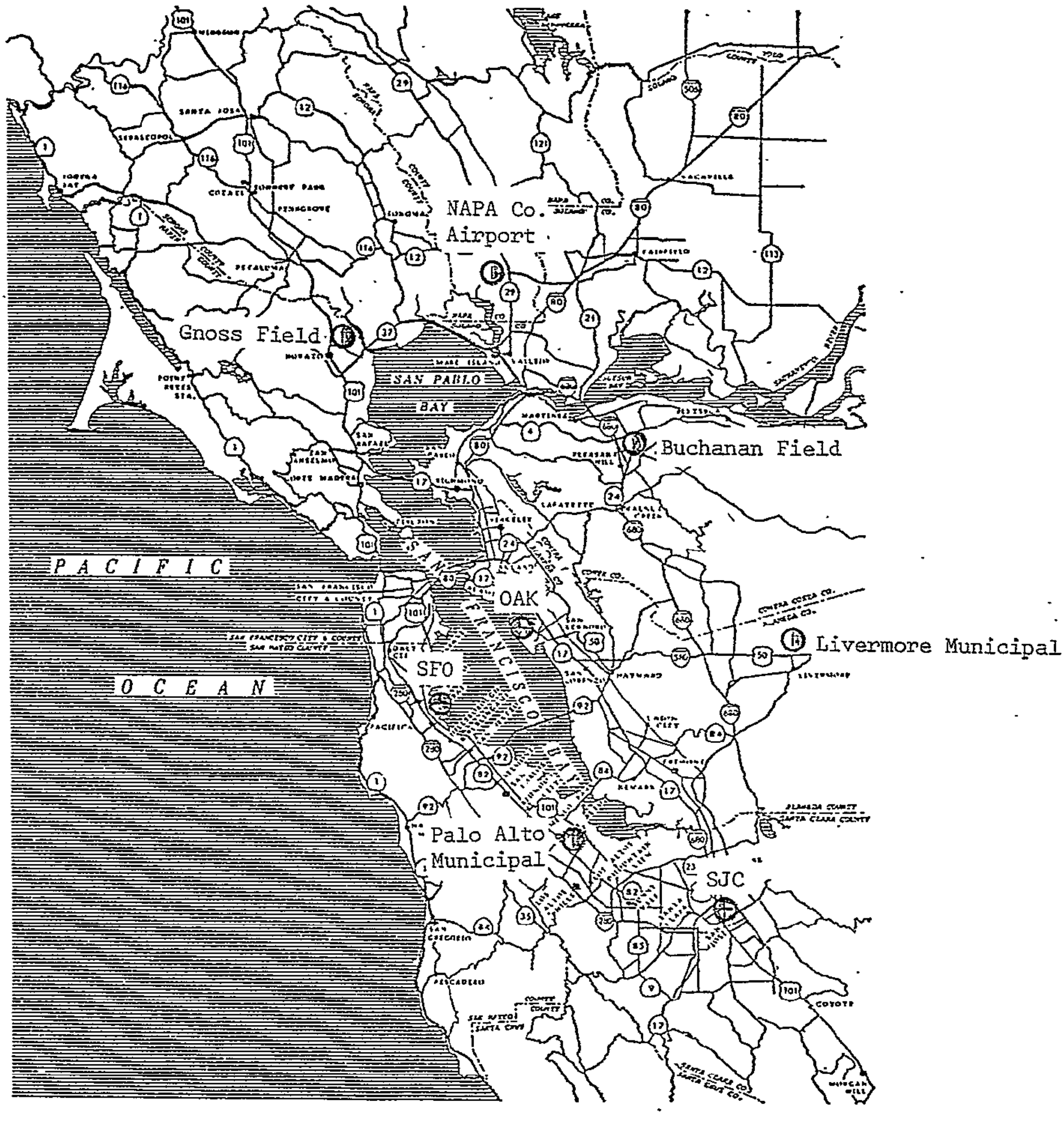


FIGURE 12

ALTERNATIVE II: STATUS QUO

Major Airports

General Aviation Fields

New Sites

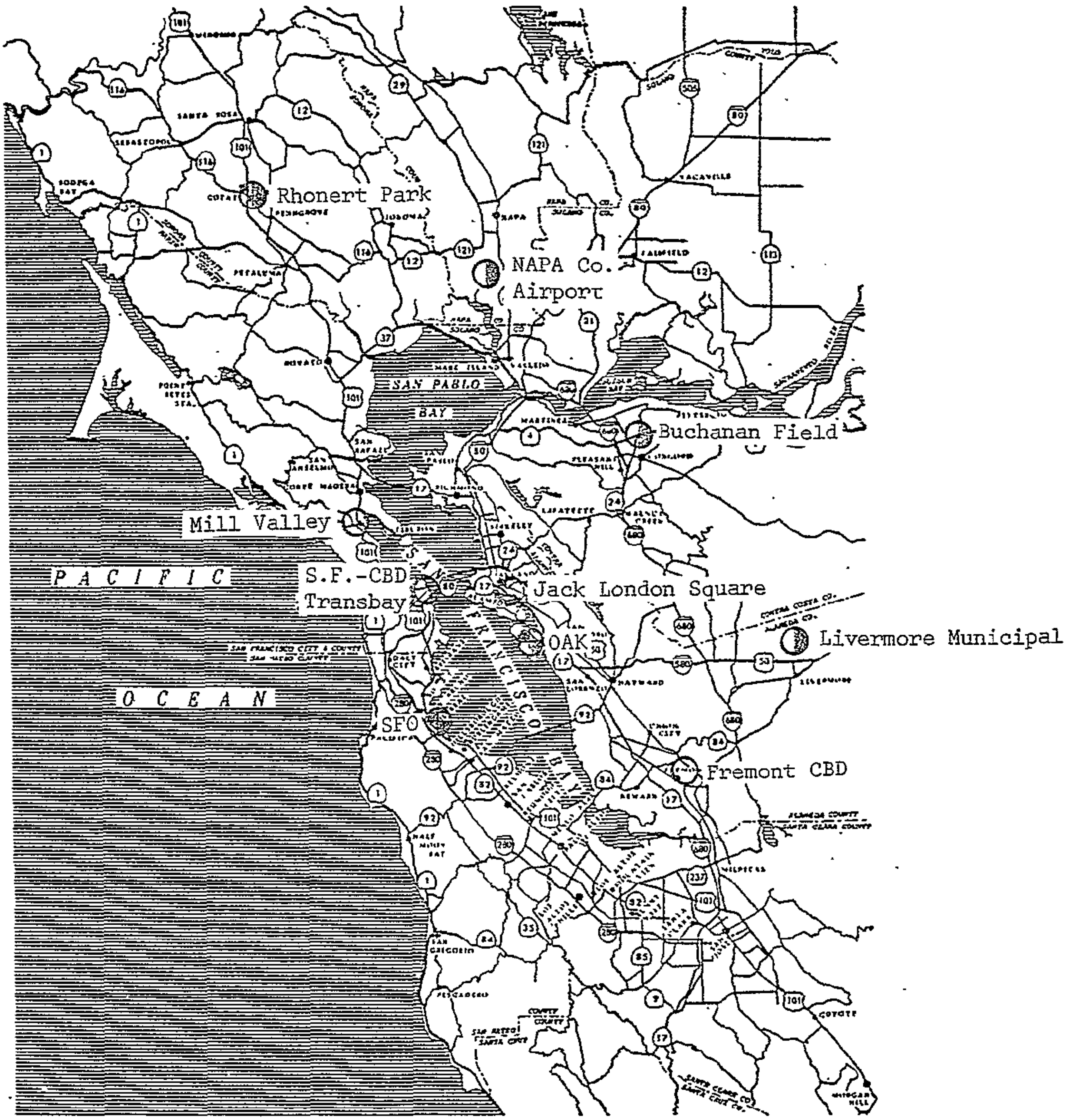


FIGURE 13

ALTERNATIVE III: LOW STOL

Alternative IV - High STOL

Major Airports - Oakland International

San Francisco International

General Aviation Fields - Rhonert Park

Napa County Airport

Buchanan Field

Livermore Municipal

Gnoss Field

New Sites - Mill Valley

San Francisco CBD - Transbay Terminal

Fremont - BART Terminus

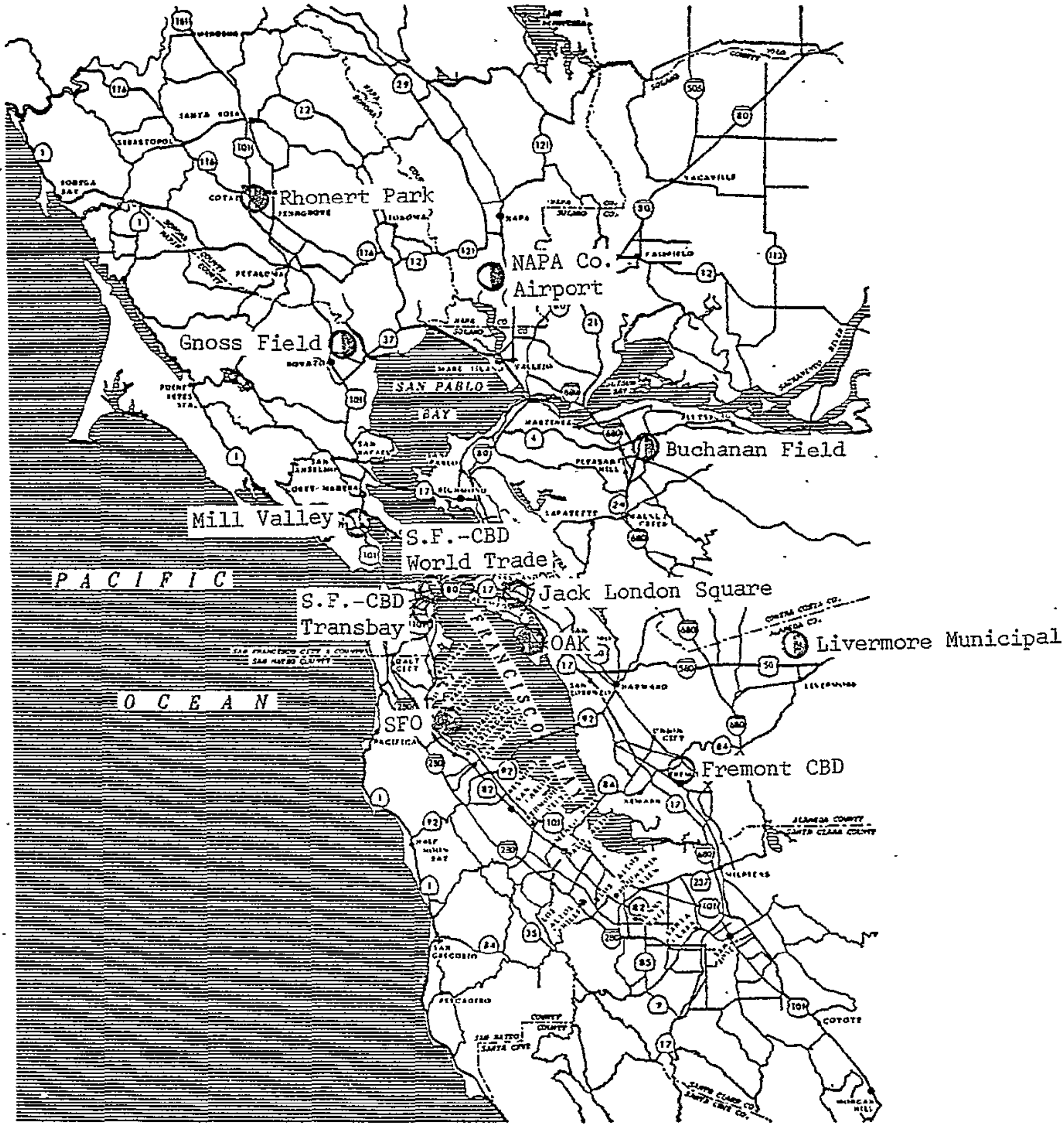
Oakland - Jack London Square

San Francisco CBD - World Trade Center - Barge

This alternative, illustrated in Figure 14, would include all of the sites considered in Alternative III as well as a site at Gnoss Field in Novato. In addition, one other new STOL site in the San Francisco CBD adjacent to the World Trade Center would also be developed for operation. As in Alternatives I and III, the above nine feeder sites would offer connecting STOL flights to San Francisco and Oakland Airports. Obviously, this alternative also relies significantly on new STOL port construction to supplement existing major airports and general aviation fields.

The above air transportation commuter alternatives will now be evaluated in detail using the Markovian decision analysis format presented in Chapter II. Chapters VI through VIII will demonstrate evaluation of the above alternatives at the regional level, while Chapter IX will illustrate the evaluation technique at site selection level of analysis within the city of Fremont, California.

ORIGINAL PAGE IS
OF POOR QUALITY



Major Airports

General Aviation Fields

New Sites

FIGURE 14

ALTERNATIVE IV: HIGH STOL

Footnotes

[1] Operational Evaluation of a Regional Air Transportation System for the San Francisco Bay Area, by Stephen Eastwood, Geoffrey Gosling, Mark Waters, September 1976, NSG-2133.

CHAPTER VI

IMPACT ANALYSIS

CHAPTER VI

IMPACT ANALYSIS

This chapter arrays the monetary and non-monetary impact components of air commuter system investment. Such components become part of the reward matrix in the evaluation model to be demonstrated in the two following chapters. The impact components relevant to the evaluation include alterations in non-residential land value, noise, air pollution emissions and energy differentials. These are structured through two types of evaluation approaches, the Value-Added Approach, and the Value Matrix Approach, to be discussed sequentially with their inputs, in this chapter.

Transition Reward Matrices

The reward matrices for the states of the system reflect the benefits to the region in its transition from state i to j during the specified time interval. The reward matrix is specific to the individual transportation alternatives due to differing costs and beneficial impacts of employing a particular transportation alternative. Notationally we have:

$$R^k = r^k_{ij} \qquad \text{where } i, j = 1, 2, 3$$
$$k = 1, 2, \ldots 4$$

Two alternate appraoches were employed in arriving at the reward values, r^k_{ij}. Each will now be detailed.

Value Added Approach

The transition from state i to j will yield an alteration in dollar value of regional activity. A reasonable surrogate for regional value added is total income generated through addition of non-residential floor space.

Thus, a reward matrix of shifts in regional value added due to the existence of different states and associated transportation alternatives could be developed. Therefore, based on the state characteristics previously detailed, a crude approximate figure can be reached for the additional change in primary monetary effects on the region due to floor space that will be added in each of the states. The second component of r_{ij}^{k} is the capital cost of the transportation alternative, and evaluation of user savings and costs associated with this particular alternative.

Non-Residential Land Use

In order to evaluate the land use component of the regional growth states developed in Chapter III, the commercial and industrial land for all nine counties was calculated as a fraction of projected and existing urbanized land for all three growth states. For the purposes of this analysis, the allocation of land use types within a given urbanized area was developed from a synthesis of studies concerning urbanized area land use, and appears in Appendic B.[1] Given the urbanized land in both the base and projected years, commercial land was found by multiplying urbanized land by a 0.046 factor.[2] Similarly, industrial land was determined via multiplying urbanized land by a 0.060 factor.[3]

Bulk square foot land values ranged from $3.00 per square foot to a high of $15.00 for commercial land,and from $2 to $10 a square foot for industrial land.[4] These values, displayed in Appendix B were a function of both location and supply, and as such, were typical for non-prime sites.

The reward matrix land use component of Table 8 was developed by analyzing the development within each growth state, and from one to another, for all three different growth states. The values were arrived at by taking the improvements in each regional growth state alternative and multiplying these values by the bulk square foot land values for commercial and industrial land.

TABLE 8

LAND USE COMPONENT OF REWARD MATRIX

Growth State	Base Case 1	Base Case 2	Base Case 3
Base Case 1	$7015.95 x 10^6	$-1622.7 x 10^6	$-810.9 x 10^6
Base Case 2	1622.7 x 10^6	5393.5 x 10^6	811.8 x 10^6
Base Case 3	510.9 x 10^6	-811.8 x 10^6	6205.05 x 10^6

The value tabulated in the above table is calculated as below:

ALV = Average Land Value

Value in (1,1) = ALV Base Case 1 - ALV Base Year 75 Data

Value in (1,2) = ALV Base Case 2 - ALV Base Case 1

Value in (1,3) = ALV Base Case 3 - ALV Base Case 1

Value in (2,1) = ALV Base Case 1 - ALV Base Case 2

Value in (2,2) = ALV Base Case 2 - ALV Base Year 75 Data

Value in (2,3) = ALV Base Case 3 - ALV Base Case 2

Value in (3,1) = ALV Base Case 1 - ALV Base Case 3

Value in (3,2) = ALV Base Case 2 - ALV Base Case 3

Air Commuter Transportation Alternative Costs

The commuter transportation alternative costs consist of capital and operating costs, and reflect the airfare revenue generated by each alternative.

The STOL Port construction cost is related to the type of facility needed for each alternative. Such costs include the cost of a new STOL port or barges and/or the renovation of the existing facility for STOL use.[5] The cost is multiplied by a capital recovery factor of .11746, for a 20 year life without major capital remodelling or renovation, at 10% compound interest, to yield the annual cost to recover capital dedicated to the STOL port. The STOL port construction cost does not include real estate, site preparation, demolition and utilities, nor does it inlcude the cost of the external access roads.

The total operating cost (TOC) for each air commuter alternative consists of Direct Operating Cost (DOC) and Indirect Operating Cost (IOC). The DOC cost includes crew cost, fuel and oil cost, vehicle maintenance cost, vehicle insurance costs and vehicle depreciation. The data for Indirect Operating Costs (IOC) are recorded in such diverse ways for each of the commuter airlines reviewed in this research that it has been impossible to make a detailed evaluation of the factors composing such costs. Therefore, a simple assumption was made that the IOC will be .87 percent of the DOC. This assumption is based on scheduled airline data over the last 10 years.[6] The factors making up the IOC are the ground transportation costs (reservation and sales, traffic service, aircraft servicing, landing fees), sales and promotion costs, general and administrative costs, advertising cost, indirect maintenance cost, and transportation related expenses.

The TOC equations used are as follows:[7]

$$TOC_{sc,\ crew} = 1.87(DOC)$$

TOC = total operating cost ($)

DOC = direct operating cost ¢/SM

Sc = Seat capacity

Crew = crew size

ATL = average trip length

SM = number of seat miles flown

$$TOC_{sc,\ crew} = \frac{1.87}{100} (-4.4 (\ln(ATL)) + 33.813)SM$$

$$ATL = \frac{\text{Mile traveled}}{\text{Fleet size}}$$

$$DFR = \frac{\text{No. of Passenger}}{(LF)(SC)}$$, where:

LF = load factor

DFR = No. of flight required

$$\text{Fleet size} = \frac{DFR}{FLPA}$$

where FLPA = flights per aircraft per day, and

$$FLPA = \frac{\text{Util } (60)}{BT + GT}$$, where:

Util = average daily utilization - hours

BT = average block time - minutes

GT = average gate time - minutes

SM = (DFR)(SC)(ALT)260 per year

The TOC analysis is based on 20 seat passenger capacity aircraft[8] and considers system economics for flight crew of two. A target load factor of 50%, along with an average gate time of seven minutes and an average daily utilization of six hours per aircraft is used as the basis for the fleet size estimate.[9]

Air fare revenue generated by each alternative is based on ($2 + .10D), where D is distance per nautical miles of air travel.[10] The minimum average airfare per passenger is $4.00. Development of these cash flow parameters utilized an interest rate of 10% and a ten year incremental cash flow. Table 9 illustrates the total operating cost for each air transportation commuter alternative. The STOL port annual recovery cost was added to the above table and multiplied by a uniform series compound amount factor of 15.94 (F/A, 10 years, 10%) to convert the cash flow for the air commuter transportation alternatives to appropriate inputs for the Markov Reward Matrix. The results are shown in Table 10, with detailed components existing in Appendix L.

Value Added Reward Matrices

The formulation of the reward matrices, $R^k_{..}$, for the value added approach consisted of combining the two components just described. Therefore, the element:

$$r^k_{ij} = v_{ij} - c^k$$

where: v_{ij} = \$ value generated through change in non-residential construction.

c^k = ten year average cost of alternative k.

i,j = 1, 2, 3, the regional growth states

k = 1, 2, . . .4, the transportation alternatives

The Markovian solution for the model was carried over two ten year iterations to be compatible with the 20 year transportation planning horizon used in the case study area. Tables 11 through 14 are presented as the single step transition reward matrices for each of the transportation alternatives. For example, the element

$$r^k_{ij} = r^1_{12}$$

TABLE 9

TRANSPORTATION ALTERNATIVE

FLEET TOTAL OPERATING COST

Alternative	Total Operating Cost
I	$21.62 x 10^6
II	0.00*
III	$33.95 x 10^6
IV	$38.38 x 10^6

* Null Alternative

TABLE 10

COMPREHENSIVE AIR COMMUTER TRANSPORTATION ALTERNATIVE COSTS

Transportation Alternative	Cost ($ x 10^6)
I	$285.49
II	0.0*
III	484.42
IV	541.96

*Null Alternative

TABLE 11

REWARD MATRIX, ALTERNATIVE I

Growth State	1	2	3
1	6730.46	-1908.2	-1096.4
2	1337.2	5107.9	526.3
3	525.5	-1097.3	5919.6

$\$ \times 10^6$

TABLE 12

REWARD MATRIX, ALTERNATIVE II

Growth State	1	2	3
1	7016.0	-1622.7	-810.9
2	1622.7	5393.25	811.8
3	810.9	-811.8	6205.1

$\$ \times 10^6$

TABLE 13

REWARD MATRIX, ALTERNATIVE III

Growth State	1	2	3
1	6531.5	-2107.12	-1295.32
2	1138.29	4908.83	327.38
3	326.5	-1296.3	5720.63

$\$ \times 10^6$

TABLE 14

REWARD MATRIX, ALTERNATIVE IV

Growth State	1	2	3
1	6474.0	-2164.7	-1352.86
2	1080.74	4851.3	269.84
3	269.0	-1353.75	5663.0

$\$ \times 10^6$

The elements, r_{ij}^k reflect the rewards accuring to the study region as a result of the state transition from state i to state j by a transportation alternative k.

can be found in Table 11, Reward Matrix, Alternative 1. Here, the reward is found to be

$$r^1_{12} = -1622.7 \times 10^6 - 285.49 \times 10^6 = -1908.19 \times 10^6$$

where

$$V_{ij} = V_{12} = -1622.7 \times 10^6 \text{ from Table 8}$$

$$C^k = C^1 = 285.49 \times 10^6 \text{ from Table 10}$$

There is a significant interpretation with respect to these r^k_{ij} values. The elements r^k_{ij} represent the benefits accruing to the system for the state transition. As a result, they incorporate the land use transition benefits from state i to j, as well as the costs of providing the transportation alternative k.

Value Matrix Approach

This section develops an alternative approach to r^k_{ij} formulation, to incorporate social and environmental concerns, along with regional economic wealth criteria in the analysis. Noise, air pollution, energy cost and regional value added related to the airport operations are the concern of many communities residing nearby. The above are each evaluated separately, than synthesized into a Markov Reward Matrix.

Noise Impact and Evaluation

The evaluation of the effect of noise on people has been accomplished by employing the delineation of noise countours by Noise Exposure Forecast (NEF).[11] This method employs the Effective Preceived Noise Level as the aircraft noise measurement units using the following formulas:[12]

$$NEF = EPNDB + 10 \log_{10} N_f - 88$$

where

NEF = Noise Exposure Forecast

EPNDB = The preceived noise level

NF = number of day-time operation + 16.7 number of night-time operation

Along with the above formula, the following assumptions were made:[13] (It is generally accepted that land areas exposed to less than 15 NEF will not be affected by noise.)

15 NEF	0% people annoyed
30 NEF	30% people annoyed

By employing the above formulas, the EPNDB for each site is determined. The EPNDB contours were used in conjunction with U-2 maps of each site to bound and delineate the areas exposed to NEF greater than 15. The number of households and dwelling units per acre were counted and two further assumptions were made:[14]

1.) 4 persons per household

2.) 25 dwelling units per acre, 2.5 persons per unit

Specific to the air commuter alternatives, the number of people affected by noise for each site was calculated. Table 15 illustrates the results. The values indicated in this table are somewhat of an overstatement, in that calculations proceed as if there were no existing airports in the vicinity of the recommended sites. In fact, some of the airport sites are already in existence (SFO, Oakland, Livermore, etc.), and are presently contributing to the people annoyance; therefore, the actual number of people impacted by STOL operation will be less than indicated in Table 15.

TABLE 15

TRANSPORTATION ALTERNATIVE NOISE IMPACT

Transportation Alternative	Number of People Impacted
I	12332.0
II	0*
III	19256.0
IV	23736.0

* Null alternative

Air Pollution Emissions Differentials

Concurrent with the estimation of commuter air travel demand in Chapter IV, the air pollutant emission factors provided by EPA were reviewed. and auto emissions reduction due to employment of an air commuter system was obtained.[15]

The demand information based on O-D data yielded the number of people using the airport. The average trip length per vehicle was calculated, and the following characteristics affecting emissions were assumed:[16]

1.	average speed	45 mph
2.	average vehicle occupancy for weekday trip	1.45
3.	average distance to STOL port	5.0 miles
4.	percent cold operation	0%
5.	ambient temperature	75 F

The demand information in conjunction with the above assumptions allowed calculation of region wide alteration in Vehicle Miles Traveled (VMT), associated with air-commuter transportation trips for each of the alternatives. The emission factros were applied to the altered VMT, to yield the emissions impact shown in Table 16.

Energy Differential

As previously illustrated, the calculation of emission impacts is based on O-D data and altered VMT (vehicle miles of travel). Likewise, by using appropriate assumptions with respect to fuel consumption (15 miles per gallon) and its average price (68¢ per gallon), the auto transportation energy and associated cost savings are determined as follows, and shown in Table 17.

$$\text{Auto transportation energy saved, gallons per day} = \frac{\text{VMT saved (miles)}}{\text{15 miles per gallon}}$$

Associated auto operating cost savings in dollars =

(energy saved in gallons/day) ($.68/gallon)

TABLE 16

REDUCTION IN EMISSIONS DUE TO EMPLOYMENT OF AN AIR TRANSPORTATION COMMUTER ALTERNATIVE

gram/day x 10^6

Alternative	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides	Particulates	Sulfur Oxides
I	11.78	1.86	3.16	.24	.091
II	0.0	0.0	0.0	0.0	0.0
III	13.63	2.15	3.66	.275	.105
IV	14.85	2.34	4.0	.3	.11

TABLE 17

EVALUATION OF AUTO ENERGY DIFFERENTIALS

DUE TO PRESENCE OF AIR COMMUTER OPTIONS

Alternative	Energy Saved gallon/year	Cost Savings $ per year
I	6.85×10^6	4.67×10^6
II	0.0	0.0*
III	7.93×10^6	5.39×10^6
IV	8.64×10^6	5.87×10^6

* Null alternative

Synthesis of the above Impacts into the Value Matrix Approach

In the value matrix approach, first each alternative is ranked according to its attainment of a certain impact, i.e. capital cost, noise pollution, auto energy differentials, etc. Each alternative received a value of 1 through 4 depending on its position relative to the other alternatives under consideration.

Next, the impact factors are weighted for each state of the system. This is necessitated by the fact that certain impacts are of greater consequence for various system states.

Each transportation alternative is then given a score based on the rank value and associated wieght. This score is determined by:

$$\text{score}_i\ k = \sum_{x=1}^{m} r^k\, w_x$$

where

i = system state, i = 1, 2, 3,

k = transportation alternative k = 1, 2, . . .4

r^k = rank value of that alternative

w_x = weight of that impact

x = number of impacts, x = 1, 2 . . .,5

The ranking of the transportation alternatives was completed in the following manner. Each alternative was given a number 1 through 4 with the higher numeric values corresponding to that alternative with the most beneficial impact. Table 18 is presented as the ranking of the various alternatives for each of the impact factors. The alternative with the least capital cost was given a rank of 4 while the most expensive alternative received a rank of 1.

TABLE 18

RANKING OF ALTERNATIVES, VALUE MATRIX ON IMPACTS

	Transportation Alternative, k			
Impact Factor, x	1	2	3	4
Capital Cost	3	4	2	1
Noise	3	4	2	1
Pollution	2	1	3	4
Energy Cost	2	1	3	4
Regional Value Added	2	1	3	4

Note: The transportation alternatives were ranked by impact factor, with the highest ranks associated with the alternative maximizing the relevant impact.

The transportation alternatives were ranked for the regional value added impact factor previously illustrated in Table 18 via considerations of the steady state transition probabilities and the commercial and industrial land development for each state. For each alternative, the regional value added is an expected value, defined by

$$E(rv^k) = \sum_{L=1}^{3} \pi_L^k \; (rv_i)$$

where

$E(rv^k)$ = expected regional value added

π_i^k = steady state probability, state i, alternative k

rv_i = regional value added, state i.

Tables 19 through 21 are three sets of weights associated with each imapct for each growth state. These tables were developed via consideration of three different weighting schemes for each growth state. The schemes in Tables 19 and 20 consist of weighting the capital related impacts low while considering a higher importance for the environmental impact, and vice versa. Table 21 presents a compromised weighting scheme using Table 19 and 20.

With the relevant transportation alternative rank and the impact factor weightings, values for the score $_i^k$ can be calculated for all three weighting schemes as previously described and are presented in Tables 22 through 24. For example,

$$\text{score}_i^k = \text{score}_1^1$$

TABLE 19

FACTOR WEIGHTING BY REGIONAL GROWTH STATE

ENVIRONMENTALLY SENSITIVE PREFERENCE SCHEME

	Regional Growth States, i		
Impact Factor, x	1	2	3
Capital Cost	5	3	3
Noise	1	4	1
Pollution	2	5	2
Energy Cost	4	1	4
Regional Value Added	3	2	5

TABLE 20

FACTOR WEIGHTING BY REGIONAL GROWTH STATE

DEVELOPMENT ORIENTED PREFERENCE SCHEME

	Regional Growth States, i		
Impact Factor, x	1	2	3
Capital Cost	1	5	2
Noise	4	1	4
Pollution	5	2	5
Energy Cost	3	3	3
Regional Value Added	2	4	1

TABLE 21

FACTOR WEIGHTING BY REGIONAL GROWTH STATE

COMPROMISE REGIONAL PREFERENCE SCHEME

	Regional Growth States, i		
Impact Factor, x	1	2	3
Capital Cost	2	4	1
Noise	3	2	3
Pollution	4	3	4
Energy Cost	5	1	5
Regional Value Added	1	5	2

Note: The impact factors are weighted by the importance each impact bears to the regional growth state with a weight 5 associated the most important, etc.

TABLE 22

VALUE MATRIX SCORES, BY TRANSPORTATION ALTERNATIVE, BY REGIONAL GROWTH STATE — ENVIRONMENTALLY SENSITIVE WEIGHTING SCHEME

	Transportation Alternative			
Regional Growth State	1	2	3	4
1	36	33	39	34
2	37	36	38	39
3	34	27	41	48

TABLE 23

VALUE MATRIX SCORES, BY TRANSPORTATION ALTERNATIVE, BY REGIONAL GROWTH STATE - DEVELOPMENT ORIENTED WEIGHTING SCHEME

	Transportation Alternative			
Regional Growth State	1	2	3	4
1	35	30	40	45
2	36	33	39	42
3	36	33	39	42

TABLE 24

VALUE MATRIX SCORES, BY TRANSPORTATION ALTERNATIVE, BY REGIONAL GROWTH STATE - COMPROMISED WEIGHTING SCHEME

	Transportation Alternative			
Regional Growth State	1	2	3	4
1	35	30	40	45
2	36	25	39	42
3	34	27	41	48

Note: The score $_{i}^{k}$ (i = regional growth state, k = transportation alternative value represents the aggregate benefits by impact factor for each regional growth state by transportation alternative.

is the score for transportation alternative one, general aviation and feeder service under the regional growth state 1, Base Case I. Here,

$$\text{Score}\ {}^{1}_{1} = \sum_{x=17}^{5} r^{k}\ w_{x}$$

$$= (3)\ (5) + (3)\ (1) + (2)\ (2) + (2)\ (4) + (3)\ (2)$$

$$= 15 + 3 + 4 + 8 + 6$$

$$\text{Score}\ {}^{1}_{1} = 36$$

Reward matrices R^{k}_{ij} are then calculated. Here r^{k}_{ij} is defined by:

$$r^{k}_{ij} = (\text{score}\ {}^{k}_{j}) - (\text{score}\ {}^{k}_{i}) \qquad i \neq j$$

and by

$$r^{k}_{ij} = \text{score}\ {}^{k}_{i} \qquad\qquad i = j$$

with the terms as defined previously.

Tables 25 through 28, 29 through 32 and 33 through 36 present the r^{k}_{ij} values for this reward matrix and are associated with tables 22, 23, and 24 respectively. For example, from Table 25 the value

$$r^{k}_{ij} = r^{1}_{11} = 36$$

is calculated by the equation

$$r^{1}_{11} = \text{score}\ {}^{1}_{1} \qquad \text{for } i = j$$

$$= 36$$

while for

$$r^{k}_{ij} = r^{1}_{12} = 1$$

REWARD MATRICES

ENVIRONMENTALLY SENSITIVE WEIGHTING SCHEME

Growth State	1	2	3
1	36	1	-2
2	-1	37	-3
3	2	3	38

TABLE 25 REWARD MATRIX, ALTERNATIVE I

Growth State	1	2	3
1	33	-3	-6
2	3	36	-9
3	6	9	27

TABLE 26 REWARD MATRIX, ALTERNATIVE II

Growth State	1	2	3
1	39	-1	2
2	1	38	3
3	-2	-3	41

TABLE 27 REWARD MATRIX, ALTERNATIVE III

Growth State	1	2	3
1	34	5	14
2	-5	39	11
3	-14	-11	48

TABLE 28 REWARD MATRIX, ALTERNATIVE IV

REWARD MATRICES

DEVELOPMENT ORIENTED WEIGHTING SCHEME

Growth State	1	2	3
1	35	+1	+1
2	-1	36	0
3	-1	0	36

TABLE 29 REWARD MATRIX, ALTERNATIVE I

Growth State	1	2	3
1	30	+3	3
2	-3	33	0
3	-3	0	33

TABLE 30 REWARD MATRIX, ALTERNATIVE II

Growth State	1	2	3
1	40	-1	-1
2	+1	39	0
3	+1	0	39

TABLE 31 REWARD MATRIX, ALTERNATIVE III

Growth State	1	2	3
1	45	-3	-3
2	3	42	0
3	3	0	42

TABLE 32 REWARD MATRIX, ALTERNATIVE IV

REWARD MATRICES

COMPROMISED WEIGHTING SCHEME

Growth State	1	2	3
1	35	1	-1
2	-1	36	-2
3	1	2	34

TABLE 33 REWARD MATRIX, ALTERNATIVE I

Growth State	1	2	3
1	30	-5	-3
2	5	25	2
3	3	-2	27

TABLE 34 REWARD MATRIX, ALTERNATIVE II

Growth State	1	2	3
1	40	-1	1
2	1	39	2
3	-1	-2	41

TABLE 35 REWARD MATRIX, ALTERNATIVE III

Growth State	1	2	3
1	45	-3	3
2	3	42	6
3	-3	-6	48

TABLE 36 REWARD MATRIX, ALTERNATIVE IV

is calculated via the relation

$$r^1_{12} = \text{score}\ ^1_2 - \text{score}\ ^1_1 = 37 - 36$$
$$= 1$$

The elements, r^k_{ij} of the reward matrices R^k based on the value matrix formulation reflect the benefits accruing to the system for each state transition and are unique for each transportation alternative. The following chapter will formulate the inputs to the transition probability matrices, which, in conjunction with the reward information in this chapter, will be synthesized in the evaluation format of Chapter VIII.

Footnotes

[1]Summary Report, Provisional Series 3 Projections: Population, Housing, Employment, and Land Uses, San Francisco Bay Region, March 2, 1977, Association of Bay Area Governments, Metropolitan Transportation Commission.

[2]Principles and Practice of Urban Planning, Editor William I. Goodman and Eric C. Freund for the International City Managers Association.

[3]Ibid.

[4]Lynn Roadik, Real Estate Associate, Allied Brokers, Fremont, California. Curt Diesner, John Houlihan, Co. appraisers San Francisco, California.

[5]Operational Evaluation of a Regional Air Transportation System for the San Francisco Bay Area, by Stephen Eastwood, Geoffrey Gosling, Mark Waters, September 1976, NSG-2133.

[6]Ibid.

[7]Ibid.

[8]Ibid.

[9]Ibid.

[10]Ibid.

[11]Data provided by Mark Waters, NASA Ames.

[12]Planning and Design of Airports, by Robert Horonjeff, second edition, 1975.

[13]op. cit. Footnote No. 11.

[14]Bay Area Transportation Report, prepared by Bay Area Transportation Study Commission, May 1969.

[15]Supplement No. 5 For Compilation of Air Pollutant Emission Factors, U.S. Environmental Protection Agency, December 1975.

[16]Ibid.

N/C

CHAPTER VII

GROWTH STATE TRANSITION PROBABILITIES

CHAPTER VII

GROWTH STATE TRANSITION PROBABILITIES

This chapter illustrates the stochastic inputs for the evaluation methodology, which consist of the single step transition probabilities for the Markov process. The determination of these probabilities are critical to the analysis, and reflect professional evaluation of the land use and transportation issues of the Bay area. After a brief discussion of the transition probabilities, an analysis of such issues will be overviewed.

Stochastic Inputs

The matrix of transition probabilities, P_{ij} is composed of the probabilities of the system, i.e., the region's land use pattern, currently in state i, moving to state j, the same or different land use patterns in the next transition. For example, for i = 1, the Base Case I land use pattern and j = 3, the Base Case III land use pattern, P_{13} represents the probability there will be a change or shift in land use patterns from 1 to 3 over the next transition period. Also if i = j = 1, then P_{11} would indicate the probability the land use pattern would remain unchanged during this transition period.

Here, the transition time period is ten years, which reflects the time span required for land use patterns to develop recognizable shifts which have regional growth implications. Thus the P_{ij} matrix exists for each alternative and is a stochastic matrix. We have

$$P^k = P_{ij}^k$$

where k = 1, 2, . . .4 for the four alternatives under study and i, j = 1, 2, 3 for the three different growth states. This reflects the inherent degree of association of changes of regional growth patterns by virtue of employment of particular types of transportation investment, and the classic land use--transportation feedback mechanism. Tables 37 through 40 present the single step transition probabilities for each of the four alternatives. As illustrated, these subjective probabilities show a long-run tendency to shift toward Base Case I (high growth dominant). The values in the P_{ij} matrix reflect historical and research knowledge of the effect a particular transportation system has on land use patterns, as well as prevailing and likely future trends in regional land use.

Concurrent with the above, a sensitivity analysis was done by developing two more sets of single step transition probabilities for each of the four alternatives. This sensitivity analysis is critical to establishing bounds on dominance of a particular air commuter transportation alternative as the potentials for land use shift change. Hence, exhibiting a meaningful sensitivity array of sets of transition probabilities is important in this chapter, to insure a base for accurate and comprehensive evaluation in the next chapter.

In the first set below the assumption was made that the growth states will ultimately shift toward Base Case 2 (low growth dominant), while the second set considered the liklihood of a shift of growth states toward Base Case 3 (medium growth dominant) over the planning horizon period. Results are illustrated in Tables 41 through 44, and 45 through 48 respectively.

HIGH GROWTH DOMINANT

Growth State	1	2	3
1	.45	.20	.35
2	.25	.45	.30
3	.30	.30	.40

TABLE 37 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE I

Growth State	1	2	3
1	.20	.50	.30
2	.25	.40	.35
3	.25	.50	.25

TABLE 38 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE II

Growth State	1	2	3
1	.30	.30	.40
2	.25	.35	.40
3	.30	.20	.50

TABLE 39 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE III

Growth State	1	2	3
1	.50	.20	.30
2	.35	.30	.35
3	.20	.35	.45

TABLE 40 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE IV

Note: The single step transition probabilities P_{ij}^{k} reflect the probability of the land use system, currently in state i, changing to state j, at the next transition, under alternative k. For example, in High Growth Dominant, $P_{13}^{4} = .3$ represents a 30% probability that given the land use is currently in Base Case I (growth state 1), it will change to Base Case II (growth state 3) in conjunction with alternative 4 (high STOL usage alternative).

LOW GROWTH DOMINANT

Growth State	1	2	3
1	.4	.3	.3
2	.20	.55	.25
3	.25	.35	.40

TABLE 41 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE I

Growth State	1	2	3
1	.20	.50	.30
2	.25	.40	.35
3	.25	.50	.25

TABLE 42 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE II

Growth State	1	2	3
1	.25	.35	.4
2	.25	.45	.3
3	.3	.4	.3

TABLE 43 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE III

Growth State	1	2	3
1	.25	.4	.35
2	.3	.45	.25
3	.25	.45	.3

TABLE 44 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE IV

MEDIUM GROWTH DOMINANT

Growth State	1	2	3
1	.30	.25	.45
2	.25	.35	.35
3	.3	.3	.40

TABLE 45 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE I

Growth State	1	2	3
1	.20	.5	.3
2	.25	.40	.35
3	.25	.5	.25

TABLE 46 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE II

Growth State	1	2	3
1	.25	.30	.45
2	.20	.40	.40
3	.25	.20	.55

TABLE 47 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE III

Growth State	1	2	3
1	.35	.20	.45
2	.25	.35	.40
3	.20	.20	.60

TABLE 48 SINGLE STEP TRANSITION PROBABILITIES

ALTERNATIVE IV

Steady State Probabilities

For the postulated Markov process previously defined, a significant assumption concerns the ergodic property. This property asserts that the final long run steady state probabilities are independent of the initial starting state. The steady state probabilities reflect the probability that the land use configuration will be found in a particular growth state i at any time of investigation. As in the alternative-specific single step transition probabilities, the land use steady state probabilities for each transportation alternative can be developed, and are presented in Tables 49 through 51.

The next chapter will demonstrate the synthesis of the above reward and stochastic inputs in evaluating the air commuter transportation alternatives. In addition, sensitivity analysis to examine the range of conditions over which particular alternatives are worthy of consideration will be performed.

TABLE 49

STEADY STATE TRANSITION PROBABILITIES

HIGH GROWTH DOMINANT

State	Transportation Alternative 1	2	3	4
1	0.334495	0.238095	0.286550	0.346535
2	0.313589	0.454546	0.269006	0.283828
3	0.351916	0.307360	0.444444	0.369637

TABLE 50

STEADY STATE TRANSITION PROBABILITIES

LOW GROWTH DOMINANT

State	Transportation Alternative 1	2	3	4
1	0.269373	0.238095	0.266331	0.271820
2	0.420664	0.454546	0.407035	0.436409
3	0.308963	0.307360	0.326634	0.291771

TABLE 51

STEADY STATE TRANSITION PROBABILITIES

MEDIUM GROWTH DOMINANT

State	Transportation Alternative 1	2	3	4
1	0.284960	0.238095	0.236025	0.249135
2	0.300492	0.454546	0.279503	0.235294
3	0.414248	0.307360	0.484472	0.515571

Note: The steady state transition probabilities reflect the probability that, for any time of observation, the land use system can be found in state i, i = 1, 2, 3, under any alternative k, k = 1,2, . . .4.

CHAPTER VIII

EVALUATION OF ALTERNATIVES

CHAPTER VIII

EVALUATION OF ALTERNATIVES

This chapter utilizes the policy iteration approach referred to in Chapter II and Appendix A to evaluate the regional air commuter transportation alternatives in light of the three possible growth states, and the stochastic and reward information pertinent to them, as developed in Chapters 6 and 7. A brief review of solution technique is relevant, prior to describing results of analysis.

Solution Technique

The Markovian solution maximizes the test quantity

$$q_i^k + \sum_{j=1}^{n} p_{ij}^k \tilde{V}_j \qquad i, j = 1, 2, 3 \qquad k = 1, 2, \ldots 4$$

where

q_i^k = the expected reward from the next stage transition, given the starting growth state i, for transportation alternative k,

p_{ij}^k = single step transition probabilities, growth state i to growth state j, for transportation alternative k,

V_j = relative total expected reward or relative value accruing to the system under the previous policy,

N = the maximum number of growth states, here N = 3,

For each growth state i, i = 1, 2, 3, the alternative k*, k = 1, 2, . . .4, is found, by comparison, which maximizes the test quantity and becomes the policy for growth state i.

The test quantity represents the selection criteria by which one alternative is considered optimal in relation to the other transportation alternatives for each land use system state. Symbolically this maximized test quantity, for each transition, arrays the alternative to be selected for each state based on a set of rewards and values relative to all alternatives. As such, this test quantity is not an absolute measure of benefits for the selected transportation alternatives. For a complete coverage of the mathematics see Howard.[1]

However, one modification was established: due to the long lead time of constructing facilities within the planning horizon, and the sunk cost, inflexible nature of system-wide transportation programs, it was presumed, for purposes of model computation, that the system chosen optimal through analysis would be held constant as to implementation policies of the chosen alternative over the planning horizon period. Thus there would be no "totally shelving the adopted plan" as is often done in the real world midway through a planning horizon, based on annual updates.

Computational Results

From this evaluation methodology, incorporating Markovian decision theory, the output results take the form of a policy vector.[2] This vector is an ordered set of optimal transportation alternatives for each state of the system under study. These state specific alternatives will maximize the rewards accruing to the system given the current state, over the planning horizon.

Due to the two formulations of the reward matrices (R_{ij}^{k}), the value added and value matrix approaches, there are two separate policy vectors. Each vector represents the optimal alternative in light of the reward matrix formulation. These will now be presented and discussed.

Value Added Approach

The value added approach involved the quantification of transition reward matrices on the basis of the regional value added due to state transition and the cost of the transportation alternative. As stated in Chapter IV, the regional value added component was measured by an aggregate total of industrial and commercial land use increments for each growth state. The transportation alternative costs were arrived at via considerations of capital and operating costs and expected revenues.

Tables 52 through 54 illustrate the policy vectors from this reward matrix formulation and a sensitivity analysis across a variety of P_{ij} reflecting high, low, and medium growth subjective estimates of P^k_{ij}.

TABLE 52

POLICY VECTOR, VALUE ADDED APPROACH

HIGH GROWTH DOMINANT

State	Policy Vector: Optimal Alternative	Value Vector
1	4	22.8993
2	3	14.7500
3	3	19,3000

TABLE 53

POLICY VECTOR, VALUE ADDED APPROACH

LOW GROWTH DOMINANT

State	Policy Vector: Optimal Alternative	Value Vector
1	4	20.0614
2	4	24.1315
3	3	15.3947

TABLE 54

POLICY VECTOR, VALUE ADDED APPROACH

MEDIUM GROWTH DOMINANT

State	Policy Vector: Optimal Alternative	Value Vector
1	4	19.2000
2	4	16.8000
3	4	23.8000

As shown in Table 52, in growth state 1 (Base Case 1) the optimal alternative is alternative 4, the high STOL air commuter and feeder system. Upon review of the results and components of the analysis, alternative 4 service patterns coincide with travel needs associated with the existing and proposed land uses under this growth state. Alternative 3 is selected as optimal for the Base Case 2 and Base Case 3 concepts. This would appear reasonable due to the growth state 2 conceptualization as a continuation of present trends but at a low level growth, and a more moderate trend with emphasis on land use in Base Case 3.

The analysis of the results in the above tables show that the alternatives 4 and 3 (High STOL and Low STOL) are selected to be the optimal solution over the three growth states, illustrating the potential that transportation needs of the region are not met with the existing transportation modes, and that high and low STOL could be valuable alternatives to complement the existing modes in Base Case 1 and Base Case 2 and 3, respectively.

Value Matrix Approach

The alternate reward matrix formulation involved the use of such social and environmental concerns intrinsically related to a selection of transportation strategies. As previously outlined, the reward matrices reflected such impacts, and the weighting of these impacts, that were critical to each transportation alternative over each state of the system.

The results of these analysis are, again, a policy vector specific to each system state. The results are shown in Tables 55 through 57 with sensitivity analysis across a variety P_{ij} reflecting high, low, and medium growth subjective estimates of P^k_{ij}.

TABLE 55

POLICY VECTOR, VALUE MATRIX APPROACH

HIGH GROWTH DOMINANT

ENVIRONMENTALLY SENSITIVE PREFERENCE SCHEME

State	Policy Vector: Optimal Alternative	Value Vector
1	4	22.8993
2	3	14.7500
3	3	19.3000

TABLE 56

POLICY VECTOR, VALUE MATRIX APPROACH

LOW GROWTH DOMINANT

ENVIRONMENTALLY SENSITIVE PREFERENCE SCHEME

State	Policy Vector: Optimal Alternative	Value Vector
1	4	20.0614
2	4	24.1315
3	3	15.3947

TABLE 57

POLICY VECTOR, VALUE MATRIX APPROACH

MEDIUM GROWTH DOMINANT

ENVIRONMENTALLY SENSITIVE PREFERENCE SCHEME

State	Policy Vector: Optimal Alternative	Value Vector
1	4	19.2000
2	4	16.8000
3	4	18.8000

Similar to the previous presentation format, each optimal alternative selected under value matrix reward formulation can be viewed against respective growth states. In Table 55, for State 1, alternative 4, high STOL is selected as the one which will yield maximum benefits accuring over the planning horizon. An equivalent point of view is that adverse impacts of the other transportation alternatives outweigh those of alternative 4 for the Base Case I growth state; and although the most expensive policy vector, this alternative minimizes such adverse consequences as pollution and energy cost. For the Base Case 2 and Base Case 3 concepts, alternative 3, low STOL, was selected as optimal, principally due to its pollution and energy cost attributes and its moderate cost of operation.

To examine the impact on different decisions in light of regional viewpoints with respect to development and growth versus environmental concern, a sensitivity analysis was performed on the weighting schemes. The results are presented in Tables 58 and 59.

TABLE 58

POLICY VECTOR, VALUE MATRIX APPROACH

MEDIUM GROWTH DOMINANT

DEVELOPMENT ORIENTED PREFERENCE SCHEME

State	Policy Vector: Optimal Alternative	Value Vector
1	4	13.80
2	3	15.80
3	4	25.80

TABLE 59

POLICY VECTOR, VALUE MATRIX APPROACH

MEDIUM GROWTH DOMINANT

COMPROMISED REGIONAL PREFERENCE SCHEME

State	Policy Vector: Optimal Alternative	Value Vector
1	4	16.50
2	4	17.85
3	4	27.00

Evaluating the results of sensitivity analysis shown in these tables, the alternative 4 was selected to be optimal under the Development Oriented Preference Scheme for growth states 1 and 3. This is due to the fact that more development will require more mobility and alternative 4 (high STOL) furnishes this mobility. For Growth state 2, continuation of existing development at a lower pace, the alternative 3 (Low STOL) was chosen to be optimal.

In the compromised weighting scheme of Table 59, the alternative 4 (high STOL) is again selected as the one which will yield the maximum benefits for all three growth states over the planning horizon. This is apparently due to the mobility requirements associated with even a compromised development preference.

Summary of Computation

A regional analysis of transportation investments must be tied closely to desired or resultant land use and spatial arrangements of growth in the planning region. Modelling the regional air commuter transportation investments as a Markovian Decision Problem is a viable approach to their evaluation and growth state changes. Some subjectivity must be employed in the transition probability formulation. However, the professional planner's knowledge of the study area and land use-transportation interactions can yield logical transition matrices. Regional surrogates for system value are often extremely difficult to obtain. In light of the need for simple, computationally concise approaches which relate to critical issues of the region, such as environment vs. growth and economic wealth, the short cut value added and value matrices were employed.

The following Chapter IX exhibits the above type of analysis at a more micro-scale, that of detailed evaluation of specific sites for STOL port operation within the community of Fremont, California.

Footnotes

[1]Howard, Ronald A., Dynamic Programming and Markov Processes, M.I.T. Press, Cambridge, Massachusetts, 1960.

[2]Summary of Progress Benefit-Cost Evaluation of an Intra-Regional Air Service in the Bay Area, NASA Grant NSG-2170, January 3, 1977, Dr. Lonnie E. Haefner, Principal Investigator.

CHAPTER IX

SITE SPECIFIC MODEL:

FREMONT CASE STUDY

CHAPTER IX

SITE SPECIFIC MODEL - FREMONT CASE STUDY

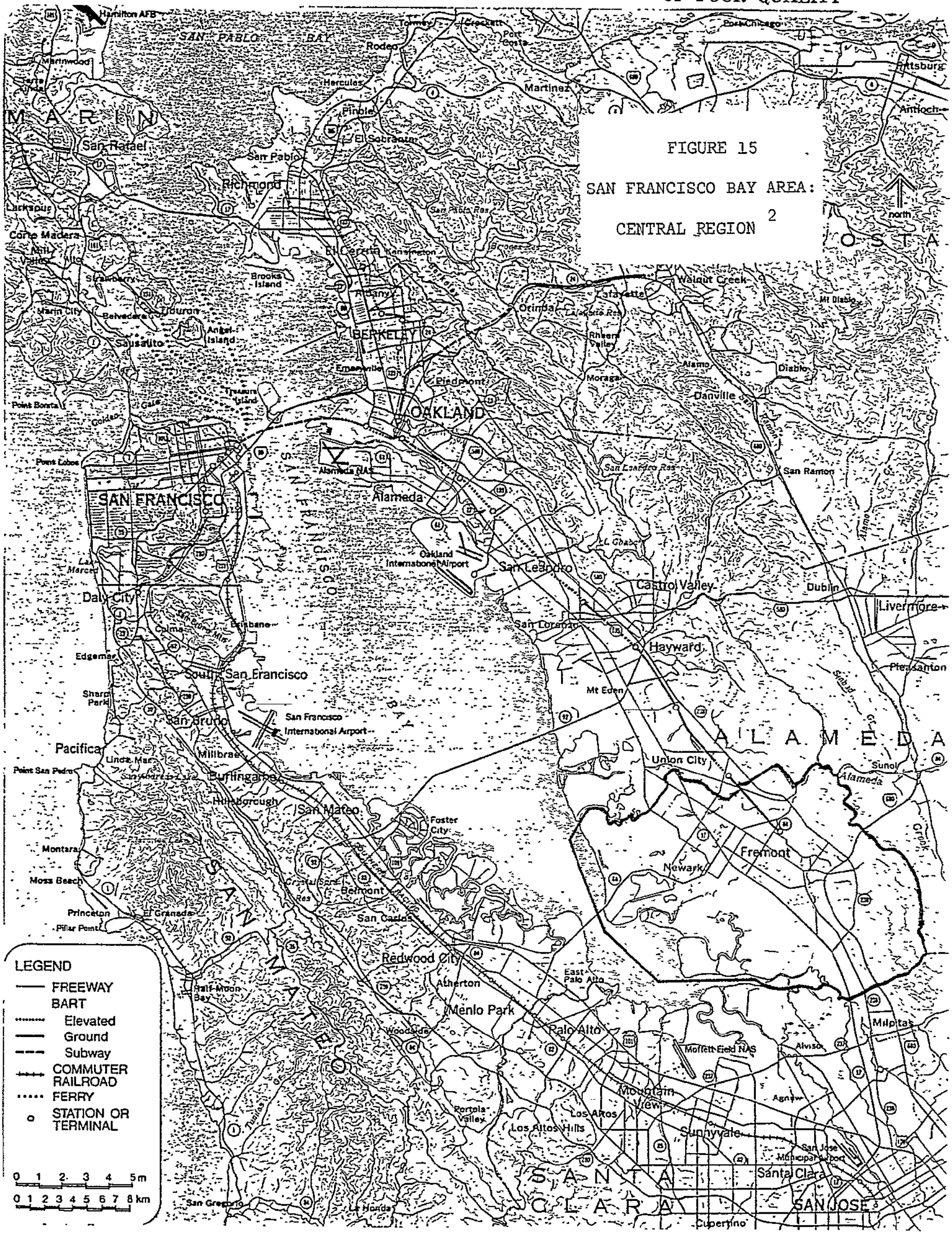
Introduction - General Review of Fremont Characteristics

The objective of this chapter is to develop a statistical decision theory model at a site specific level of STOL port location. This model will incorporate user and non-user information, yielding an evaluation of specific STOL Port sites within Fremont, California which fit the optimal policy of regional commuting previously formulated. The section will review the characteristics of the study site, and proceed with a discussion of the employment of the model and its associated output.

Fremont is a 96 square mile community in Alameda County, California, a part of the San Francisco Bay Region. The city of Fremont was incorporated as a municipality in January 1956 and lies along the east edge of San Francisco Bay near its southern terminus as shown in Figure 15. It uses a City Council-Manager type of government and is the fourth largest city in the San Francisco Bay Area based on population, and the fifth largest city in California based on size. The city has an assessed valuation (1976-77) of $407,237,973 where the ratio of assessed value to appraised value is 25% of real cash value.[1]

The city of Fremont has 22 miles of San Francisco Bay Shoreline within its city limits, which is one of the largest amounts of shoreline in the southern part of the Bay Region. To the west of Fremont, on the other side of the Bay at a distance of 20 miles, are the mountains of the San Francisco peninsula, rising to a height of 2800 feet.

ORIGINAL PAGE IS
OF POOR QUALITY



The Pacific Ocean lies 30 miles to the west of Fremont. To the East lies a series of ridges within which lies the Livermore Valley. These ridges rise to 2500 feet 12 miles from Fremont, increasing to 3500 feet at a distance of 18 miles. Much of Fremont lies at sea level within an old flood plane. Moderate temperatures exist throughout the year ranging from 38 F in the winter to a maximum of 90 F in the summer. The average temperature for the area is 77 F with light precipitation averaging only 15 inches per year. Sunshine is generally the rule with average winds of around 9 miles per hour.[3]

Transportation Facilities

The city of Fremont is a suburban community at the Southeast terminus of the BART system shown in Figure 16 and 17. The Fremont Station, on the northeastern edge of the Central Business District provides quick and comfortable transportation to Oakland, San Francisco and other parts of the Bay Region. In addition, A. C. Transit operates five fixed routes throughout the City and has just initiated a Dial-a-Ride service throughout certain portions of the city. Inter-city bus service operations are operated by both Peerless Stages and Greyhound Bus Lines.[4]

Major airports within the area include Oakland International Airport, which is 22 miles away, San Francisco International Airport which is 30 miles away, and the San Jose Municipal Airport, twelve miles from Fremont. The private airfield of Hayward Airport, ten miles from Fremont, and the Fremont Airport are available for small types of private aircraft.

The city has an extensive roadway network within it, in addition to routes connecting the city to other areas of the San Francisco Bay. State

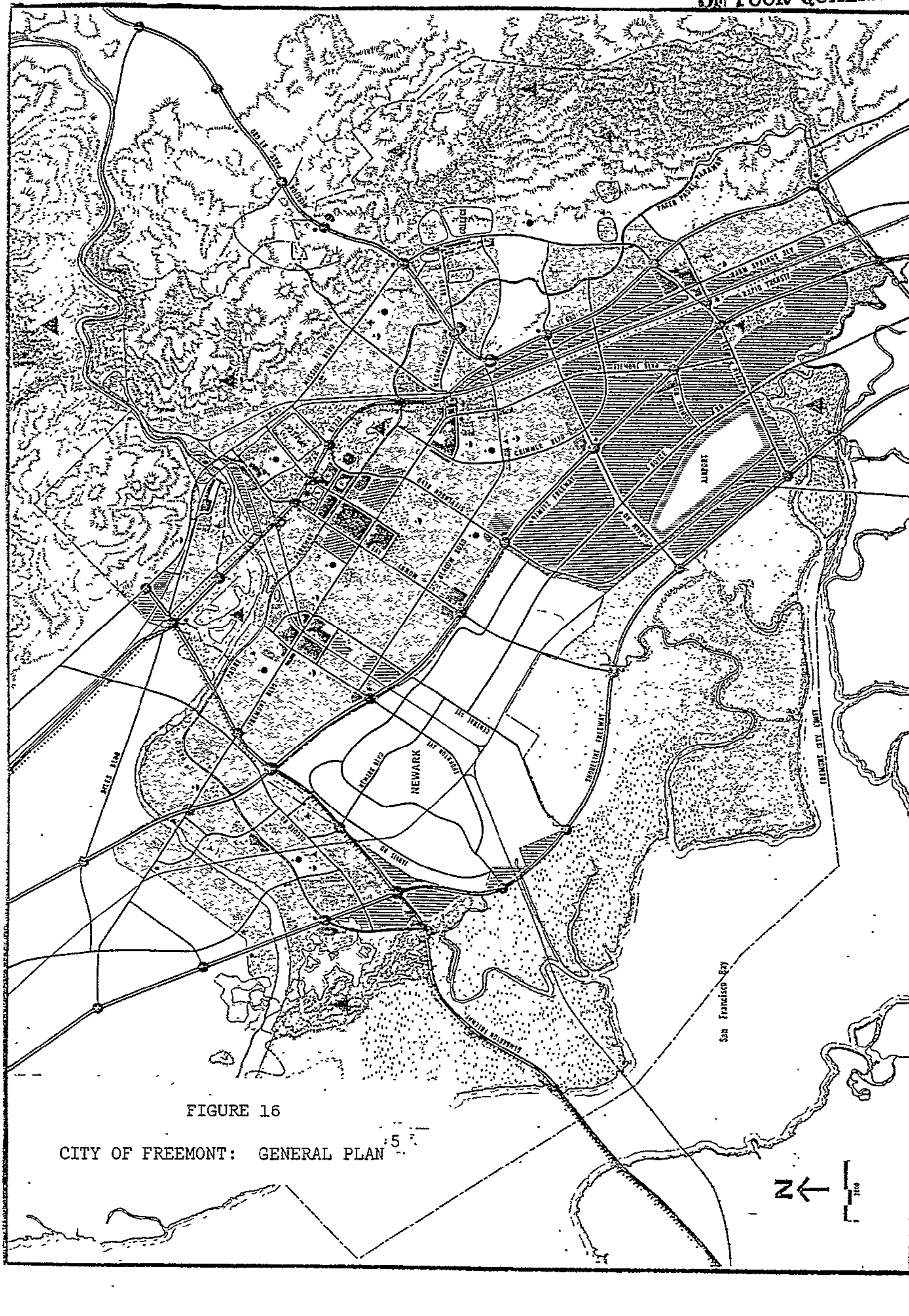


FIGURE 16

CITY OF FREEMONT: GENERAL PLAN[5]

ORIGINAL PAGE IS
OF POOR QUALITY

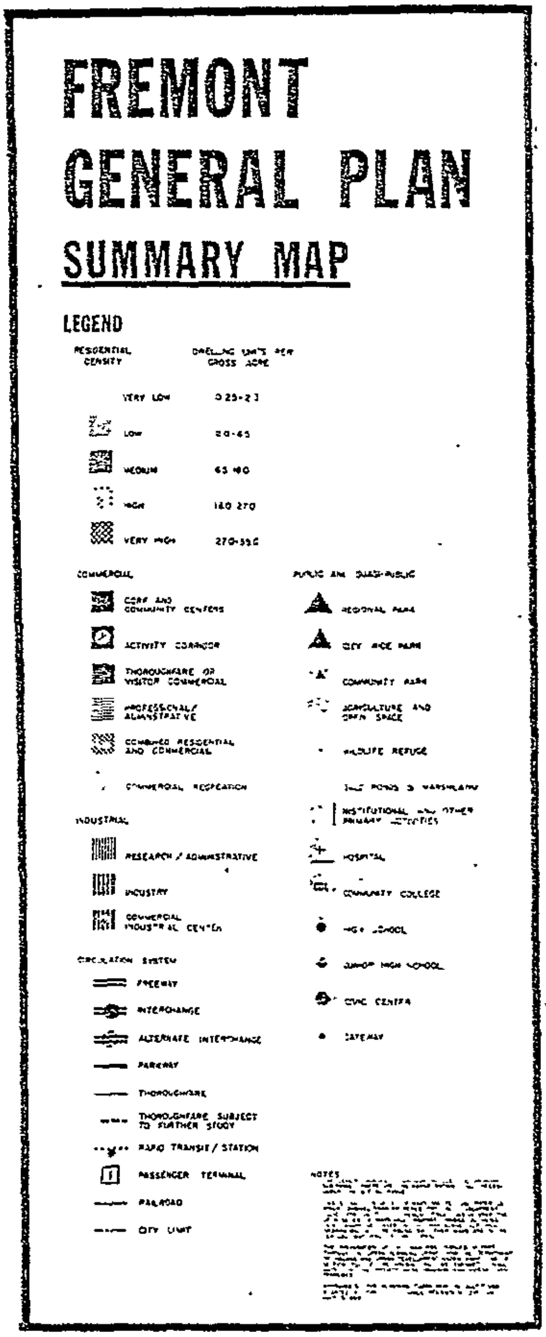


FIGURE 17

CITY OF FREMONT: GENERAL PLAN

LEGEND[6]

Highways 9, 21, 84, 238, and State Highway 17, the Nimitz Freeway and Interstate 680 and the Mission Pass Freeway all carry large volumes of traffic during the peak periods of the day, as shown in Figure 17.

Freight movement in the community exists by virtue of service by over fifty common carriers and over 250 radial carriers serving the continental United States. In addition, there is overnight delivery to Los Angeles, Sacramento, Reno, and Portland Oregon. Main rail lines of the Southern Pacific and Western Pacific service Fremont with intrastate, interstate, and transcontinental through service.

As a result of its location with respect to the San Francisco Bay, Fremont has access to deep water port facilities in Oakland located about twenty-five miles to the north and facilities in San Francisco located forty miles to the northwest.

Open Space Preservation

It appears that Fremont will always have extensive open space.[7] Approximately the western quarter of the city will be a part of the San Francisco Bay National Wildlife Refuge. Further, approximately one quarter of the eastern sector of the city is in hills and is virtually undeveloped. Within Fremont there are a variety of open space land uses (open space exists for agriculture, resources preservation, private recreation, and for public health, safety and welfare) resulting in the creation of a single open space zoning regulation covering many varieties of situations. Since there are a variety of open space land use types, any development or change must comply with strict performance standards. This allows for both the flexibility necessary to administer the different open space types, along with the simplicity of administering a single zoning regulation.

Agricultural Preserve

The California Land Conservation Act of 1965 (the Williamson Act) is based on the necessity of the State to preserve agricultural land in order to conserve one of the State's economic resources. Under this act, lands being used for either farming or open space are placed under a contract whereby the owner will not develop his property for ten years. In return, the State then assesses the property based on the lands' agricultural potential rather than on the lands "highest and best use." These agricultural preserves are currently being widely used in Fremont.

Communities of Fremont

As stated before, the City of Fremont is a community of roughly 96 square miles in the southeastern part of the Bay Area Region. The community is institutionally composed of a series of separate planning areas having many common characteristics. These areas exhibited in Figure 18 are the Bay Lands, Centerville, the Central Area, the Northern Plain, Irvington, Mission San Jose, the Niles Area, and Warm Springs. These planning areas will be further elaborated on from the Fremont General Planning Text.[8]

The Bay Lands

This area includes all the land generally west and south of Coyote Hills, the Newark boundary, and the Pacific Gas and Electric power line running from Newark southeasterly to meet the Nimitz Freeway near the southern boundary of Newark. General objectives or policies concerning the Bay Lands include:

a. To retain most of the Bay Lands as open space and recreation area.

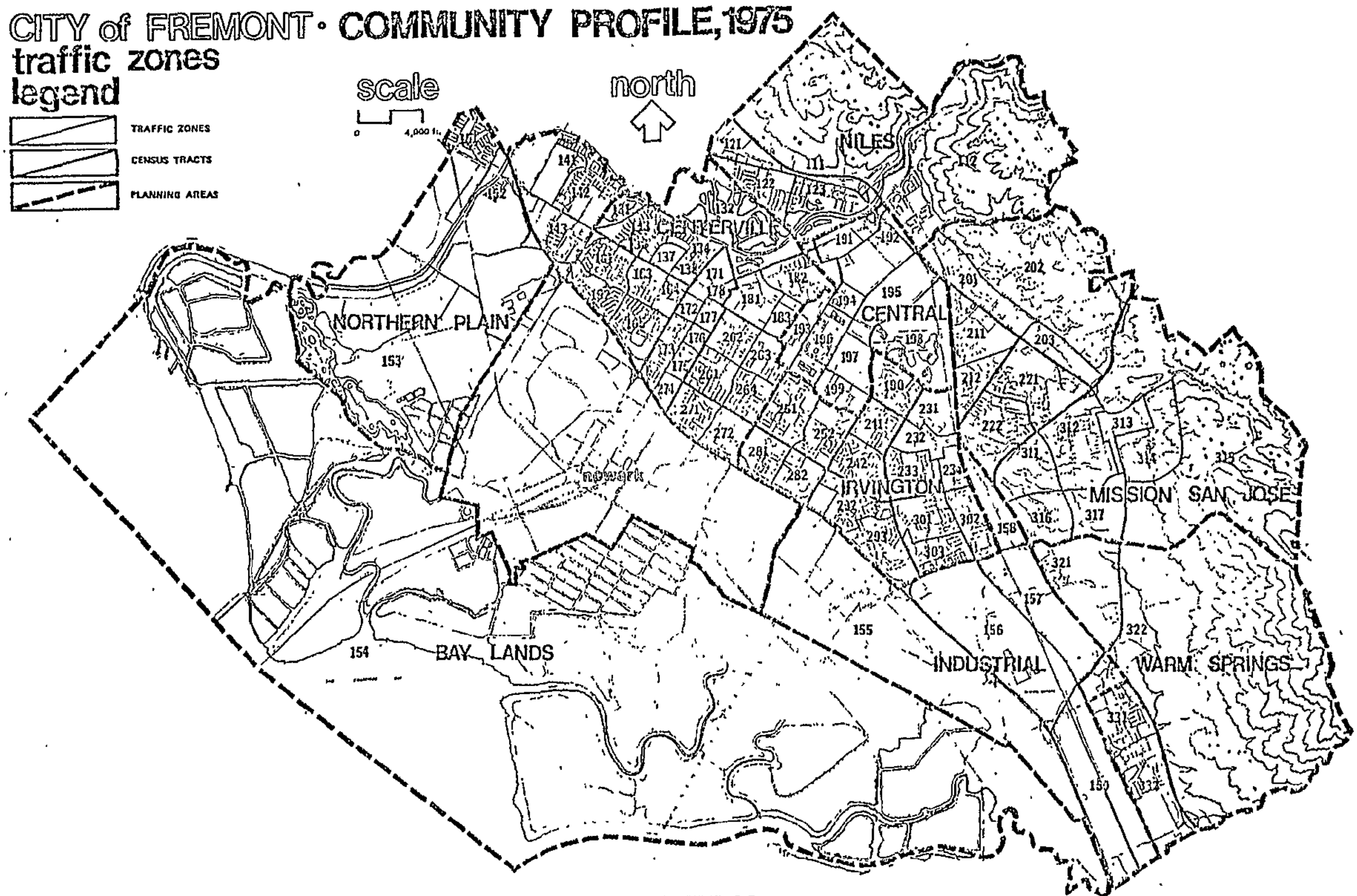


FIGURE 18

PLANNING AREAS AND TRAFFIC ZONES [9]

b. To preserve the habitats of and provide refuges for such native creatures as harbor seals and marsh birds.

c. To provide for improved public access to the Bay proper.

Centerville

This is the area generally bounded by the Alameda Creek flood control channel, the proposed future Freeway 239, County Drive, Argonaut Way, Mowry Avenue, the Nimitz Freeway, and the future Dumbarton Freeway. General objectives or policies concerning Centerville in the General Plan include:

a. To complete improvements to existing streets and to plan for a future circulation system which will accommodate the high volume of use which is expected as a result of continued city-wide development.

b. To maintain the community center as the primary focus of commercial activity in the district and to encourage continued development of vacant or underutilized lands in this area.

c. To develop an aquatic park of regional significance in the quarry area to serve recreational as well as conservation purposes.

d. To encourage development of remnant parcels within the guidelines of the General Plan.

e. To preserve and stabilize existing neighborhoods, particularly those containing housing units which are less costly.

f. To resolve the long term issues related to the proposed Dumbarton Freeway (Route 84) and Route 238 based on city-wide as well as district considerations upon completion of on-going traffic studies.

The Central Area

This is the area within the center of Fremont which is generally bounded by Mission Boulevard, the Western Pacific Railroad, Paseo Padre Parkway, Stevenson Boulevard, Bidwell Drive, and Argonaut Way, Country Drive, the proposed future Freeway 238, and the Western Pacific Railroad. The Central Area is composed of two major subareas: The Central District (everything southwest of the proposed future Freeway 238), and the Central Area East. General objectives or policies concerning the Central Area include:

a. Central District - special area policies as opposed to community area policies, which encompass those geographic areas requiring special planning and development concerns.

b. Central Area East - to provide supporting facilities to the Central District.

The Northern Plain

This is the area generally bounded by Alameda Creek (Union City Boundary), the future Dumbarton Freeway, Coyote Hills, and the city boundary. General objectives concerning the Northern Plain include:

a. To develop a new large residential community with its own community center and with a unique character which sets it apart from the existing communities.

b. To coordinate development in Fremont with that of neighboring Newark and Union City.

Irvington

This is the area generally bounded by the Western Pacific Railroad, Durham Road, the Nimitz Freeway, Mowry Avenue, Argonaut Way, Bidwell Drive, Davis Street, Stevenson Boulevard, and Paseo Padre Parkway. General objectives or policies concerning Irvington include:

a. To improve the physical appearance and economic viability of the older community commercial area through public and private programs of renewal and development.

b. To provide an adequate trail system through the Irvington Area.

c. To improve vehicular circulation in Central Irvington through improvement and redesign of the street system.

d. To provide the Irvington Community Commercial Center with adequate parking facilities.

e. To provide for special combined residential and commercial areas which will encourage the start of new businesses within the community.

f. To maintain and enhance the appearance and stability of Irvington's residential development through programs of neighborhood conservation and landscaping and the enforcement of ordinances designed to insure proper maintenance of these areas.

Mission San Jose

This area is bounded by the eastern City boundary, proposed Durham Road extension and Durham Road, the proposed future freeways 680 and 238, the Western Pacific Railroad, Mission Boulevard and Morrison Canyon Road.

General objectives or policies concerning the Mission San Jose area include:

a. To preserve and enhance the historical attributes and atmosphere of the Mission San Jose Area.

The Niles Area

The Niles Area is generally bounded by the northern and eastern city boundaries, Morrison Canyon Road, Mission Boulevard, the Western Pacific Railroad, and the Alameda Creek flood control channel. General objectives or policies concerning the Niles area include:

a. To maintain and enhance the physical characteristics which provide the historical continuity and individuality that give Niles a small town character and distinguish it from other areas of the City.

b. To maintain a housing balance in the overall Niles community between newer and older, larger and smaller, and more and less expensive units.

c. To focus community commercial activity on both sides of Niles Boulevard and to provide improvements which will enhance the identification of this area as the center of the district.

d. To preserve the architectural features characteristic of "Old Niles," and to ensure that new construction contributes to this character.

e. To provide a rich and varied park and recreation system through regional, community, neighborhood, and historic parks and trails which will assure the Niles community of long-term desirability as a living and working environment.

f. To permit large lot residential and other low intensity development in the hill areas to the degree that such development is consistent with the natural capacities of the land.

g. To provide a City trail system which links the Niles hills, the commercial center, historic sites, and park areas via the regional trail system to Niles Canyon and Coyote Hills.

h. To plan a circulation system which is adequate to handle anticipated traffic volumes but which does not encourage unnecessary through traffic.

The Warm Springs Area

This area is generally bounded by the eastern and southern city boundaries, Warm Springs Boulevard, Mission Boulevard, future Freeway 680, Durham Road and its further extension. General objectives or policies concerning the Warm Springs Area include:

a. To build upon the existing development to create a relatively self-sustaining community.

b. To capitalize on the abundant natural and historical resources to create an area of beauty and character.

Population

The City of Fremont has grown from a scattered group of communities before incorporation in the late 1950's to the fourth largest city in the San Francisco Bay Area. In 1965 the population for Fremont was 84,000 and, has since grown to over 116,500. By 1995, it is anticipated that Fremont will have a population of around 194,000.[10] The total current population for the respective planning areas within Fremont appears in Table 61 in the top of the first row, from left to right.

Housing and Household Characteristics

The growth of households in the City of Fremont area has been even greater than that of population growth, due to a shift in the average household size, which has been steadily decreasing. This trend in household size took a sudden sharp downward turn in the late 1960's which has resulted in an increase in the demand for new housing.[11] As shown in Tables 60 and 61, there are currently 36,100 households in Fremont and it is projected there will be 65,700 households in 1995. The current housing existing in 1975 for each traffic zone appears in Table 62 and Figure 19. In this table, housing is broken down into the categories of single family, multi-family, mobile home, and total dwelling units per zone.

Rentals for one and two bedroom apartments and duplexes in the Fremont area range from $150.00 to $300.00 per month.[12] Rentals for two and three bedroom houses range from $200.00 to $350.00 per month.

Housing sales for 1977 in the Fremont area generally ranged from $30,000 to $125,000.[13] Actual housing values along with undeveloped residential industrial and commercial acreage values appear in Figure 19. In addition, within 20 miles of Fremont there are fourteen suburban residential areas with homes selling for from $30,000 to $150,000.[14] There are currently three mobile home parks and five motels, with a total of 367 rooms currently within the community of Fremont.

Employment

While the population of Fremont has increased by 175% since 1961, employment has increased by 345% in roughly the same period.[15] Fremont, with a 1977 population of 147,000 currently has an estimated total employment of 46,730, composed of the categories which appear in Table 63 and

TABLE 60

FREMONT TRENDS AND PROJECTIONS[16]

	1965	1970	1975	1980	1985	1990	1995
Population (in 1000's)	84.0	102.7	116.5	134.0	152.0	173.0	194.0
Households (in 1000's)	21.4	27.1	36.1	42.6	49.6	57.5	65.7
School Enrollment	14,416	18,688	15,141				
Buying Power (in millions) 1975 $	428	618	884	1,045	1,210	1,410	1,610
Buying Power per Capita (1975 $)	5,100	6,020	7,590	7,780	7,990	8,140	8,300
Average Buying Power per Household (1975 $ in 1000's)	20.0	22.8	24.5	24.5	24.5	24.5	24.5

TABLE 61

FREMONT: 1975 PLANNING AREA DATA[17]

COMMUNITIES OF FREMONT (PLANNING AREAS)

Category	Indicator	CITY OF FREMONT TOTAL	CITY OF FREMONT % OF CITY	CENTERVILLE ACTUAL	CENTERVILLE Equivalent To City's Average	CENTERVILLE Above(+) Below(−) Average	IRVINGTON ACTUAL	IRVINGTON Equivalent To City's Average	IRVINGTON Above(+) Below(−) Average	MISSION SAN JOSE ACTUAL	MISSION SAN JOSE Equivalent To City's Average	MISSION SAN JOSE Above(+) Below(−) Average
SELECTED RESIDENTIAL INDICATOR/CATEGORY	POPULATION AGE: 65 & OVER	115,461 4,640	100% 4 02%	34,189 1,454	1,374	+80	37,620 1,046	+513	−407	14,708 540	591	−51
	POPULATION AGE: 18 & UNDER	115,461 46,543	100% 40 39%	34,109 12,165	13,809	−1,644	37,620 15,665	15,198	+407	14,706 5,404	5,940	−446
	HOUSEHOLDS INCOME: UNDER $9000/YR	35,410 3,818	100% 10 78%	10,870 1,172	1,172	0	10,269 1,151	1,107	+44	4,222 281	455	−174
	LABOR FORCE UNEMPLOYED	60,891 2,409	100% 4 91%	15470 762	760	+2	15,342 815	753	+102	6,432 217	316	−99
	HOUSEHOLDS MINORITIES	35,410 4,207	100% 11 88%	10,870 1,111	1,291	−180	10 269 1,371	1,220	+151	4,222 251	502	−251
	POPULATION OVER 25 EDUCATION: ELEM OR LESS	48,223 7,434	100% 15 42%	15030 2,105	2,318	−213	16,558 2,266	2,553	−297	6,965 624	1,074	−450
	DWELLING UNITS POOR MAINT QUALITY	31,743 450	100% 1 42%	8,969 29	127	−98	9,401 19	134	−115	4,325 56	61	−5
	POPULATION FIRE	115,461 1,259	100% 1 09per 100 pop	34,109 317	373	−56	37,028 407	410	−3	14,706 127	160	−33
	POPULATION CRIME	115,461 11,004	100% 9 51 per 100,000	34,189 2,918	3,286	−368	37,629 3,595	3,616	−21	14,706 1,083	1,413	−330
	DWELLING UNITS I/V RATIO. 1 OR LESS	37,358 1,737	100% 4 65%	11,272 295	524	−229	10,514 238	489	−251	4,397 175	204	−29
	DWELLING UNITS AGE OF STRUCTURE: BEFORE 1950	27,303 2,171	100% 7.95%	8,774 471	698	−227	9,177 280	730	−450	3,593 260	286	−26
	HOUSEHOLDS WELFARE RECIPIENTS	35,410 2,025	100% 5 72%	10,870 579	622	−43	10,269 862	587	+275	4,222 105	241	−136
SELECTED COMMERCIAL INDICATOR/CATEGORY	TOTAL COMMERCIAL ACREAGE I/V RATIO 0.5 OR LESS	634 9 92.3	100% 14 54%	109.3 22.7	15 9	+6 8	128.3 27.1	18 4	+8 7	78 3 7.1	11 4	−4.3
	CITY AVERAGE COMM SQ FT PER PARKING SPACE PLANNING AREA AVG COMM SQ FT PER PARKING SPACE	237		230	237	−7	181	237	−56	271	237	+34
	AVERAGE AREA LENGTH OF DEFICIENT THOROUGHFARES LENGTH OF DEFICIENT THOROUGHFARE IN AREA	10,464		25,075	10,464	+10,411	15,625	10,464	+5,161	6,250	10,464	−4,214

Category	Indicator	NILES ACTUAL	NILES Equivalent To City's Average	NILES Above(+) Below(−) Average	WARM SPRINGS ACTUAL	WARM SPRINGS Equivalent To City's Average	WARM SPRINGS Above(+) Below(−) Average	CENT BUS DIST ACTUAL	CENT BUS DIST Equivalent To City's Average	CENT BUS DIST Above(+) Below(−) Average	NORTHERN PLAIN ACTUAL	NORTHERN PLAIN Equivalent To City's Average	NORTHERN PLAIN Above(+) Below(−) Average
SELECTED RESIDENTIAL INDICATOR/CATEGORY	POPULATION AGE: 65 & OVER	6,646 620	236	+353	5,863 141	230	−95	7,919 560	318	+248	8,228 230	331	−101
	POPULATION AGE: 18 & UNDER	6,646 1,829	2,684	−855	5,883 2,349	2,368	−19	7,919 2,134	3,198	−1,064	8,228 2,915	3,323	−408
	HOUSEHOLDS INCOME: UNDER $9000/YR	2 451 416	264	+152	1,688 122	182	−60	3,113 377	336	+41	2,686 180	290	−110
	LABOR FORCE UNEMPLOYED	3,031 146	149	−3	2,400 117	122	−5	3,328 170	163	+7	3,759 106	185	−79
	HOUSEHOLDS MINORITIES	2,451 412	291	+121	1,688 179	201	−22	3,113 354	370	−16	2,606 574	319	+255
	POPULATION OVER 25 EDUCATION: ELEM OR LESS	3,606 1,051	541	+510	2,309 328	368	−40	2,722 769	420	+349	1,048 301	162	+139
	DWELLING UNITS POOR MAINT QUALITY	2 567 239	36	+203	1,745 18	25	−7	1,770 20	25	−5	2,841 43	40	+3
	POPULATION FIRE	6,646 85	72	+13	5,063 81	64	+17	7,919 149	86	+63	8,228 48	90	−42
	POPULATION CRIME	6,646 602	639	−37	6,063 537	563	−26	7,919 1,847	761	+1,086	8,228 459	791	−332
	DWELLING UNITS I/V RATIO. 1 OR LESS	2,704 821	126	+696	1,780 15	83	−68	3,773 102	175	−73	2,854 55	133	−78
	DWELLING UNITS AGE OF STRUCTURE: BEFORE 1950	2,012 742	160	+582	1,364 31	108	−77	1,747 175	139	+36	636 212	51	+161
	HOUSEHOLDS WELFARE RECIPIENTS	2,451 124	140	−16	1,688 28	97	−69	3,113 212	178	+34	2,606 115	153	−38
SELECTED COMMERCIAL INDICATOR/CATEGORY	TOTAL COMMERCIAL ACREAGE I/V RATIO 0.5 OR LESS	40 6 3 8	5.9	−2.0	17 0 3.0	2.5	+ .5	169.5 28.6	24.7	+3.9	— —	—	—
	CITY AVERAGE COMM SQ FT PER PARKING SPACE PLANNING AREA AVG COMM SQ FT PER PARKING SPACE	1,181	237	+944	346	237	+109	189	237	−48	531	237	+294
	AVERAGE AREA LENGTH OF DEFICIENT THOROUGHFARES LENGTH OF DEFICIENT THOROUGHFARE IN AREA	5,000	10,464	−5,464	0	10,464	−10,464	11,500	10,464	+1,036	9,000	10,464	−1,464

TABLE 62

CURRENT HOUSING UNITS PER TRAFFIC ZONE: FREMONT 1975[18]

GENERAL INFORMATION

PLANNING AREA	CITY TOTAL	CENTERVILLE																												
TRAFFIC ZONE		132	133	134	135	136	137	138	161	162	163	164	165	171	172	173	174	175	176	177	178	181	182	183	281	202	263	264	271	272
No. of Single Family D.U.'s	27,010	2	701	409				7	834	508	507	20	799	5	108	380		172	3	39	27	644	438	75	552	383	382	573	454	366
No. of Multiple Family D.U.'s	8 836		336						32		300		357		7	191		16	140	53	2	298	163	14		653		177	14	151
No. of Mobile Home D.U.'s	612															1														
Total No. of Dwelling Units	37,358	2	1,037	409	0	0	0	7	866	508	807	20	1,156	5	115	572	0	187	143	92	29	942	601	89	552	1,036	382	750	468	517
Population	115,461	3	3,105	1,535	0	0	0	25	2,076	1,947	2,666	48	3,550	19	262	1,739	0	569	380	203	52	2,176	1,768	297	1,692	2,430	1,268	2 281	1,579	1,616
Population (%) of City		.003	2.7	1.3	0	0	0	.02	1.8	1.7	2.3	.04	3.1	.02	.2	1.5	0	.5	.3	.2	.05	1.9	1.5	.26	1.5	2.1	1.1	2.0	1.4	1.4

PLANNING AREA	IRVINGTON																MISSION SAN JOSE														
TRAFFIC ZONE	190	231	232	233	234	241	242	251	252	281	282	292	293	301	302	303	201	202	203	211	212	221	222	311	312	313	314	315	316	317	
No. of Single Family D.U.'s	544	139	64	517	322	678	865	983	640	338	600	773	829	782	769	370	35	9	33	655	647	847	1000	85	760	48	6	73	6	18	
No. of Multiple Family D.U.'s	7	225	20	193	116		142	2	232			70		5		43	2		2		2	4	104		124	30					
No. of Mobile Home D.U.'s		10														230		1		1								3	2		
Total No. of Dwelling D.U.'s	551	374	84	710	438	678	1 007	985	872	338	600	843	829	787	769	643	37	10	35	656	649	851	1104	85	884	78	6	76	8	18	
Population	2,135	821	179	2 239	1,301	2 628	3,553	3,680	3 186	1 206	2 010	3,093	3,250	2 998	3,012	2,260	49	27	99	2 405	1 662	2,911	3859	323	2,709	31	4	222	27	75	
Population (%) of City	1.8	.7	.2	1.9	1.1	2.3	3.1	3.2	2.7	1.1	1.7	2.7	2.8	2.6	2.6	2.0	.04	.02	.09	2.1	1.4	2.5	3.3	.3	2.3	.03	.02	.2	.02	.06	

PLANNING AREA	NILES					WARM SPRINGS				CENTRAL BUSINESS DISTRICT									NORTHERN PLAIN							INDUSTRIAL DISTRICT					BAY
TRAFFIC ZONE	111	112	121	122	123	321	322	331	332	191	192	193	194	195	196	197	198	199	131	141	142	143	151	152	153	155	156	157	158	159	154
No. of Single Family D.U.'s	46	575	182	505	497	287	77	571	582	23	274	52		20	16	8		154	167	171	830	520	573	4	9	7	12	21	45	18	
No. of Multiple Family D.U.'s	34	90	42	412	147			257		203	312	1,308		11		672		635			400										
No. of Mobile Home D.U.'s	3	171	1			1	5				1									3		2	2	105		1			1	2	
Total No. of Dwelling Units	83	836	224	917	644	288	82	828	582	231	587	1 440	0	31	16	680	0	789	167	174	1,230	522	575	109	9	8	12	22	46	20	–
Population	157	2,393	616	1,917	1,563	902	203	2,641	2,117	391	1,550	3 122	0	77	42	1,104	0	1,625	613	604	3,484	1,717	1,411	364	34	16	33	57	127	63	
Population (%) of City	.1	2.1	.5	1.7	1.4	.8	.2	2.3	1.8	.3	1.3	2.7	0	.07	.04	1.0	0	1.4	.5	.5	3.0	1.5	1.2	.3	.03	.01	.03	.05	.1	.05	

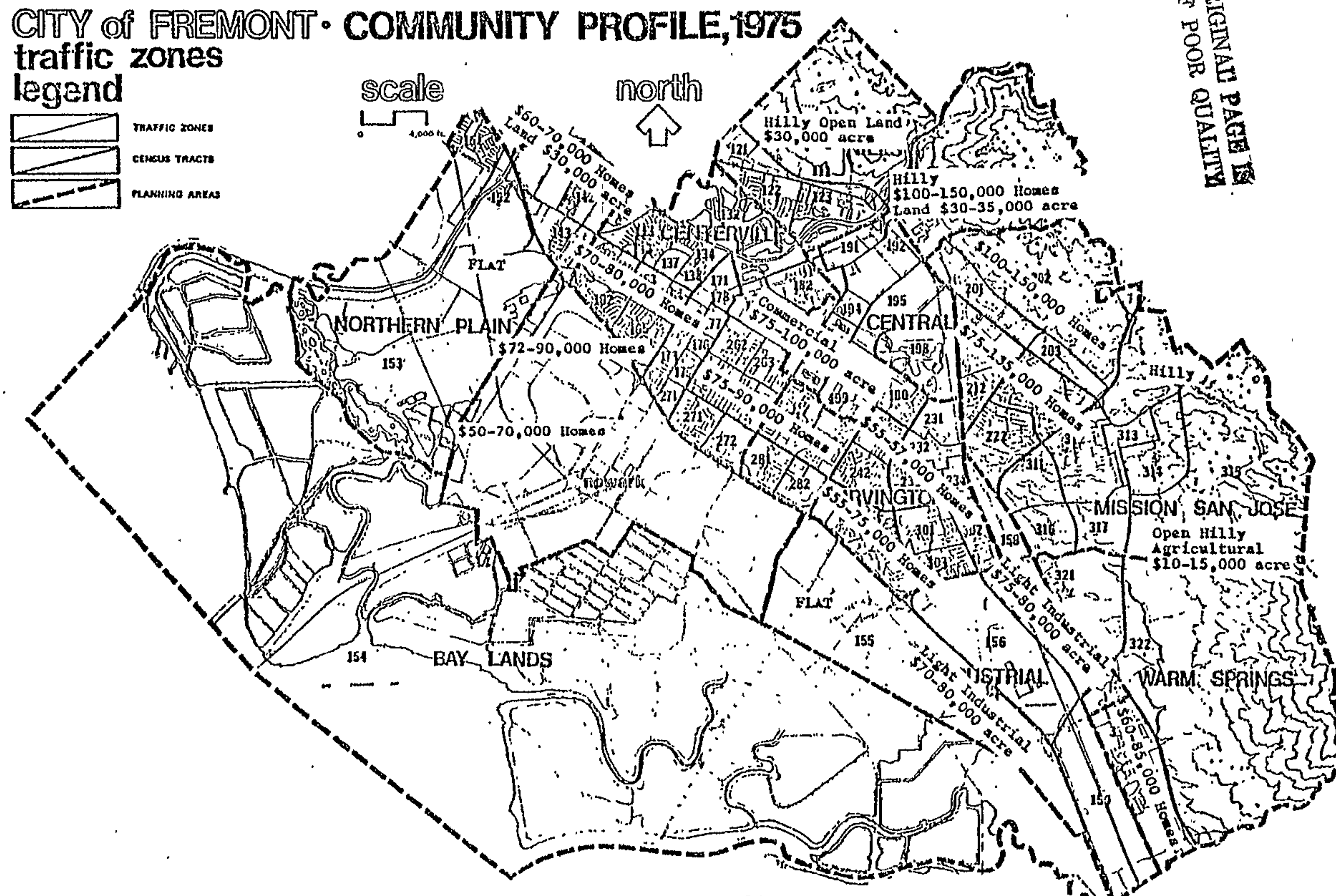


FIGURE 19[19]

FREMONT REAL ESTATE VALUES

TABLE 63

THE FREMONT-NEWARK LABOR MARKET [20]

January 1977

Est. Area Population 147,000

Est. Total Employment 46,730

Agriculture, Agriculture Services	1,830
Construction	1,600
Manufacturing	14,700
Trans/Comm/Utilities	1,720
Retail Trade, Wholesale Trade	9,800
Finance/Real Estate/Insurance	1,580
Services	7,100
Government	8,400
	46,730

The majority of the industrial workers of Fremont are union members affiliated with the AFL-CIO and the UAW. Labor relations between labor and management are generally excellent in the area.

spatially arranged as shown in the land use map of Figure 20. Unemployment in the Fremont area as of 1974 was 4.9% of the total labor force.

There are over 125 manufacturing plants in the Fremont community area. As shown in Table 64, the leading employers are in auto assembly (General Motors Assembly Division) fabricated metal products (Hussman-California Corp.), furniture manufacturing (Kroehler Mfg. Co.), metal container fabricating (C.T. Supply) and electronics (Industrial Electric Mfg., Inc.)

In addition to the manufacturing and other business firms located in the Fremont area, there are many attributes which hold promise for the area. Those areas zoned for industrial purposes are bordered by two interstate freeways, and two major railroads bisect the industrial area.

There are currently 5,700 acres in the Fremont City limits currently zoned for all types of industry. Of this, roughly 40% is currently vacant and available in parcels ranging from ½ to 500 acres. Within the City there are 8 industrial parks. Sales price of industrial land in 1976 ranged from $9,000 to $40,000 per acre. Non-manufacturing employment and community facilities for the City of Fremont appears in Tables 65 and 66 respectively.

Retail

In 1974 retail sales in Fremont amounted to about $321 million. Retail sales have shown a dramatic increase since the early 1960's, increasing by 170% compared to a 64% increase in population over that same period. A large part of the increase can be explained by the increase in the number of households relative to population, and the increase in personal income, as illustrated in Table 67.

Table 68 is spatially representative of retail sales locations for 1974 for various commercial centers around Fremont. Within the City of

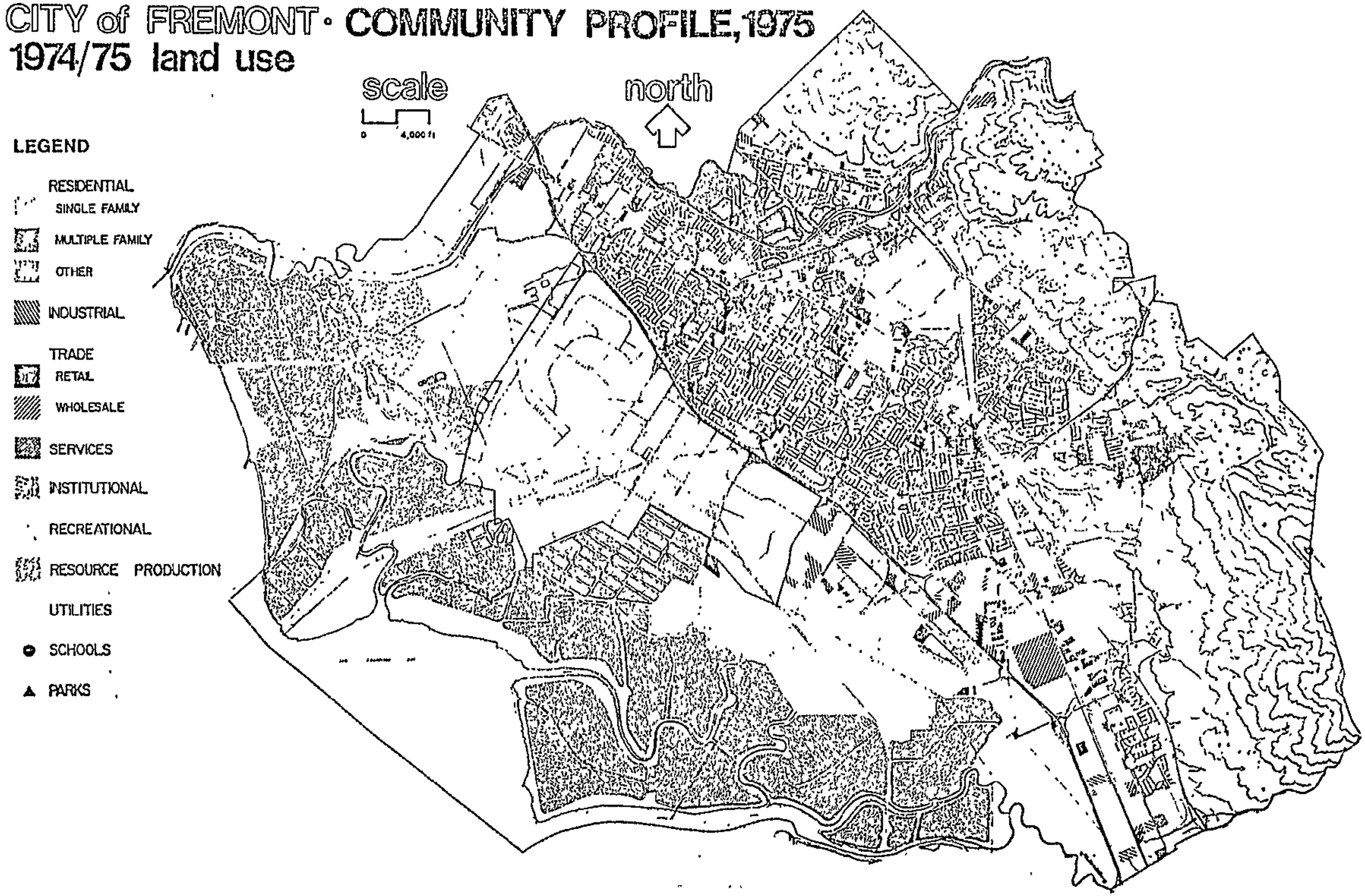


FIGURE 20

CITY OF FREMONT 1974/75 LAND USE[21]

TABLE 64

MANUFACTURING EMPLOYMENT[22]

The largest manufacturing firms in the community are:

Name of Company	Employment	Type of Business
General Motors Assembly Division	5,300	Passenger cars, trucks
C.T. Supply	260	Food cans
Kroehler Mfg. Co.	240	Furniture
Hussmann-California Corp.	149	Modular display shelving
Industrial Electric Mfg., Inc.	140	Electric Switchboards
Borden Chemical Co.	90	Chemicals, Adhesives
Pacific Union Metals	70	Street lighting equipment
Ethyl Corp. Visqueen Division	65	Polyethylene Sheeting & Tubing

Facilities include: 5 machine shops, 1 public warehouse.

Major raw material resources include: Quarries, hillside & pit.

TABLE 65

NON-MANUFACTURING EMPLOYMENT[23]

Name of Company	Employment	Products
Safeway Stores Inc	907	Grocery Distribution
Washington Hospital	595	General Hospital
City of Fremont	533	Municipal Government
U.S. Government--F.A.A.	458	Air Traffic Control
Fleming Foods	400	Grocery Distribution
Pacific Telephone & Telegraph	275	Utility - telephone
Insured Transporters	250	Auto Transport
EMCO Distributors	225	Distribution/Toiletries
Pacific Gas & Electric Co.	165	Utility - gas & electric
Fudenna Bros.	150	Agriculture

TABLE 66

COMMUNITY FACILITIES [24]

HEALTH: Fremont has 1 general hospital with 325 total bed capacity; 100 physicians/surgeons, 75 dentists, 12 optometrists, 13 chiropractors, and 7 convalescent hospitals or sanitariums.

EDUCATION: 37 elementary schools, 6 junior high schools, 6 high schools and 1 junior college.

CULTURAL: 60 churches, 4 libraries, 1 newspaper, 2 radio stations, 9 TV channels, received direct, 1 TV cable system, 18 banks, 9 savings and loan, 25 parks and playgrounds, 3 theaters. Other recreational facilities include: Water oriented activities including swimming, fishing, sailing and hiking.

TABLE 67

FREMONT RETAIL SALES [25]

Types of Stores	1974 Sales	% of City
* Convenience Goods	$150 million	47%
Food, drug, and liquor stores Service stations		
* Shoppers Goods	$82 million	25%
General merchandise, apparel, specialty, and home furnishings and appliances stores		
* Other Store Types	$89 million	28%
Automobile dealers and auto parts stores Eat and drink establishments Building materials stores		

Fremont there are seven commercial centers: the CBD, the community business districts of Centerville, Irvington, Mission San Jose, Niles, Warm Springs, and the shopping center at Mowry West. In addition to these large centers, there are a series of local and convenience type centers and other retail shops which are scattered throughout the city. These stores are not classified into any one large center and are designated as other Fremont in Table 68.

The retail establishments discussed above currently occupy 2.2% of the City's developable area. In return they contribute about 7.2% to the city's total property taxes, and contribute directly 17.8% of the county's income through a combination of local property taxes, sales taxes (5% state, 1½% city-county) and business taxes. Fremont also receives additional monies from other specific property taxes on service and office establishments, as well as hotel and motel tax. The employment provided by Fremont's retail sectors is 10,260 or about 27% of the total employment in the area.

It is estimated that by 1995, when Fremont will have a population of about 195,000, the additional retail acreage needs will be 504 acres. Table 69 lists the acreage needs by product class for 1995. As can be seen from the estimates, there will be roughly a doubling in the amount of commercial acres needed.

Generalized Raw Land Costs and Development Issues

Within the city of Fremont, land costs vary from a low of 25 cents a square foot to in excess of 7 dollars a square foot. Land costs along Fremont Boulevard in the center of town which are not planned or zoned

TABLE 68

RETAIL SALES LOCATIONS: 1974 (in millions of 1975$)[26]

Central Business District	91.8
Centerville	46.0
Irvington	25.0
Mowry-West	18.7
Niles	3.3
Mission San Jose	10.8
Warm Springs	4.5
Other Fremont	97.2
Nilpitas	65.1
Newark	40.7
Union City	29.8

TABLE 69

POTENTIAL ACREAGE NEEDS: FREMONT (1975 - 1995)[27]

	Current 1974	Theoretical Projection 1974-95 Increase	Adjusted Estimate 1974 - 95 Increase
Convenience Stores[1]	57[2]	134	134
Eat and Drink	61	77	77
General Merchandise	57	85	85
Apparel	17	33	33
Specialty/Other Retail	115	56	56
Home Furnishings	18	23	23
Building Materials	34	19	9[4]
Auto Dealers/Parts	134	87	87
RETAIL SUBTOTAL	493	514	504
Personal Services	22[3]	17	13
Business Services	22[3]	67	50
Auto and Repair Services	34	79	39[4]
Commercial Recreation	25[3]	61	46
Hotels and Motels	15[3]	55	41
SERVICE/OFFICE SUBTOTAL	118	279	189[5]
OFFICES SUBTOTAL	126[3]	90	68[5]
COMMERCIAL TOTAL	737	883	761

1. Food, Drug, Liquor, Service Stations.
2. Food Stores only; drug & liquor in 'Other,' service stations in auto.
3. Estimated: Total prof. & financial services = 170 acres. No data for Commercial Recreation or Hotels and Motels.
4. Since these uses can develop in areas designated industrially, allowance has been made for a 50% addition to commercial designations.
5. Since the uses in this group are closely related to the amount of industrial or commercial activity in the city, acreages were reduced by 25% to reflect the city's anticipated level of industrial activity within the time frame of this study.

for commercial use are being offered from $2.00 to $6.00 a square foot. The Fremont Land prices, as in most communities, reflect the availability of marketable sites.

Concern among groups within the Fremont community with respect to development expectations has been raised. Specifically, it is felt development in the CBD area has not been up to expectations. It is pointed out that about 25% of the land area in the CBD remains vacant. Further, there are only two department stores, and several buildings are incomplete or unoccupied.[28]

However, full or ultimate development of Fremont, according to the General Plan, will not occur until after 1995. In 1995, it is anticipated that Fremont will have 194,000 residents living in 65,700 dwelling units. Commercial acreage will occupy 1,300 acres and industrial acreage will require 1,500 acres. As stated in the <u>City of Fremont: Freeway Deletion Impact Study</u>, completed August 1976:[29]

> . . . major land use features of the City in 1995 will include a significant amount of development in the Northern PLain and the Mission Hills West Areas. Residential development on large lots in the most accessible portions of the hills will have occurred. Greater local shopping and employment will be available within the City. Landmarks will include an office center, the courthouse, a high-rise area adjacent to BART, the State schools and an expanded Civic Center and Central Park complex in the Central Area. The Quarry Recreation Area will have developed. Overall, the City will have achieved 85 percent of its ultimate development with moderate redevelopment having occurred in some of the older areas in Centerville, Irvington and Niles.[83]

B. Statistical Decision Models

As stated before, the purpose of this section is to develop and test the two statistical decision theory models at the site specific level. These models will yield an evaluation of specific sites within Fremont which fit the optimal policy of regional commuting for the region. It is appropriate at the outset of analysis to state that none of the sites under study in Fremont proved feasible as appropriate STOL port sites, except under very qualified conditions. As such, the objective of the remainder of this section will be to demonstrate the model usage at a site specific level.

The specific sites being tested in Fremont appear in Figures 21 through 25. These consist of four major areas, with some areas having more than one site alternative to be tested. In Area 1, which is at the current BART terminus in Fremont, there will be three site locations tested. In Area 2, which is the area zoned for airport development by the City of Fremont, there are two site locations to be tested. In Area 3, which is near the Nimitz Freeway and Mission Blvd. interchange, there are two site locations to be tested. Finally, in Area 4, there is one site location near the Alameda Flood Control Channel and the locus of the BART line to be tested.

Bayesian Decision Theory[34]

The first model under development is the Bayesian Decision Theory approach. This methodology follows the general format in Figure 26. The feasibility of various STOL port locations are tested for sites within the City of Fremont. The advantage of a Bayesian model for STOL port site locational analysis is in the degree of flexibility and realism which it

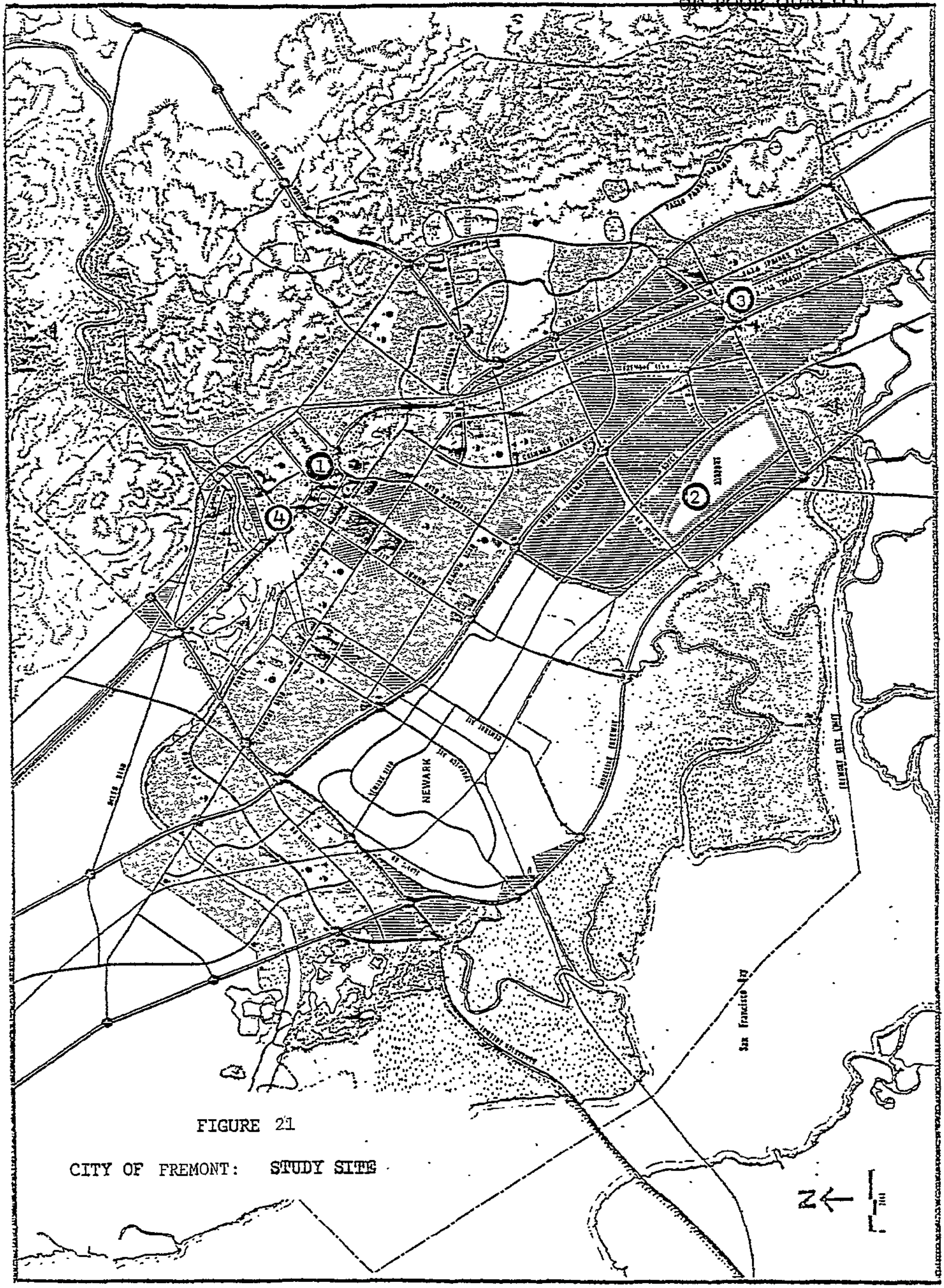


FIGURE 21

CITY OF FREMONT: STUDY SITE

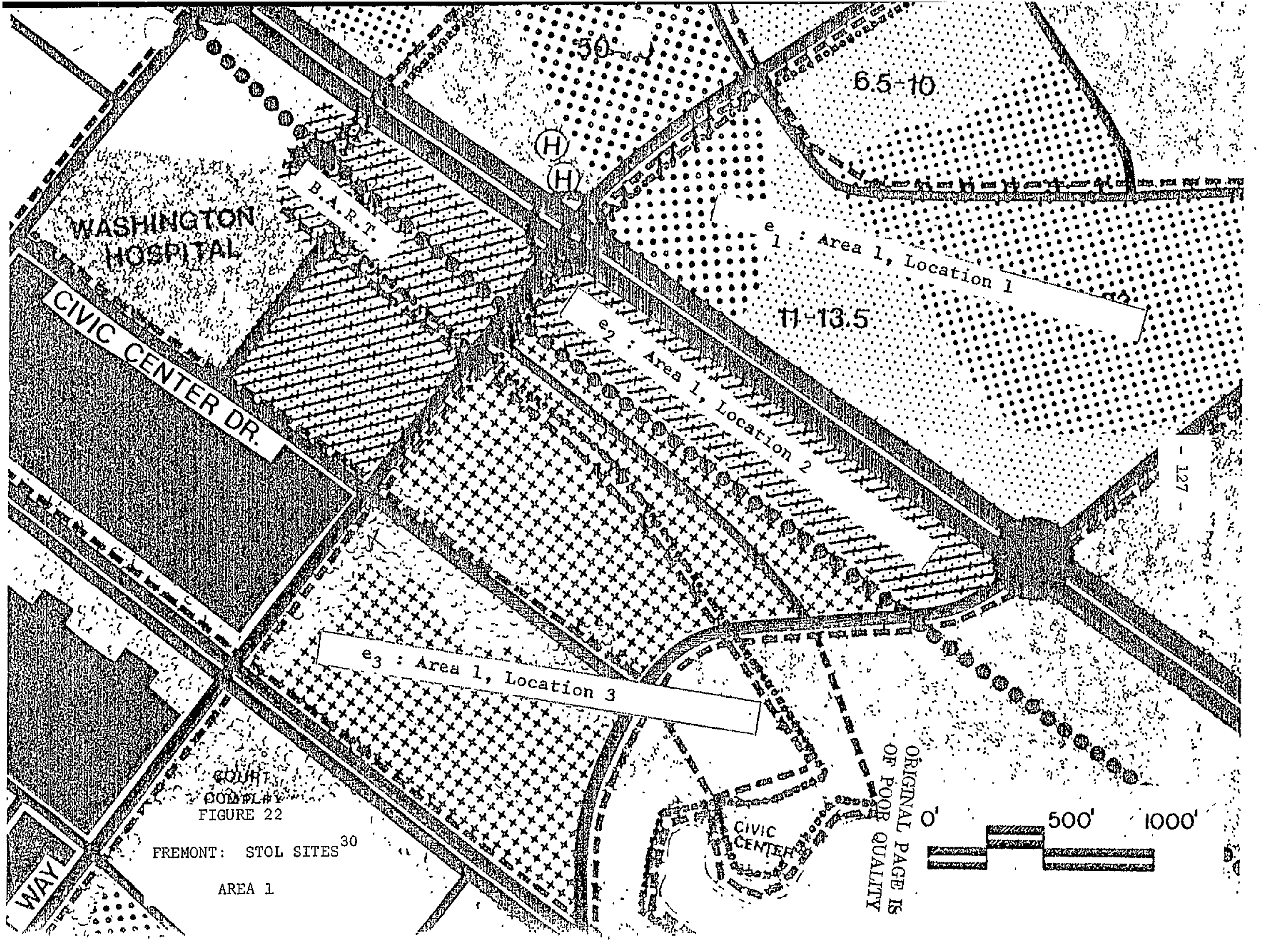


FIGURE 22

FREMONT: STOL SITES[30]

AREA 1

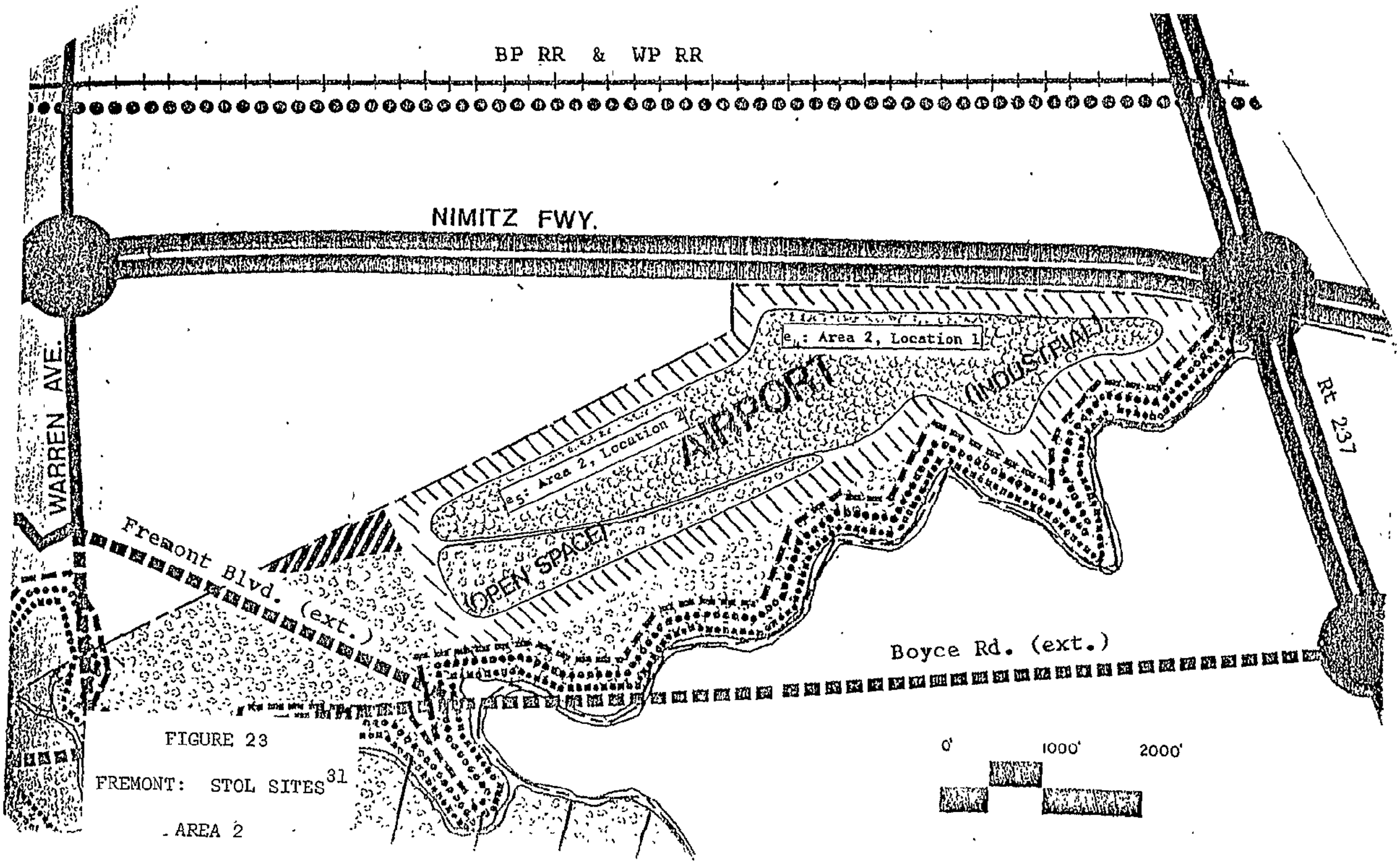


FIGURE 23

FREMONT: STOL SITES[31]

AREA 2

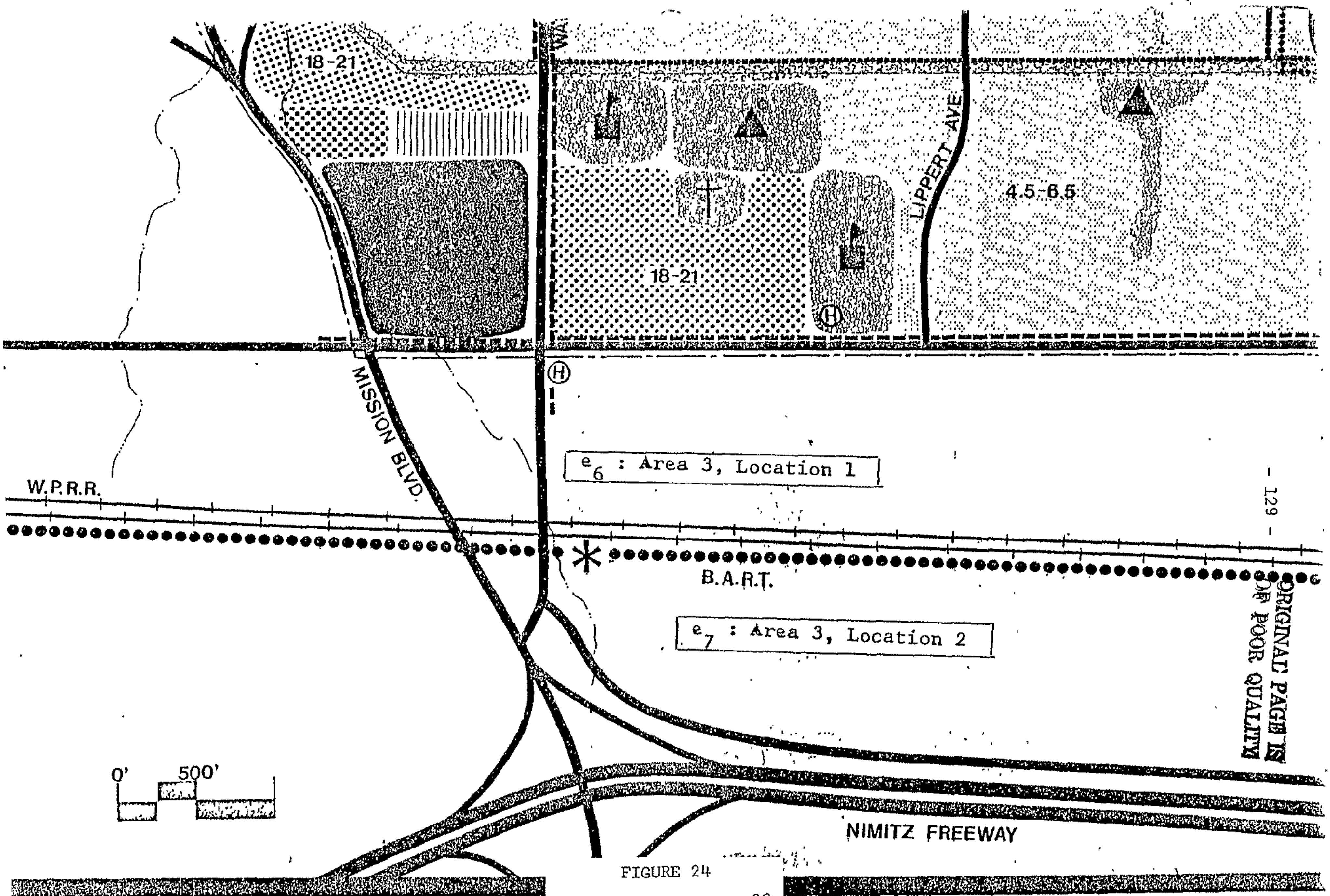


FIGURE 24

FREMONT: STOL SITES[32]

AREA 3

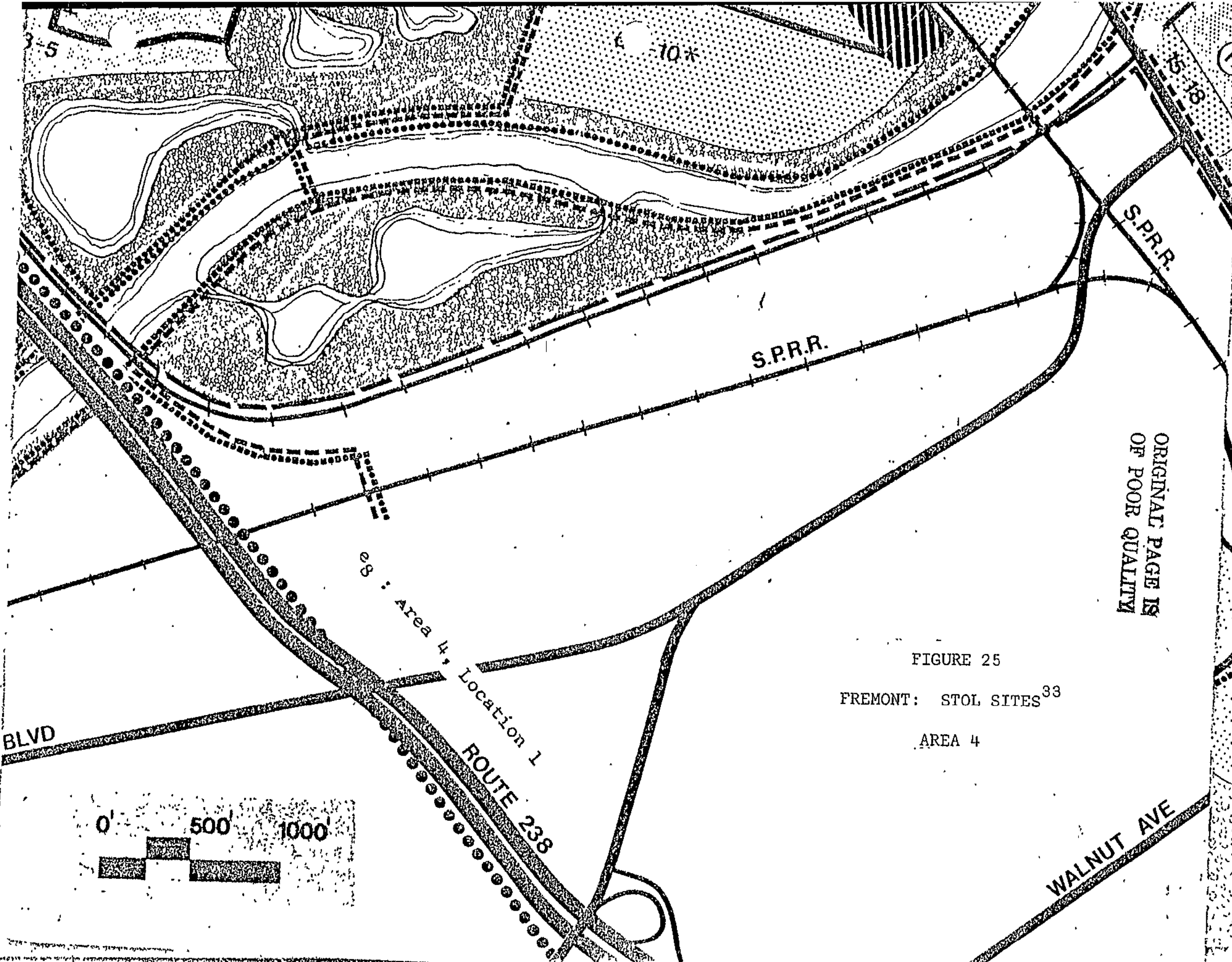


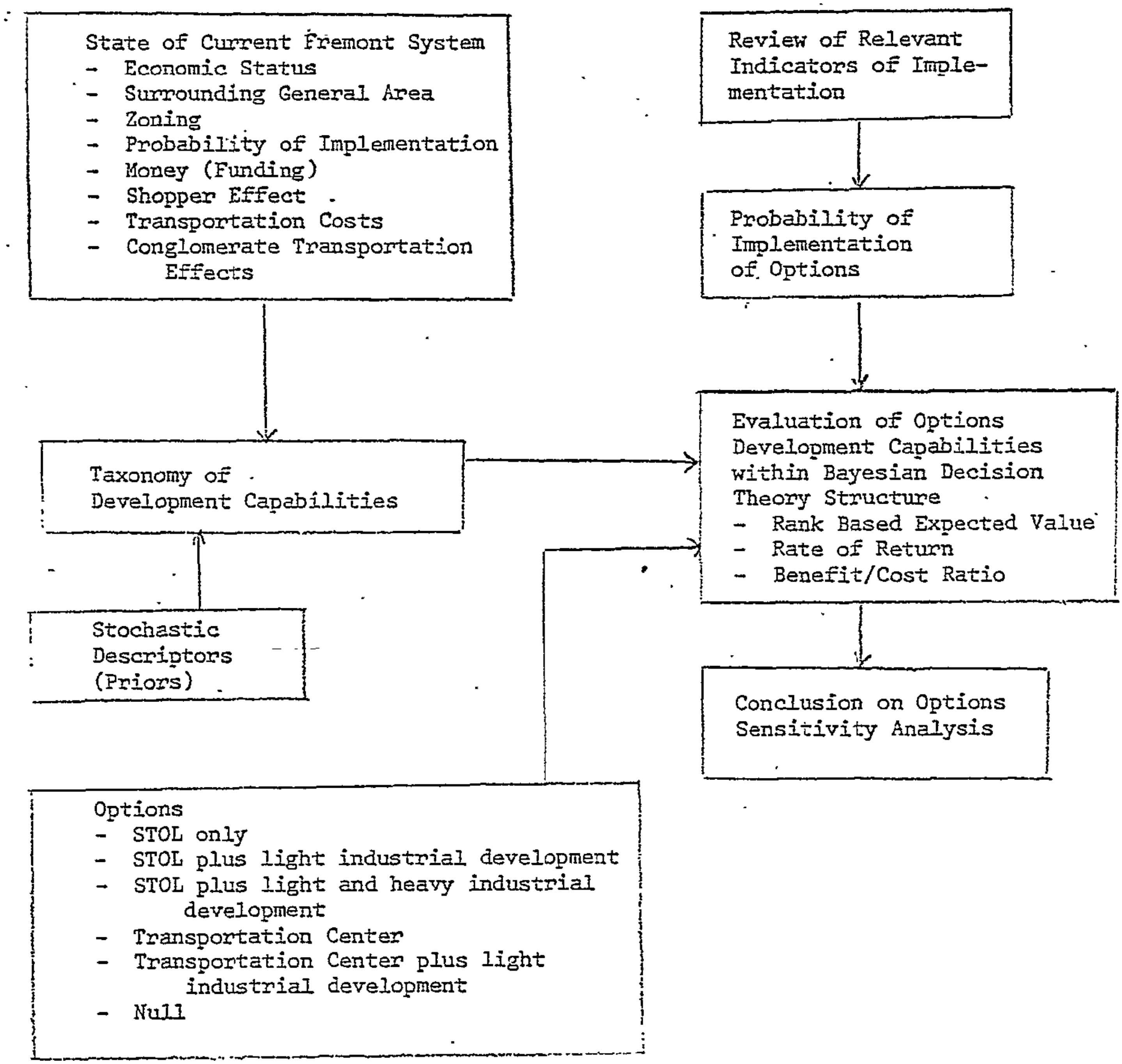
FIGURE 25

FREMONT: STOL SITES[33]

AREA 4

FIGURE 26

BAYESIAN SITE MODELLING FORMAT



allows in the evaluation process. For a detailed discussion of the mathematics of Bayesian Decision Theory, see Appendix M.

The purpose of the Bayesian model is to determine the expected utility of developing a specific STOL site within a city such as Fremont. In classical Bayesian Decision Theory analysis, the decision-maker is confronted with a complex system about which he has incomplete knowledge. As such, in the Bayesian scheme, the decision maker performs "experiments," i.e. feasibility studies to yield more information as to the site which should be chosen. Associated with each experiment, there is a study cost.

Such above experiments have a set of outcomes associated with them. The outcomes are descriptions of the results of the experiments. As a result of the information gained on the potential sites through the feasibility study experiments and outcomes, an action is indicated. Such actions represent various types of development that might appropriately take place given the site chosen and the outcome associated with the feasibility study.

The above actions are taken in the face of the possible end states which may obtain over the long run, which are known in a probabalistic sense. Hence, the gain or utility of a given action ultimately depend upon the actual states of the system subsequent to implementation activities.

Development of e_i

The possible feasibility study experiments e_i, that could be performed prior to selection of a decision appear in Table 70. These experiments yield more information to the user about the probability of occurance of the various

TABLE 70

POSSIBLE FEASIBILITY STUDY EXPERIMENTS

Feasibility Study of	
e_1 Area 1, Location 1	
e_2 Area 1, Location 2	Downtown Fremont, near the current BART terminus.
e_3 Area 1, Location 3	
e_4 Area 2, Location 1	The area currently zoned for airport development in the city of Fremont.
e_5 Area 2, Location 2	
e_6 Area 3, Location 1	The area near the Nimitz Freeway and Mission Blvd. interchange.
e_7 Area 3, Location 2	
e_3 Area 4, Location 1	The area near the Alameda Flood Control Channel and the lows of the BART Line.

end states. In this problem the experiments represent feasibility studies of the possible sites within Fremont which may be capable of supporting STOL development. The associated outcomes of the experimental feasibility studies are prognoses for successful STOL port development.

Development of Z_j

The possible experimental outcomes Z_1 and Z_2 that may be observed with the above experiments are:

Z_1 Development likely to be successful.

Z_2 Development unlikely to be successful.

Arrayal of d_k

The alternative terminal decisions open to a decisionmaker are d_1, d_2, d_3, d_4, d_5 and d_6 where the possible d_k's vary from STOL to STOL within a transportation center adjoining light industrial and commercial development, as illustrated in Table 71. In addition, the null set, i.e. a no development decision is also considered.

Development of θ_r

The possible end states structured for evaluation consist of four descriptions of ultimate feasibility of development; θ_1, θ_2, θ_3, and θ_4.

θ_1 Conditions are ideal for development.

θ_2 Some aspects are favorable for development.

θ_3 Few aspects are favorable for development.

θ_4 Development is impossible.

TABLE 71

TERMINAL DECISIONS

d_1 STOL development only

d_2 STOL and Light industrial development

d_3 Transportation Center (STOL, RAIL, BUS, Commercial Area, Hotel, BART)

d_4 Transportation Center and Light industrial

d_5 Null alternative - No STOL port development

An uncertain knowledge exists with respect to which of the above four states the potential site will actually be in as the site decision is implemented. This uncertainty is articulated in the form of the probability $P(\theta_k)$ which the decisionmaker assigns to the distribution over θ_ℓ for each of the potential site feasibility study experiments.

Development of U

To each path through the Bayesian decision tree (i.e. experiments e_i experimental outcomes Z_j alternative terminal decisions, d_k and end states θ_ℓ) illustrated in Figure 27, which describes the above problem, a value is attached. This value represents the utility of a particular combination of experiment, experimental outcome, terminal decision, and end state $U(e_i, z_j, d_k, \theta_\ell)$.

For example, a decision is made to employ a particular experiment, e_i, which results in an outcome z_j that has a probability associated with it. On the basis of the added knowledge about the end states and an original assessment, an alternative d_k is chosen, and is executed in the face of θ_ℓ, the resulting state of the world, which also has a probability associated with it. The above probabilistic outcomes and deterministic choices result in a utility accruing to the decision maker. In this problem, the utilities will be derived using the Internal Rate of Return method (ROR) and Rank-based Expected Value (REV) methods. The ROR method was used where STOL development was considered a private venture. The REV technique was employed where the development was pursued as a public works project allowing for the inclusion of broader, non-monatary community impacts in the utility formulation.

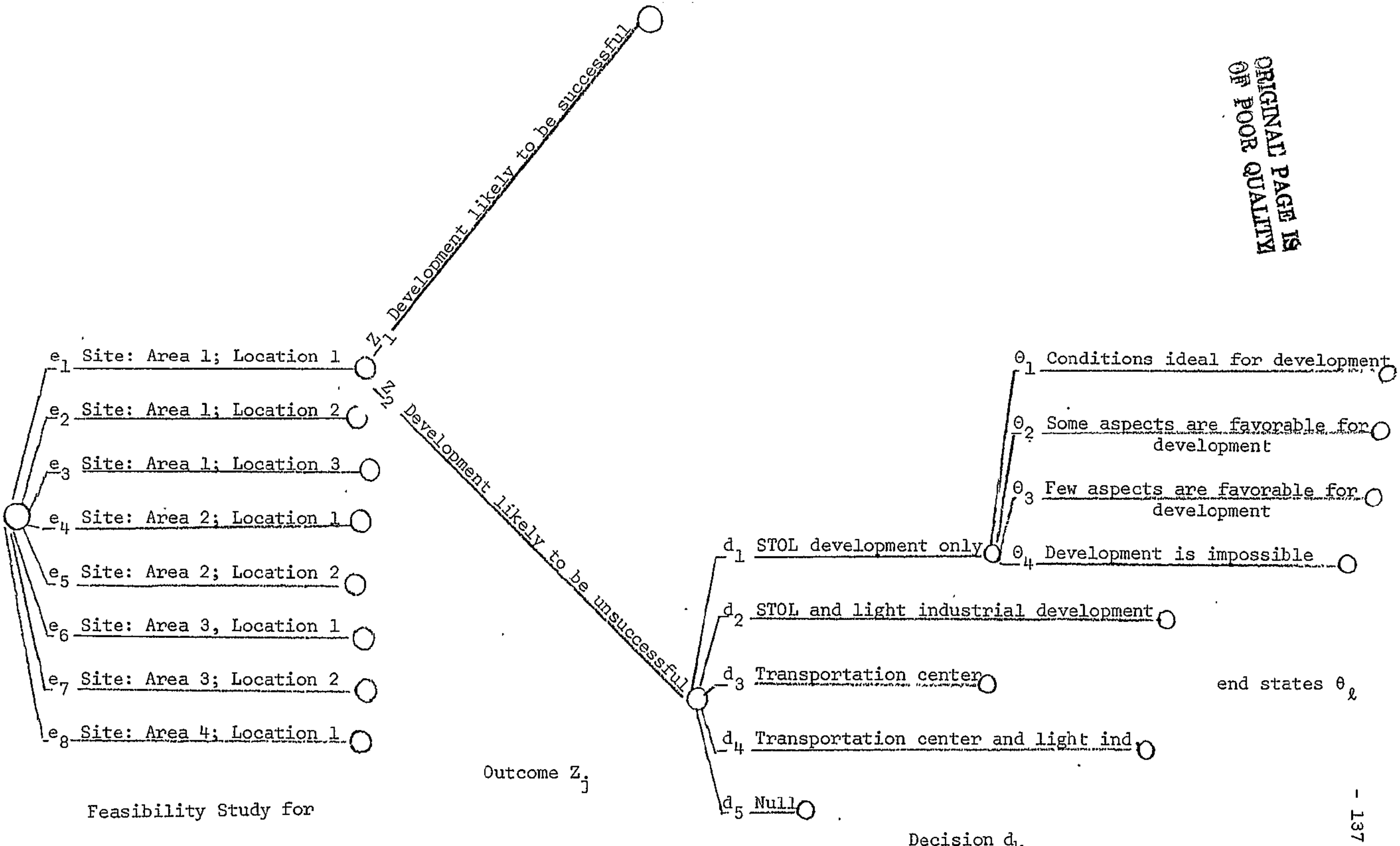


FIGURE 27

PARTIAL BAYESIAN DECISION TREE FOR LOCATIONAL DEVELOPMENT

Development of Probabilities

In using the Bayesian modelling format, it is necessary to subjectively estimate two different types of probabilities. The first probability is the $P'(\theta_\ell)$ for all ℓ, the a priori probability of state ℓ occuring. The other set of probabilities to be estimated are the conditional probababilities $P(z_j|e_i, \theta_\ell)$ which are the probabilities of an experimental outcome j, given a particular feasibility site experiment i, and a state ℓ with respect to the specific site. These two subjective estimates of probabilities are developed by making use of the analyst's experience, judgement, and interpretation of the feasibility and historical indicators with respect to site development.

Internal Rate of Return Method (ROR)

The Rate of Return Method requires a series of cash flows for the purposes of analysis. Cash flows for the transportation alternative sites were based on land costs, capital costs for STOL terminals, aircraft costs, travel demand, fares, non-fare income, lease prices for facilities and capital costs of facilities, etc.

In the ROR analysis, the assumption is made that a private developer will assemble land and facilities and operate the STOL port with tenants on a long term (20 year) lease basis. The STOL carriers' rate of return was computed at an unsubsidized fare level (See Table 72) and at a demand level of 440 passengers per day. A summary of the STOL air carriers income, expenses and rates of return for the routes into Fremont appear in Table 73.

Based on the travel demand for Fremont it should be noted that STOL operation suffers a loss. At this projected demand level in order to provide STOL service, the STOL operator would need a subsidy of roughly four times the current fare levels.

TABLE 72

DAILY TRAVEL DEMAND: CITY OF FREMONT

	Daily travel Demand	Miles	Knot-Miles	Fare	Daily Rev	Daily TOC
Napa Co	23	47.7	54.8	$7.48	172.04	1097.1
Buchanan	56	29.6	34.0	5.40	302.40	1657.6
SFO	341	22.8	26.2	4.62	1575.42	7774.8
Transbay Terminal	20	28.3	32.5	5.25	105.00	566
TOTAL					2,154.86	$11095.5

TABLE 73

RATE OF RETURN ANALYSIS FOR STOL CARRIER

No. of flights daily	44
No. of planes	3
Daily passenger demand	440
Capital cost per plane	1.2 m
yearly operating cost	$2,900,000 or 2.6 m

Flow	Year	Amount ($ x 10^3) Fare from Table 53
1	0	-3600
220	1-20	-2,324

Rate of Return = Non convergence

In detailing the ROR analysis for STOL port options, tables 74 through 78 illustrate the results.

The rate of return analysis for action 1, d_1, STOL development only, assumes that a private operator will lease and operate the STOL facility. The revenues, expenditures and rate of return for this action appear in Table 74. The rate of return is -10.991%.

The second alternative, action 2, d_2: STOL and light industrial development, assumes that a private operator will lease both airport and industrial park facilities to tenants. The light industrial component would cover approximately 50 acres with approximately 50,000 square feet of building space. The cash flows for this alternative appear in Table 75. The rate of return for this alternative is -9.287%.

The third alternative is, action 3, d_3: Transportation Center. This alternative is a facility which is composed of STOL, bus, and rail transfer facilities, all within the confines of one main terminal area. The objective of this type of operation is to provide a multi-modal interchange facility which serves the community. The cash flows for this alternative appear in Table 76. The rate of return for the developer was -6.366%.

The fourth alternative, action 4, is d_4: Transportation Center and light industrial development. In this alternative, in addition to the Transportation Center, there is 50,000 square feet of light industrial facilities on roughly 50 acres surrounding the Transportation Center. The cash flow for this alternative appear in Table 77, with a rate of return of -6.236%.

The fifth and final alternative is action 5, d_5: Null alternative, that is, no STOL port development of any type.

TABLE 74

RATE OF RETURN FOR d_1, STOL DEVELOPMENT ONLY

STOL port annual operating costs	418,000
No. flights per day	44
Landing Fee	$40
Day per year of operation	260
Miscellaneous income per passenger	$.94
Travel demand	440 per day
Capital cost of STOL port	$10m
Land	2.4 m

Year	Amount
0	-12,400,000
1-20	+147,136

Rate of Return -10.991%.

TABLE 75

RATE OF RETURN FOR d_2 STOL AND LIGHT INDUSTRIAL DEVELOPMENT

STOL port annual operating costs	$418,000
No. of flights per day	44
Landing Fee	$40
Days per year of operation	260
Miscellaneous income per passenger	$.94
Travel demand	440 per day
Capital cost of STOL port	$10 m
Land Cost (STOL)	$2.4 m
Land for Light Industrial (50 acres)	$3.75m
Light industrial building cost ($11 x 50,000)	$550,000
Lease income from light industrial annually	$110,000

Year	Amount
0	-16.7 m
1-20	257,136

Rate of Return -9.287

TABLE 76

RATES OF RETURN FOR d_3 TRANSPORTATION CENTER

Transportation Center	
Capital costs	
Bus, Rail	\$6 m
Land (10 acres)	750,000
STOL	
Capital	10 m
Land	2.4 m
STOL port annual operating costs	418,000
No. of flights per day	44
Landing Fee	\$40
Days per year of operation (STOL)	260
Travel demand	440
Miscellaneous income per STOL passenger	\$.94
Rent for bus and rail	\$300,000

Year	Amount
0	-19.15 m
1-20	447,136

Rate of Return -6.366%

TABLE 77

RATE OF RETURN FOR d_4 TRANSPORTATION CENTER AND LIGHT INDUSTRIAL DEVELOPMENT

Transportation Center	
Capital Costs	
Bus, Rail	$6 m
Land (10 acres)	750,000
STOL	
Capital	10 m
Land	2.4 m
STOL port annual operating costs	418,000
No. of flights per day	44
Landing fee	$40
Days per year of operation (STOL)	260
Travel demand	440
Miscellaneous income per STOL passenger	$.94
Rent for bus and rail	$300,000
Light industrial	
Land	$3.75 m
Capital	550,000
Lease income	110,000

Year	Amount
0	-23.45 m
1-20	557,136

Rate of Return -6.236%

ROR Evaluation Over Decision Tree

The complete Bayesian input data for the ROR analysis sets (estimates of $P(z_j|e_i, \theta_\ell)$ and the utilities) is presented in Appendix N. A summary of the sensitivity analysis performed on the a priori probabilities of the different development states occuring appears in Table 78. The sensitivity analysis demonstrates that in using the Rate of Return method for arrival at utility estimates, that the indicated optimal action for all outcomes is dominated by action 5, the null or no development action. The implication is that procurement of additional information via execution of more feasibility experiments will not change the optimal action for the various outcomes.

Rank-based Expected Value

The alternative use of Bayesian analysis employed is the rank-based expected value approach, which requires the capital costs of all facilities, noise impact levels on adjoining land uses, levels of air quality, energy cost, and the benefit-cost ratio of the STOL development. These particular impact categories chosen are most typical of the various impacts considered in modern multi-dimensional transportation analsyis having community consequences.

In the analysis, the actions are ranked from least to most desirable with respect to the following five impacts:

1. The benefit/cost ratio of the STOL facility, reflecting savings in user travel time ratioed against transport facility capital costs.
2. The total energy use by the action.

TABLE 78

BAYESIAN ANALYSIS RESULTS WITH RATE OF RETURN UTILITY ESTIMATES

Estimates of Priors on				Optimal Experiment	Expected Reward	Optimal Action for Outcome	
Θ_1	Θ_2	Θ_3	Θ_4			Z_1	Z_2
.25	.25	.25	.25	2	0	5	5
.30	.25	.25	.20	1	1	5	5
.50	.20	.20	.10	1	1	5	5
.05	.05	.05	.85	6	1	5	5
.05	.05	.85	.05	8	1	5	5
.05	.85	.05	.05	4	0	5	5
.85	.05	.05	.05	1	1	5	5

3. Noise impact.

4. Air quality impact.

5. Capital cost of development.

The modified benefit/cost assumptions for the different actions are shown in Table 79 together with the resulting B/C for each action and its ranking. The null alternative was arbitrarily assigned a B/C of 1. A highly narrow user monetary B/C ratio was developed, with the benefits including only user travel time savings, and costs including only transport facility capital costs. It should again be noted, due to the travel demand relevant to Fremont, that these, like the ROR in the previous section are not at a feasible monetary level.

The energy cost criteria were based on diversion of passengers to more energy efficient modes. These rankings were made subjectively and are depicted in Table 80. The noise impact rankings shown in Table 81 were also estimated with respect to impacts on various categories of adjacent land uses. Air quality rankings were estimated based on an action's potential for indirect source problems, as well as the presence of industrial source difficulties. These rankings are shown in Table 82. The capital cost of all facilities included in an action are also ranked in Table 83.

This REV analysis illustrated herein used adjusted weights to reflect a heavy regional emphasis on environmental quality, particularly with respect to air and noise impacts. The complete data and computation for the REV analysis is presented in Appendix N. A summary of the analysis appears in Table 84.

TABLE 79

IMPACT RANKING FOR

BENEFIT COST ANALYSIS

Rank	Action	B/C
1	Transportation Center/Light Industrial	.13
2	Transportation Center	.16
3	STOL/Light Industrial	.18
4	STOL Development only	.25
5	Null	1

TABLE 80

IMPACT RANKING: ENERGY

Rank	Action (d)
1	STOL and Light industrial development
2	Transportation Center and Light Industrial
3	STOL Development only
4	Transportation Center
5	Null

TABLE 81

IMPACT RANKING: NOISE

Rank	Action (d)
1	Transportation Center and Light Industrial
2	Transportation Center
3	STOL and Light Industrial Development
4	STOL Development only
5	Null

TABLE 82

IMPACT RANKING: AIR QUALITY

Rank	Action (d)
1	STOL and Light industrial development
2	Transportation Center and Light Industrial
3	STOL development only
4	Transportation Center
5	Null alternative

TABLE 83

IMPACT RANKING: CAPITAL COST

Rank	Action (d)
1	Transportation Center and Light Industrial
2	Transportation Center
3	STOL and Light Industrial Development
4	STOL development only
5	Null alternative

RANK / RESULT

TABLE 84

RBEV ANALYSIS

HEAVY REGIONAL EMPHASIS ON ENVIRONMENT

Criteria	Weight	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
B/C	10	4 / 40	3 / 30	2 / 20	1 / 10	5 / 50
Energy Cost	10	3 / 30	1 / 10	4 / 40	2 / 20	5 / 50
Noise Impact	30	4 / 120	3 / 90	2 / 60	1 / 30	5 / 150
Air Quality	20	3 / 60	1 / 20	4 / 80	2 / 40	5 / 100
Capital Cost	15	4 / 60	3 / 45	2 / 30	1 / 15	5 / 75
TOTALS		310	195	230	115	425

REV Evaluation over Decision Tree

The complete Bayesian input data for the REV analysis sets (estimates of $P(z_j|e_i, \theta_\ell)$ and the utilities) is presented in Appendix N. A summary of the sensitivity analysis performed on the a priori probabilities of the different development states occuring appears in Table 85. The sensitivity analysis for REV results are similar to those of the ROR analysis. The indicated optimal action for all outcomes is again dominated by action 5, the null or no development action. Like the ROR analysis, the implication is that procurement of additional information via execution of further feasibility experiments will not change the optimal action over the various outcomes.

Markovian Decision Theory

The second model being explored and tested is the Markovian Decision Theory Decision approach articulated in previous chapters at the regional level. Its use at the site level is essentially the same, with more detailed individual analysis of impacts and site phenomenon likely to influence specific location decisions.

Fremont State Space Formulation

The Fremont state space formulation with respect to forecasted housing, population, and employment appears in Table 86. The commercial and industrial land values for Fremont for the various growth states is calculated and appears in Appendix P.

After determination of industrial and commercial land values, the combined average land value for each growth state for Fremont over each transition period was obtained, and used in development of the first component of the reward matrix, illustrated in Table 87.

TABLE 85

BAYESIAN ANALYSIS RESULTS WITH RANK BASED EXPECTED VALUE UTILITY ESTIMATES

Estimates of Priors on				Optimal Experiment	Expected Reward	Optimal Action for Outcome	
θ_1	θ_2	θ_3	θ_4			Z_1	Z_2
.25	.25	.25	.25	2	212	5	5
.30	.25	.25	.20	1	217	5	5
.50	.20	.20	.10	1	234	5	5
.05	.05	.05	.85	6	246	5	5
.05	.05	.85	.05	8	246	5	5
.05	.25	.05	.05	8	212	5	5
.85	.05	.05	.05	1	263	5	5

TABLE 86

FREMONT

GROWTH STATES

(x 10^3)

		State 1	State 2	State 3
1975	Population	116.5	116.5	116.5
	Housing	36.1	36.1	36.1
	Employment	48.3	48.3	48.3
1980	Population	135	133	134
	Housing	43.5	41.6	42.6
	Employment	58.5	55.2	56.9
1990	Population	174.2	171.7	173
	Housing	58.7	56.2	57.5
	Employment	78.8	74.5	76.7

TABLE 87

LAND USE COMPONENT OF REWARD MATRIX-

RELATIVE VALUES DUE TO TRANSITION

($\$ \times 10^6$)

	Growth State 1	Growth State 2	Growth State 3
Growth State 1	127	-5	-3.3
Growth State 2	5	122.8	1.7
Growth State 3	3.3	-1.7	124.5

Value Added Approach

The value added approach involved the formulation of the transition reward matrices on the basis of the value added to the community of Fremont due to the state transition and the cost of the transportation alternative. These reward matrices are illustrated in Tables 88-96 along with single step transition probabilities in Tables 97-105. The value added reward components were measured by an aggregate total of industrial and commercial land use increments for each growth state. The transportation alternative costs were arrived at via considerations of expected capital and operating costs, and revenues.

Table 106 is a presentation of the policy vector from this reward matrix formulation. In this example for all three growth states, the optimal alternative is the null, or no development alternative, that of alternative 9.

Value Matrix Approach

As stated previously, in the value matrix approach, each alternative is ranked according to its attainment of a certain impact, i.e. capital cost, noise, air pollution, levels of regional value added, etc. These rankings for the Fremont analysis are illustrated in Table 107. The impact factors are weighted by state as shown in Table 108, to yield the composite of value matrix scores shown in Table 109. These result in the reward matrices for each alternative exhibited in Tables 110-118, used in conjunction with the historical single step state transition probabilities illustrated in Tables 97-105.

REWARD MATRICES

FREMONT: VALUE ADDED APPROACH

Growth State	1	2	3
1	66.6	-65.4	-63.7
2	-55.4	62.4	-58.7
3	-57.1	-62.1	64.1

TABLE 88 REWARD MATRIX, ALTERNATIVE 1
($\times 10^6$)

Growth State	1	2	3
1	66.6	-65.4	-63.7
2	-55.4	62.4	-58.7
3	-57.1	-62.1	64.1

TABLE 89 REWARD MATRIX, ALTERNATIVE 2
($\times 10^6$)

Growth State	1	2	3
1	66.6	-65.4	-63.7
2	-55.4	62.4	-58.7
3	-57.1	-62.1	64.1

TABLE 90 REWARD MATRIX, ALTERNATIVE 3
($\times 10^6$)

Growth State	1	2	3
1	67.0	-65.0	-63.3
2	-55.0	62.8	-58.3
3	-56.7	-61.7	64.5

TABLE 91 REWARD MATRIX, ALTERNATIVE 4
($\times 10^6$)

Growth State	1	2	3
1	67.0	-65.0	-63.3
2	-55.0	62.8	-58.3
3	-56.7	-61.7	64.5

TABLE 92 REWARD MATRIX, ALTERNATIVE 5

($x\ 10^6$)

Growth State	1	2	3
1	66.3	-65.7	-64.0
2	-55.7	62.1	59.0
3	-57.4	-62.4	63.8

TABLE 93 REWARD MATRIX, ALTERNATIVE 6

Growth State	1	2	3
1	66.3	-65.7	-64.0
2	-55.7	62.1	59.0
3	-57.4	-62.4	63.8

TABLE 94 REWARD MATRIX, ALTERNATIVE 7

Growth State	1	2	3
1	66.9	-65.1	-63.4
2	-55.1	62.7	-58.4
3	-56.8	61.8	64.4

TABLE 95 REWARD MATRIX, ALTERNATIVE 8

Growth State	1	2	3
1	127.0	-5.0	-3.3
2	5.0	122.8	1.7
3	3.3	-1.7	124.5

TABLE 96 REWARD MATRIX, ALTERNATIVE 9

Note: The elements, r_{ij}^{k} reflect the rewards accruing to the study region as a result of the state transition from state i to state j by a transportation alternative k.

REWARD MATRICES

FREMONT: SINGLE STEP TRANSITION PROBABILITIES

Growth State	1	2	3
1	.55	.10	.35
2	.30	.25	.45
3	.30	.30	.40

TABLE 97 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 1

Growth State	1	2	3
1	.50	.15	.35
2	.30	.25	.45
3	.30	.30	.40

TABLE 98 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 2

Growth State	1	2	3
1	.50	.15	.35
2	.30	.25	.45
3	.30	.30	.40

TABLE 99 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 3

Growth State	1	2	3
1	.40	.25	.35
2	.25	.35	.40
3	.30	.30	.40

TABLE 100 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 4

Growth State	1	2	3
1	.40	.25	.35
2	.25	.35	.40
3	.30	.30	.40

TABLE 101 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 5

Growth State	1	2	3
1	.55	.10	.35
2	.25	.30	.45
3	.30	.25	.45

TABLE 102 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 6

Growth State	1	2	3
1	.55	.10	.35
2	.25	.30	.45
3	.30	.25	.45

TABLE 103 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 7

Growth State	1	2	3
1	.35	.30	.35
2	.30	.30	.40
3	.35	.30	.35

TABLE 104 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 8

Growth State	1	2	3
1	.20	.55	.75
2	.25	.40	.35
3	.25	.50	.25

TABLE 105 SINGLE STEP TRANSITION PROBABILITIES, ALTERNATIVE 9

Note: The single step transition probabilities P_{ij}^{k} reflect the probability of the land use system, currently in state i, changing to state j, at the next transition, under alternative k.

TABLE 106

POLICY VECTOR, VALUE ADDED APPROACH

State	Policy Vector: Optimal Alternative	Value Vector
1	9	30.1628
2	9	56.1953
3	9	38.1362

TABLE 107

RANKING OF ALTERNATIVES, VALUE MATRIX ON IMPACTS

	Transportation Alternative, k								
Impact Factor, x	1	2	3	4	5	6	7	8	9
Capital Cost	6	4	5	2	1	7	8	3	9
Noise	1	2	3	8	7	5	6	4	9
Pollution	4	3	2	9	8	6	7	5	1
Energy Cost	4	3	2	9	8	6	7	5	1
Regional Value Added	9	8	7	4	3	6	5	2	1

Note: The transportation alternatives were ranked by impact factor, with the highest ranks associated with the alternative maximizing the relevant impact.

TABLE 108

FACTOR WEIGHTING BY REGIONAL GROWTH STATE

Impact Factor, x	Regional Growth States, i 1	2	3
Capital Cost	5	1	4
Noise	2	4	3
Pollution	1	5	2
Energy Cost	3	3	1
Regional Value Added	4	2	5

Note: The impact factors are weighted by the importance each impact bears to the regional growth state with a weight 5 associated the most important, etc.

TABLE 109

VALUE MATRIX SCORES, BY TRANSPORTATION ALTERNATIVE, BY REGIONAL GROWTH STATE

	Transportation Alternative								
Regional Growth State	1	2	3	4	5	6	7	8	9
1	84	68	67	78	63	93	100	51	71
2	60	52	47	114	99	87	98	63	55
3	84	71	70	79	64	91	96	49	71

Note: The score $^{k}_{i}$ (i = regional growth state, k = transportation alternative) represents the aggregate benefits by impact factor for each regional growth state by transportation alternative.

REWARD MATRICES

FREMONT: VALUE MATRIX APPROACH

Growth State	1	2	3
1	84	-24	0
2	24	60	24
3	0	-24	84

TABLE 110 REWARD MATRIX, ALTERNATIVE 1

Growth State	1	2	3
1	68	-16	3
2	16	52	19
3	-3	-19	71

TABLE 111 REWARD MATRIX, ALTERNATIVE 2

Growth State	1	2	3
1	67	-20	3
2	20	47	23
3	-3	-23	70

TABLE 112 REWARD MATRIX, ALTERNATIVE 3

Growth State	1	2	3
1	78	36	1
2	-36	114	-35
3	-1	35	79

TABLE 113 REWARD MATRIX, ALTERNATIVE 4

Growth State	1	2	3
1	63	36	1
2	-36	99	-35
3	-1	35	64

TABLE 114 REWARD MATRIX, ALTERNATIVE 5

Growth State	1	2	3
1	93	-6	-2
2	6	87	4
3	2	-4	91

TABLE 115 REWARD MATRIX, ALTERNATIVE 6

Growth State	1	2	3
1	100	-2	-4
2	2	98	-2
3	4	2	96

TABLE 116 REWARD MATRIX, ALTERNATIVE 7

Growth State	1	2	3
1	51	12	-2
2	-12	63	-14
3	2	14	49

TABLE 117 REWARD MATRIX, ALTERNATIVE 8

Growth State	1	2	3
1	71	-16	0
2	16	55	16
3	0	-16	71

TABLE 118 REWARD MATRIX, ALTERNATIVE 9

Note: r_{ij}^{k} element of the respective reward matrices for the value matrix reward formulation represent the aggregate impacts accruing to the system for each state transition by transportation alternative.

Table 119 exhibits the results of the policy iteration analysis. For State 2, the no development alternative is most appropriate. For either states 1 or 3, both of which represent higher growth rates, alternative 8, which is site location in Area 4 location 1 as shown in Figure 50, is optimal. The reason that this site proved optimal for states 1 and 3 (the higher level growth states with respect to land use, population, employment, etc.) is that while not having any outstanding attributes, it scored above average in each of the rankings of the impact factors.

Conclusions

Upon examing the output from the Bayesian ROR and REV analysis and the Markovian Value Added and Value Matrix analysis it can be seen that STOL development within the community should not be recommended. Since a new STOL port would need to be constructed within the community and only 440 passengers per day are forecast to use STOL, a large capital outlay for STOL construction does not appear worth while.

TABLE 119

POLICY VECTOR, VALUE MATRIX APPROACH

State	Policy Vector: Optimal Alternative	Value Vector
1	8	26.7475
2	9	36.0808
3	8	25.5975

Footnotes

[1] Community Economic Profile for Fremont, Alameda County, California, March, 1977.

[2] Bart Impact Program: Transportation and Travel Impacts of BART: Interim Service Findings. April 1976, Final Report prepared for U.S. DOT and U.S. HUD pg V.

[3] Fremont: Exceptional Livability and its Importance to Business, Fremont Chamber of Commerce, 39737 Paseo Padie Parkway, Fremont, California 94538.

[4] op. cit. Footnote #1.

[5] op. cit. Footnote #1.

[6] op. cit. Footnote #1.

[7] Open Space Element of the General Plan, Community Development Department, Fremont, California, December 1973.

[8] City of Fremont: General Plan Text, May 9, 1977.

[9] City of Fremont Community Development Block Grant Program, Community/Economic Development Department, Community Profile, 1975, pg. 8.

[10] City of Fremont: Commercial Activity Study, January, 1976, pg. 2.

[11] Ibid.

[12] Ibid.

[13] Lynn Randik, Real Estate Association, Allied Brokers, Fremont, California.

[14] Ibid.

[15] op. cit. Footnote #10.

[16] op. cit. Footnote #10.

[17] op. cit. Footnote #9.

[18] op. cit. Footnote #9.

[19] op. cit. Footnote #13.

[20] op. cit. Footnote #1.

[21] op. cit. Footnote #9.

[22]op. cit. Footnote #1.

[23]op. cit. Footnote #1.

[24]op. cit. Footnote #10.

[25]op. cit. Footnote #10.

[26]op. cit. Footnote #10.

[27]op. cit. Footnote #10.

[28]op. cit. Footnote #10.

[29]City of Fremont: Freeway Deletion Impact Study, August 1976, by T. J. KM and Consis Corp.

[30]Map from Fremont General Plan, Fremont, California, 1976.

[31]Ibid.

[32]Ibid.

[33]Ibid.

[34]"Development of an Evaluation Model for Transportation Research and Development Program," by Robert W. Meyer, A thesis presented to the Sever Institute of Technology, Washington University, August, 1976.

CHAPTER X

CONCLUSIONS

CHAPTER X

CONCLUSIONS

It is appropriate to conclude with some discussion of results, issues raised, and areas of further research that have been developed during this last 12 months of study effort.

In conclusion, we have demonstrated the following:

1.) The Regional Commuter Air Transportation problem for a metropolitan region, such as the Bay Area, can be modelled using a Markovian Decision Theory Approach, with appropriate historical inputs to the transition matrices, and incorporation of a variety of monetary and non-monetary components of costs and gains input to the reward matrix.

2.) The results of Chapters 6-8 with respect to the above show that medium or high STOL alternatives appear to offer optimal benefit levels, complementing the Bay Area regional transportation investments to date, and warrant consideration for further implementation, particularly in a complex commuting region such as the Bay Area.

3.) Likewise, the Bayesian and Markovian approaches are also viable evaluation modelling structures for analysis of specific STOL port sites, incorporating both private venture capital viewpoints, and public works and non-monetary community impact viewpoints.

4.) With respect to the above, use of the evaluation models for the case site of Fremont California produced minimal incentives for STOL Port siting in the community, due to low travel demand levels, and the dominance of highest and best use land values associated with Agricultural use throughout all areas of the city. Highly altered travel demand and highly focused associated external stimuli for industrial park development in the future could alter such results.

5.) Based on the use of the above approaches at the regional and site specific level in the Bay Region, with its expansive, sophisticated and complex regional travel characteristics, it is concluded that the models have proven themselves structurally functional to be considered transferable to other regions as general evaluation approaches. It should be pointed out again, as in previous volumes, the models closely approximate the real world decision process, and do require reasonable regional data travel inputs and historical analysis of transportation-land use trends in the region, ordering and structuring this information through the modelling format to yield a manageable decision framework and output.

Needs for Further Research

As in any research, this study has yielded notation of places where gaps in the research have hindered the effort, and discovered further potential use of the modelling tools developed. Specifically:

1.) The issue of subsidizing a metropolitan intra-regional air commuter service that should complement the transportation supply of the region is a particularly difficult problem. The issue of who pays, and the similarity of the subsidy ratios to other urban transportation investments (highways, mass transit) is a very open question. Much hinges on the philosophical viewpoint of either requiring a pure market approach, where "inefficient" operators are forced out of the market, or an incentive approach, where the subsidy is viewed as a beginning entity, leveraging the region's resources and opening up more opportunities for new and efficient travel, thus stimulating land use and commercial, tourist and private capital investment.

2.) The above is critical due to the shifts that subsidy, along with travelers' perception of value of their own travel time, cause in fare levels. Unsubsidized STOL fare levels to cover costs are likely to be so high as to truncate the market to levels not inducing operation, site renovation or construction. Should wage rate, or auto and transit energy and pollution costs become so high, such that the value of travel time shifts upward significantly, STOL will be the recipient of a substantial travel market share. The size and procedural application of subsidy to fare levels is a major lever in the above market shift. Further research on simulation of subsidy levels against different fare levels, travel demand states, and fleet scenarios is definitely worthwhile, regardless of the long lead time before STOL may be regularly implemented on a regional level.

The modelling approaches also have functional relevance for application and development in the following research extensions:

1.) Use of the model in a multi-regional commuter scenario, such as the Pacific Northwest Region, where air commuting offers incentives for tourist, cultural, commercial and administrative efficiency in a rural region.

2.) To discover optimal plane size, design and fleet characteristics for regional or multi-regional air commuter programs, by study of sensitivity analyses of monetary costs and gains against employment of alternative candidate commuter aircraft.

3.) Broadening of evaluation at a regional, or national level to use the model format in multimodal transportation planning evaluation use either at the regional scale employed herein, or in gross multi-modal technology assessment of bounds of optimality of different types and mixes of transportation for various city types and scenarios.

4.) Development of a comprehensive methodological approach to evaluation of appropriate aeronautical manufacturing and airline industry expansion paths over the coming decades, in light of American life styles, energy and economic requirements, and Federal perspective with respect to them. Such a modelling approach could be used to develop compatible long range strategies and short range adjustment programs across the aircraft industry, the operator's activity and the government scientific, policy and regulatory sectors, thus yielding maximum benefit for the nation's air transport resources and users.

In conclusion, the model is usable for regional and site specific evaluation. The research has drawn some conclusions from the Bay Area, and allowed testing of the model to the point where it is functionally transferable to other general regional problem scenarios. The research has raised some procedural, philosophical, and operating questions with respect to subsidy, and has yielded discovery of several other multi-regional and national areas for further research and model development.

APPENDIX A

MARKOVIAN DECISION THEORY

APPENDIX A

MARKOVIAN DECISION THEORY

A. Expected Reward of a Policy

The expected reward $v_i(n)$ from a set of staged decisions (policy), given a starting point (i) is defined by the recurrence relationship

$$v_i(n) = \sum_{j=1}^{N} p_{ij}\left(r_{ij} + v_j(n-1)\right) \qquad i = 1, 2, \ldots N, \quad n = 1, 2, \ldots$$

By defining q_i, the expected reward from the next stage transition, given the starting state i

$$q_i = \sum_{j=1}^{N} p_{ij} r_{ij} \qquad i = 1, 2, \ldots N$$

the recurrence relationship can be written in the form

$$v_i(n) = q_i + \sum_{j=1}^{N} p_{ij} v_j(n-1) \qquad i = 1, 2, \ldots N, \; n = 1, 2, \ldots$$

As an example, suppose our problem contained two states, with matrices

$$R = \begin{bmatrix} 9 & 3 \\ 3 & -7 \end{bmatrix} \qquad P = \begin{bmatrix} .5 & .5 \\ .4 & .6 \end{bmatrix}$$

Then, after computing

$$q = \begin{bmatrix} 6 \\ -3 \end{bmatrix}$$ the recurrence relationship can be used to construct the values in the following table:

TOTAL EXPECTED REWARD AS A FUNCTION OF STATE
AND NUMBER OF STAGES REMAINING

n =	0	1	2	3	4	5
$v_1(n)$	0	6	7.5	8.55	9.555	10.5555
$v_2(n)$	0	-3	-2.4	-1.44	-0.444	0.5556

APPENDIX A
(continued)

B. Gain of an Ergodic Process

The gain (g) of an ergodic process can be found from

$$g = \sum_{i=1}^{N} \pi_i q_i$$

where q_i is the expected immediate return in state i and π_i is the steady state probability of state i. The gain can be visualized as the return per transition of the process.

C. The Policy Iteration Method

Expected total return is defined as

$$v_i(n) = q_i + \sum_{j=1}^{N} p_{ij} v_j(n-1) \qquad i = 1, 2, .. N \qquad n = 1, 2, ...$$

As n increases, $v_i(n)$ asymptotically approaches the line

$$v_i(n) = ng + v_i$$

for the ergodic process (where g is the gain and v_i is the axis intercept). If the system is run for a large number of stages one can use

$\sum_{j=1}^{N} p_{ij} = 1$ to develop the relationship

$$g + v_i = q_i + \sum_{j=1}^{N} p_{ij} v_j \qquad i = 1, 2, ... N$$

which is a set of N simultaneous linear equations with N + 1 unknowns (N v_i's and one g). Setting $v_N = 0$ allows solution of the system for g, the expected (relative) gain of a policy. By comparing gains for the set of possible policies, the optimal policy can be determined.

If an optimal policy exists up to stage n, the best alternative in the ith state at stage n+1 can be found by maximizing the function

APPENDIX A
(continued)

$$q_i^k + \sum_{j=1}^{N} p_{ij} v_j^k(n)$$

over all alternatives (k) in the ith state. Using the results obtained in the last section for large n, substitute

$$v_i(n) = ng + v_i$$

and obtain the test quantity

$$q_i^k + \sum_{j=1}^{N} p_{ij}^k v_j$$ with respect to the alternatives in the ith state. In summary: for each state i, find the alternative k that maximizes the test quantity using the relative values determined under the old policy. The alternative k now becomes d_i, the decision in the ith state. A new policy has been determined when this procedure has been performed for every state. The iteration cycle is as follows:

VALUE-DETERMINATION OPERATION

Use p_{ij} and q_i for a given policy to solve

$$g + v_i = q_i + \sum_{j=1}^{N} p_{ij} v_j \qquad i = 1, 2, \ldots N$$

for all relative values v_i and g (by setting $v_N = 0$).

POLICY IMPROVEMENT ROUTINE

For each state i, find the alternative k* that maximizes

$$q_i^k + \sum_{j+1}^{N} p_{ij}^k v_j$$

using the relative values v_i of the previous policy. Then k* becomes the new decision in the ith state, q_i^{k*} becomes q_i, and p_{ij}^{k*} becomes p_{ij}.

APPENDIX A
(continued)

The process can begin in either of the boxes. If value determination is selected as the starting point, an initial policy must be selected. If policy improvement is to start, then a starting set of values is necessary. If nothing else is *a priori* better, it is convenient to start in policy improvement with all $v_i = 0$. The optimal policy is reached when two successive iterations are identical in policy chosen. In our examples above, we are given the following data:

State	Alternative	Transition Probabilities		Rewards		Expected Immediate Return
i	k	p_{i1}^k	p_{i2}^k	r_{i1}^k	r_{i2}^k	q_i^k
1	1	.5	.5	9	3	6
	2	.8	.2	4	4	4
2	1	.4	.6	3	-7	-3
	2	.7	.3	1	-19	-5

Step 1: Set $v_1 = v_2 = 0$ and enter policy improvement routine

Step 2: It chooses maximum immediate returns, giving

$$d = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \qquad P = \begin{bmatrix} .5 & .5 \\ .4 & .6 \end{bmatrix} \qquad q = \begin{bmatrix} 6 \\ -3 \end{bmatrix}$$

Step 3: Entering the value determination routine:

$g + v_1 = 6 + .5v_1 + .5v_2$ and

$g + v_2 = -3 + .4v_1 + .6v_2$ By setting $v_2 = 0$ we solve and obtain

$g = 1 \qquad v_1 = 10 \qquad v_2 = 0.$

Step 4 Applying the policy improvement routine:

APPENDIX A
(continued)

State	Alternative	Test Quantity
i	k	$q_i^k + \sum_{j=1}^{2} p_{ij}^k v_j$
1	1	$6 + .5(10) + .5(0) = 11$
	2	$4 + .8(10) + .2(0) = 12*$
2	1	$-3 + .4(10) + .6(0) = 1$
	2	$-5 + .7(10) + .3(0) = 2*$

yields

$$d = \begin{bmatrix} 2 \\ 2 \end{bmatrix} \qquad p = \begin{bmatrix} .8 & .2 \\ .7 & .3 \end{bmatrix} \qquad q = \begin{bmatrix} 4 \\ -5 \end{bmatrix}$$

Step 5: Repeating the process:

$$g + v_1 = 4 + .8v_1 + .2v_2$$

$$g + v_2 = -5 + .7v_1 + .3v_2$$

yielding $v_2 = 0$ $\qquad g = 2$ $\qquad v_1 = 10$

Step 6: As one can see, the computations will be identical, and will yield the same results. Then we have reached two successive identical policies, implying that this is the optimal policy:

$$d = \begin{bmatrix} 2 \\ 2 \end{bmatrix}$$

APPENDICES B AND C

REGIONAL GROWTH STATE TRANSITIONS

Appendix B is a presentation of the urbanized land projections developed by ABAG and MTC for the 1980 and 1990 planning years. Appendix C is presented to show the percentage changes for urbanized land over each of the planning time horizons. The data in Appendices B and C was arrived at using the current Series 3 projections.

In Appendix B, land use types used were of three types, Urbanized Area, Commercial Land, and Industrial Land. Urbanized Area as defined for the purposes of this report includes land in four sub-categories. These are:

Basic Acreage: The land which is used for activities classified as "basic." This land is used for the production of goods and services mainly for export out of the region or for intermediate use by other firms within the region. Further, it is composed of economic activities which depend primarily on interregional transportation facilities and this land area is viewed as the "priming" agent in the employee locational process.

Local - Serving Acreage: The land which is utilized for industries which are dependent primarily upon the location of the night-time residential population from which most of the demand for consumer service and goods originates, and upon the day-time location of workers who also generate some demand for these goods and services. These industries are broken down into five categories: (1) Retail Trade, (2) Business Services, (3) Retail Services, (4) Public Schools, and (5) Other.

Residential Acreage: That land occupied by housing units and residential group quarters.

Streets and Highways: That land occupied by all streets, highways, freeways, and interchanges.

One final point is that the image of urbanized area is one of closely packed land uses (i.e. commercial strip) along highways and streets. In reality, development does not always take place in this manner. In urbanized areas there are locales of sparsely used land with intermittent cluster development. As a result, definitions of urbanized areas can yield perceptual problems. For the purposes of this report, in locations where available land is only partially developed, judgement has been applied, with great dependence being given to the principle of contiguity of development in the definition of urbanized area.

In arriving at the commercial land and industrial land categories, appropriate factors were applied to the urbanized land figure to arrive at respective values for each of the time periods. Given the urbanized land in both the base and projected years, commercial land was found by multiplying the urbanized land by a 0.046 factor. Similarly, industrial land was determined via multiplying urbanized land by a 0.060 factor. These values were critical in the formation of the value added transition reward matrices.

APPENDIX B

LAND USE CHANGES BY GROWTH STATE: Series 3 Projections

	Base 1975 Data			Base Case 1: 1980			Base Case 1: 1990		
County	Urbanized Area	Commercial Land	Industrial Land	Urbanized Area	Commercial Land	Industrial Land	Urbanized Area	Commercial Land	Industrial Land
San Francisco	23,990	1,103.5	1,439.4	24,078.2	1,107.6	1,444.7	24,255	1,115.7	1,455.3
Marin	28,109	1,293.0	1,686.5	38,503.9	1,771.2	2,310.2	59,325	2,729.0	3,559.5
San Mateo	59,754	2,748.7	3,585.2	70,014.7	3,220.7	4,200.9	90,567	4,166.1	5,434.0
Sonoma	34,503	1,587.1	2,070.2	48,120.4	2,213.5	2,887.2	75,396	3,468.2	4,523.8
Napa	12,642	581.5	758.5	15,101.5	694.7	906.1	20,028	921.3	1,201.7
Solano	20,763	955.1	1,245.8	32,133.3	1,478.1	1,928.0	54,908	2,525.8	3,294.5
Contra Costa	68,063	3,130.9	4,083.8	90,127.6	4,145.9	5,407.7	134,323	6,178.9	8,059.4
Santa Clara	108,290	4,981.3	6,497.4	146,713.9	6,748.8	8,802.8	223,677	10,289.1	13,420.6
Alameda	90,432	4,159.9	5,425.9	98,235.9	4,518.9	5,894.2	113,867	5,237.9	6,832.0
Total	446,546	20,541.1	26,792.8	563,029.4	25,899.4	33,781.8	796,346	36,631.9	47,780.8

APPENDIX B
(continued)

County	Base Case 2: 1980			Base Case 2: 1990		
	Urbanized Area	Commercial Land	Industrial Land	Urbanized Area	Commercial Land	Industrial Land
San Francisco	24,051.6	1,106.4	1,443.1	24,175	1,112.1	1,450.5
Marin	35,205.2	1,619.4	2,112.3	49,419	2,273.3	2,965.1
San Mateo	69,920.8	3,216.4	4,195.2	90,285	4,153.1	5,417.1
Sonoma	40,922.2	1,882.4	2,455.3	53,780	2,473.9	3,226.8
Napa	13,440.2	618.2	806.4	15,039	691.8	902.3
Solano	25,946.8	1,193.6	1,556.8	36,330	1,671.2	2,179.8
Contra Costa	86,154.6	3,963.1	5,169.3	122,392	5,630.0	7,343.5
Santa Clara	139,837.4	6,432.5	8,390.2	203,027	9,339.2	12,181.6
Alameda	97,898.5	4,503.3	5,873.9	112,854	5,191.3	6,771.2
Total	533,377.4	24,535.4	32,002.6	707,301	32,535.9	42,438.1

APPENDIX B
(continued)

County	Base Case 3 Data: 1980			Base Case 3 Data: 1990		
	Urbanized Area	Commercial Land	Industrial Land	Urbanized Area	Commercial Land	Industrial Land
San Francisco	24;064.9	1,107.0	1,443.9	24,215	1,113.9	1,452.9
Marin	36,854.6	1,695.3	2,211.3	54,372	2,501.1	3,262.3
San Mateo	69,967.8	3,218.5	4,198.1	90,426	4,159.6	5,425.6
Sonoma	44,521.3	2,048.0	2,671.3	64,588	2,971.0	3,875.3
Napa	14,270.9	656.5	856.3	17,533.5	806.5	1,052.0
Solano	29,040.0	1,335.8	1,742.4	45,619	2,098.5	2,737.1
Contra Costa	88,141.1	4,054.5	5,288.5	128,357.5	5,904.4	7,701.4
Santa Clara	143,275.6	6,590.7	8,596.5	213,352	9,814.2	12,801.1
Alameda	98,067.2	4,511.1	5,884.0	113,360.5	5,214.6	6,801.6
Total	548,203.4	25,217.4	32,892.2	751;823.5	34,583.9	45,109.4

APPENDIX C

PROJECTED URBANIZED LAND: Series 3 Projections

County	Base Case 1			± % increase or decrease x 10^{-2}		
	Base Data 1975	1980	1990	% 1980 to Base Data	% 1990 to Base Data	% 1990 to 1980
San Francisco	23,990	24,078.2	24,255	+.004	+.011	+.007
Marin	28,109	38,503.9	59,325	+.370	+1.111	+.541
San Mateo	59,754	70,014.7	90,567	+.172	+.516	+.294
Sonoma	34,503	48,120.4	75,396	+.395	+1.185	+.567
Napa	12,642	15,101.5	20,028	+.195	+.584	+.326
Solano	20,763	32,133.3	54,908	+.548	+1.645	+.709
Contra Costa	68,063	90,127.6	134,323	+.324	+.974	+.490
Santa Clara	108,290	146,713.9	223,677	+.355	+1.066	+.525
Alameda	90,432	98,235.9	113,867	+.086	+.259	+.159
Total	446,546	563,029.4	796,346	+.261	+.783	+.414

APPENDIX C
(continued)

	Base Case 2			% $\overset{+}{\text{increase}}$ or $\overset{-}{\text{decrease}}$ x 10^{-2}		
County	Base Data 1975	1980	1990	% 1980 to Base Data	% 1990 to Base Data	% 1990 to 1980
San Francisco	23,990	24,051.6	24,175	+.003	+.008	+.005
Marin	28,109	35,205.2	49,419	+.252	+.758	+.404
San Mateo	54,754	69,920.8	90,285	+.277	+.649	+.291
Sonoma	34,503	40,922.2	53,780	+.186	+.559	+.314
Napa	12,642	13,440.2	15,039	+.063	+.190	+.119
Solano	20,763	25,946.8	36,330	+.250	+.750	+.400
Contra Costa	68,063	86,154.6	122,392	+.266	+.798	+.421
Santa Clara	108,290	139,837.4	203,027	+.291	+.875	+.452
Alameda	90,432	97,898.5	112,854	+.083	+.248	+.153
Total	446,546	533,377.4	707,301	+.194	+.584	+.326

APPENDIX C
(continued)

County	Base Case 3			% increase or decrease x 10^{-2}		
	Base Data 1975	1980	1990	% 1980 to Base Data	% 1999 to Base Data	% 1990 to 1980
San Francisco	23,990	24,064.9	24,215	+.003	+.009	+.006
Marin	28,109	36,854.6	54,372	+.311	+.934	+.475
San Mateo	59,754	69,967.8	90,426	+.171	+.513	+.292
Sonoma	34,503	44,521.3	64,588	+.290	+.872	+.451
Napa	12,642	14,270.9	17,533.5	+.129	+.387	+.387
Solano	20,763	29,040.0	45,619	+.399	+1.197	+.571
Contra Costa	68,063	88,141.1	128,357.5	+.295	+.886	+.456
Santa Clara	108,290	143,275.6	213,352	+.323	+.970	+.489
Alameda	90,432	98,067.2	113,360.5	+.084	+.254	+.156
Total	446,546	548,203.4	751,823.5	+.228	+.684	+.371

APPENDIX D

PROVISIONAL SERIES 3 PROJECTIONS

APPENDIX D

PROVISIONAL SERIES 3 PROJECTIONS

TOTAL POPULATION: 1990

County	1975	Base Case 1	Base Case 2	Base Case 3
San Francisco	672.6	641.9	645.1	643.5
Marin	216.1	251.9	237.2	244.55
San Mateo	576.4	606.1	597.0	601.55
Sonoma	245.4	345.9	280.6	313.25
Napa	90.0	109.0	90.3	99.65
Solano	186.3	345.6	227.5	286.55
Contra Costa	582.8	774.3	690.5	732.4
Santa Clara	1169.7	1367.0	1352.0	1359.5
Alameda	1089.9	1180.3	1163.4	1171.85
Total	4829.2	5621.9	5283.7	5452.8

APPENDIX D
(continued)

PROVISIONAL SERIES 3 PROJECTIONS

OCCUPIED HOUSING UNITS: 1990

County	1975	Base Case 1	Base Case 2	B. Case 3
San Francisco	299.3	307.7	308.9	308.3
Marin	79.2	108.4	108.4	108.4
San Mateo	208.1	244.6	253.2	248.9
Sonoma	100.5	166.6	139.5	153.05
Napa	28.4	39.7	32.6	36.15
Solano	62.3	150.9	101.7	126.3
Contra Costa	201.7	321.0	314.2	317.6
Santa Clara	392.4	537.8	575.3	556.55
Alameda	396.6	487.3	508.8	498.05
Total	1768.6	2363.9	2342.7	2353.3

ORIGINAL PAGE IS
OF POOR QUALITY

APPENDIX D
(continued)

PROVISIONAL SERIES 3 PROJECTIONS

EMPLOYMENT AT PLACE OF WORK: 1990

County	1975	Base Case 1	Base Case 2	B. Case 3
San Francisco	495.4	594.5	567.8	581.15
Marin	55.7	66.2	61.6	63.9
San Mateo	225.1	254.6	241.4	248.0
Sonoma	77.3	114.9	98.5	106.7
Napa	28.6	36.3	34.6	35.45
Solano	52.3	70.7	66.2	68.45
Contra Costa	160.1	212.9	189.0	200.95
Santa Clara	517.8	723.2	661.7	692.45
Alameda	434.3	507.4	479.6	493.5
Total	2046.6	2580.6	2400.5	2490.55

APPENDICES E, F, AND G

TRAVEL DEMAND RELATIONSHIPS

	Mill Valley	Gnoss	Rhonert Park	Napa Co.	Buchanan	Richmond	Jack London	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trade	Trans Bay
Mill Valley							.91		.99				.99			
Gnoss							.99		.99							
Rhonert Park									.99							
Napa Co.						.87	.99	.99	.99					.99	.99	.99
Buchanan									.99					.99	.91	.89
Richmond										.94			.99	.93		
Jack London										.04		.98	.76	.91		
Oak										.13		.96	.94	.99		
Fremont														.50	.98	.98
Livermore														.99	.99	.99
SJC														.74		
Cupertino															.99	.99
Palo Alto															.77	.72
SFO																
World Trade																
Trans Bay																

APPENDIX E

MODAL SPLIT PERCENTAGES

	Mill Valley	Gnoss	Rhonert Park	Napa Co.	Buchanan	Richmond	Jack London	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trade	Trans Bay	
Mill Valley																	
Gnoss				17.19	21.94		-5.17	9.67		24.59	47.9	37.92	40.51	38.43	15.77	-7.16	-4.57
Rhonert Park							6.62	18.98		33.74		59.41	61.39	42.97	35.36	16.6	7.45
Napa Co.							23.57			34.86						36.65	36.0
Buchanan						-1.14	7.86	18.32	28.75	36.71	25.44	56.6	60.81	59.81	43.31	29.8	30.9
Richmond									.37	10.06	1.64	19.44	21.34	34.63	24.96	8.39	9.42
Jack London										-2.23	11.11	21.51	27.91	25.91	10.77	-3.17	0.02
Oak										-10.76	-12.36	10.24	16.63	4.8	9.54	-6.3	-7,87
Fremont										-16.49	-7.33	7.14	13.54	11.54	20.15	2.66	2.57
Livermore													-1.06		0.07	18.25	17.91
SJC													5.58	12.9	31.86	53.43	53.6
Cupertino															4.31	22.76	20.75
Palo Alto															7.3	22.25	23.07
SFO																3.92	4.92
World Trade																-5.76	-5.27
Trans Bay																	

APPENDIX F
EQUIVALENT MINUTES OF TRAVEL
AUTO-AIR @ $.20/MIN. TRAVEL TIME VALUE

	Mill Valley	Gnoss	Rhonert Par	Napa Co.	Buchanan	Richmond	Jack London	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trade	Trans Bay	
Mill Valley								6						632			
Gnoss																	
Rhonert Park								6						284			
Napa Co.								6						331			
Buchanan														532			
Richmond																	
Jack London																	
Oak														495			
Fremont																	
Livermore														495			
SJC																	
Cupertino																	
Palo Alto																	
SFO																	
World Trade																	
Trans Bay																	

J - Factor .60

APPENDIX G
FINAL DEMAND: AIR FEEDER
ALTERNATIVE I

	Mill Valley	Gnoss	Rhonert Park	Napa Co.	Buchanan	Richmond	Jack London	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trade	Trans Bay
Mill Valley								6						632		
Gnoss																
Rhonert Park								6						284		
Napa Co.								6						331		
Buchanan														532		
Richmond																
Jack London														248		
Oak	6		6	6										248		
Fremont														248		
Livermore														248		
SJC																
Cupertino																
Palo Alto																
SFO	316	316	284	331	532		248	248	248	248						
World Trade																
Trans Bay																

Alternative III

Alternative IV

FINAL DEMAND: AIR FEEDER

I - Factor .6

ALTERNATIVE III AND IV

ORIGINAL PAGE IS OF POOR QUALITY

	Mill Valley	Gnoss	Rhonert Park	Napa Co.	Buchanan	Richmond	Jack London	Oak	Fremont	Livermore	SJC	Cupertino	Palo Alto	SFO	World Trade	Trans Bay	
Mill Valley			523	43			91	13	11	5	6	15	20	165			
Gnoss							31		1		6	17		59			
Rhonert Park						7			3						5	28	
Napa Co.						62	49	17	23					4	16	18	
Buchanan								89	56					57	213	91	
Richmond										14			4	30			
Jack London										9		4	16	69			
Oak										27		7	20	40			
Fremont														93	17	20	
Livermore														19	10	16	
SJC														7			
Cupertino															18	17	
Palo Alto															33	52	
SFO																	
World Trade																	
Trans Bay																	

FINAL DEMAND: AIR COMMUTER

APPENDICES H, I, AND J

LAND VALUE RELATIONSHIPS

APPENDIX H

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

BASE 1975 DATA

1	2	3	4	5 (3 x 4 x 43,560)	6	7	8 (6 x 7 x 43,560)
County	Urbanized Area	Commercial Land Acres	Value $/sq. ft.	Commercial Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	23,990	1,103.5	21.50	1033.0×10^6	1,439.4	12.50	783.8×10^6
Marin	28,109	1,293.0	12.00	675.8×10^6	1,686.5	5.50	404.1×10^6
San Mateo	59,754	2,748.7	16.00	1915.7×10^6	3,585.2	6.40	999.5×10^6
Sonoma	34,503	1,587.1	6.50	449.4×10^6	2,070.2	4.00	360.7×10^6
Napa	12,642	581.5	10.75	272.3×10^6	758.5	6.00	198.2×10^6
Solano	20,763	955.1	5.50	228.8×10^6	1,245.8	2.50	135.7×10^6
Contra Costa	68,063	3,130.9	10.75	1466.1×10^6	4,083.8	6.00	1067.3×10^6
Santa Clara	108,290	4,981.3	7.50	1627.4×10^6	6,497.4	4.50	1273.6×10^6
Alameda	90,432	4,159.9	5.50	996.6×10^6	5,425.9	2.50	590.9×10^6
TOTAL	446,546	20,541.1	-	8665.1×10^6	26,792.8	-	5813.8×10^6

APPENDIX H
(continued)

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

Base Case 1: 1980

1	2	3	4	5 (3 x 4 . 43,560)	6	7	8 (6 x 7 x 43,560)
County	Urbanized Area	Commerical Land	Value $/sq. ft.	Commercial Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	24,078.2	1,107.6	21.50	1037.3×10^6	1,444.7	12.50	786.6×10^6
Marin	38,503.9	1,771.2	12.00	925.8×10^6	2,310.2	5.50	553.5×10^6
San Mateo	70,014.7	3,220.7	16.00	2244.7×10^6	4,200.9	6.40	1171.1×10^6
Sonoma	48,120.4	2,213.5	6.50	626.7×10^6	2,887.2	4.00	503.1×10^6
Napa	15,101.5	694.7	10.75	325.3×10^6	906.1	6.00	236.8×10^6
Solano	32,133.3	1,478.1	5.50	354.1×10^6	1,928.0	2.50	209.9×10^6
Contra Costa	90,127.6	4,145.9	10.75	1941.4×10^6	5,407.7	6.00	1413.4×10^6
Santa Clara	146,713.9	6,748.8	7.50	2204.8×10^6	8,802.8	4.50	1725.5×10^6
Alameda	98,235.9	4,518.9	5.50	1082.6×10^6	5,894.2	2.50	641.9×10^6
TOTAL	563,029.4	25,899.4	-	10742.7×10^6	33,781.8	-	7241.8×10^6

APPENDIX H
(continued)

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

Base Case 1: 1990

1	2	3	4	(3 x 4 x 43,560) 5	6	7	(6 x 7 x 43560) 8
County	Urbanized Area	Commercial Land	Value $/sq. ft.	Commercial Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	24,255	1,115.7	21.50	1044.9×10^6	1,455.3	12.50	792.4×10^6
Marin	59,325	2,729.0	12.00	1426.5×10^6	3,559.5	5.50	852.8×10^6
San Mateo	90,567	4,166.1	16.00	2903.6×10^6	5,434.0	6.40	1514.9×10^6
Sonoma	75,396	3,468.2	6.50	981.9×10^6	4,523.8	4.00	788.2×10^6
Napa	20,028	921.3	10.75	431.4×10^6	1,201.7	6.00	314.1×10^6
Solano	54,908	2,525.8	5.50	605.1×10^6	3,294.5	2.50	358.8×10^6
Contra Costa	134,323	6,178.9	10.75	2893.4×10^6	8,059.4	6.00	2106.4×10^6
Santa Clara	223,677	10,289.1	7.50	3361.5×10^6	13,420.6	4.50	2630.7×10^6
Alameda	113,867	5,237.9	5.50	1254.9×10^6	6,832.0	2.50	744.0×10^6
TOTAL	796,346	36,631.9	-	14903.2×10^6	47,780.8	-	10102.0×10^6

APPENDIX H
(continued)

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

Base Case 2: 1980

1	2	3	4	5 (3 x 4 x 43,560)	6	7	8 (6 x 7 x 43,560)
County	Urbanized Area	Commercial Land	Value $/sq. ft.	Commerical Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	24,051.6	1,106.4	21.50	1036.2×10^6	1,443.1	12.50	785.7×10^6
Marin	35,205.2	1,619.4	12.00	846.5×10^6	2,112.3	5.50	506.1×10^6
San Mateo	69,920.8	3,216.4	16.00	2241.7×10^6	4,195.2	6.40	1169.6×10^6
Sonoma	40,922.2	1,882.4	6.50	532.9×10^6	2,455.3	4.00	427.8×10^6
Napa	13,440.2	618.2	10.75	289.5×10^6	806.4	6.00	210.8×10^6
Solano	25,946.8	1,193.6	5.50	285.9×10^6	1,556.8	2.50	169.5×10^6
Contra Costa	86,154.6	3,963.1	10.75	1855.8×10^6	5,169.3	6.00	1351.0×10^6
Santa Clara	139,837.4	6,432.5	7.50	2101.5×10^6	8,390.2	4.50	1644.6×10^6
Alameda	97,898.5	4,503.3	5.50	1078.9×10^6	5,873.9	2.50	639.7×10^6
TOTAL	533,377.4	24,535.4	-	10268.9×10^6	32,002.6	-	6904.8×10^6

APPENDIX H
(continued)

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

Base Case 2: 1990

1	2	3	4	(3 x 4 x 43,560) 5	6	7	(3 x 4 x 43,560) 8
County	Urbanized Area	Commercial Land	Value $/sq. ft.	Commercial Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	24,175	1,112.1	21.50	1041.5×10^6	1,450.5	12.50	789.8×10^6
Marin	49,419	2,273.3	12.00	1188.3×10^6	2,965.1	5.50	710.4×10^6
San Mateo	90,285	4,153.1	16.00	2894.5×10^6	5,417.1	6.40	1510.2×10^6
Sonoma	53,780	2,473.9	6.50	700.5×10^6	3,226.8	4.00	562.2×10^6
Napa	15,039	691.8	10.75	323.9×10^6	902.3	6.00	235.8×10^6
Solano	36,330	1,671.2	5.50	400.4×10^6	2,179.8	2.50	237.4×10^6
Contra Costa	122,392	5,630.0	10.75	2636.4×10^6	7,343.5	6.00	1919.3×10^6
Santa Clara	203,027	9,339.2	7.50	3051.1×10^6	12,181.6	4.50	2387.8×10^6
Alameda	112,854	5,191.3	5.50	1243.7×10^6	6,771.2	2.50	737.4×10^6
TOTAL	707,301	32,535.9	-	13480.3×10^6	42,438.1	-	9090.3×10^6

APPENDIX H
(continued)

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

Base Case 3: 1980

1	2	3	4	(3 x 4 x 43,560) 5	6	7	(6 x 7 x 43,560) 8
County	Urbanized Area	Commercial Land	Value $/sq. ft.	Commercial Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	24,064.9	1,070.0	21.50	1036.8×10^6	1,443.9	12.50	786.2×10^6
Marin	36,854.6	1,695.3	12.00	886.2×10^6	2,211.3	5.50	529.8×10^6
San Mateo	69,967.8	3,218.5	16.00	2243.2×10^6	4,198.1	6.40	1170.4×10^6
Sonoma	44,521.3	2,048.0	6.50	579.9×10^6	2,671.3	4.00	465.5×10^6
Napa	14,270.9	656.5	10.75	307.4×10^6	856.3	6.00	223.8×10^6
Solano	29,040.0	1,335.8	5.50	320.0×10^6	1,742.4	2.50	189.8×10^6
Contra Costa	88,141.1	4,054.5	10.75	1898.6×10^6	5,288.5	6.00	1382.2×10^6
Santa Clara	143,275.6	6,590.7	7.50	2153.2×10^6	8,596.5	4.50	1685.1×10^6
Alameda	98,067.2	4,511.1	5.50	1080.8×10^6	5,884.0	2.50	640.8×10^6
TOTAL	548,203.4	25,217.4	-	10506.1×10^6	32,892.2	-	7073.6×10^6

APPENDIX H
(continued)

INDUSTRIAL AND COMMERCIAL LAND AREA BY GROWTH STATE

Base Case 3: 1990

1	2	3	4	(3 x 4 x 43,560) 5	6	7	(6 x 7 x 43,560) 8
County	Urbanized Area	Commerical Land	Value $/sq. ft.	Commercial Land Value	Industrial Land	Value $/sq. ft.	Industrial Land Value
San Francisco	24,215	1,113.9	21.50	1043.2×10^6	1,452.9	12.50	791.1×10^6
Marin	54,372	2,501.1	12.00	1307.4×10^6	3,262.3	5.50	781.6×10^6
San Mateo	90,426	4,159.6	16.00	2899.1×10^6	5,425.6	6.40	1512.6×10^6
Sonoma	64,588	2,971.0	6.50	841.2×10^6	3,875.3	4.00	675.2×10^6
Napa	17,533.5	806.5	10.75	377.7×10^6	1,052.0	6.00	274.9×10^6
Solano	45,619	2,098.5	5.50	502.8×10^6	2,737.1	2.50	298.1×10^6
Contra Costa	128,357.5	5,904.4	10.75	2764.9×10^6	7,701.4	6.00	2012.8×10^6
Santa Clara	213,352	9,814.2	7.50	3206.3×10^6	12,801.1	4.50	2509.3×10^6
Alameda	113,360.5	5,214.6	5.50	1249.3×10^6	6,801.6	2.50	740.7×10^6
TOTAL	751,823.5	34,583.9	-	14191.9×10^6	45,109.4	-	9596.3×10^6

APPENDIX I

AVERAGE LAND VALUE BY GROWTH STATE

Growth State		Average Land Value ($ x 10^6)
	Base Year Data (1975)	$14478.9
1	Base Case 1	21494.85
2	Base Case 2	19872.15
3	Base Case 3	20683.95

APPENDIX J

EQUATIONS AND VALUES FOR LAND USE COMPONENT OF REWARD MATRIX

($\$ \times 10^6$)

Value in (1.1) = 21494.85 - 14478.9 = 7015.95

Value in (1,2) = 19872.15 - 21494.85 = -1622.7

Value in (1,3) = 20683.95 - 21494.85 = -810.9

Value in (2,1) = 21494.85 - 19872.15 = 1622.7

Value in (2,2) = 19872.15 - 14478.9 = 5393.25

Value in (2,3) = 20683.95 - 19872.15 = 811.80

Value in (3,1) = 21494.85 - 20683.95 = 810.9

Value in (3,2) = 19872.15 - 20683.95 = -811.80

Value in (3,3) = 20683.95 - 14478.9 = 6205.05

APPENDIX K

SPECIFICATIONS OF RESEARCH CASE STUDY TEST AIRCRAFT AND SUPPORTING ITEMS

APPENDIX K

SPECIFICATIONS OF RESEARCH CASE

STUDY TEST AIRCRAFT AND SUPPORTING ITEMS

Aircraft Selection

Twin Otter DHC-6

Take off distance over 50* ft. *at full gross weight	1200

DHC-6 Proposed Modifications

Propulsión

- Engines

  Standard PT6A-27 with takeoff at reduced power settings

  PT6A-45 with low speed gearbox (now certified)

  PT6A-27 with low speed gearbox

- Propeller

  3,4,5 Bladed Hartzell props now available

Wing

- Install leading edge slats plus spoilers for lateral control

Empennage

- Possibly increase vertical tail size for engine out lateral control

APPENDIX K
(continued)

BUDGETED ESTIMATES

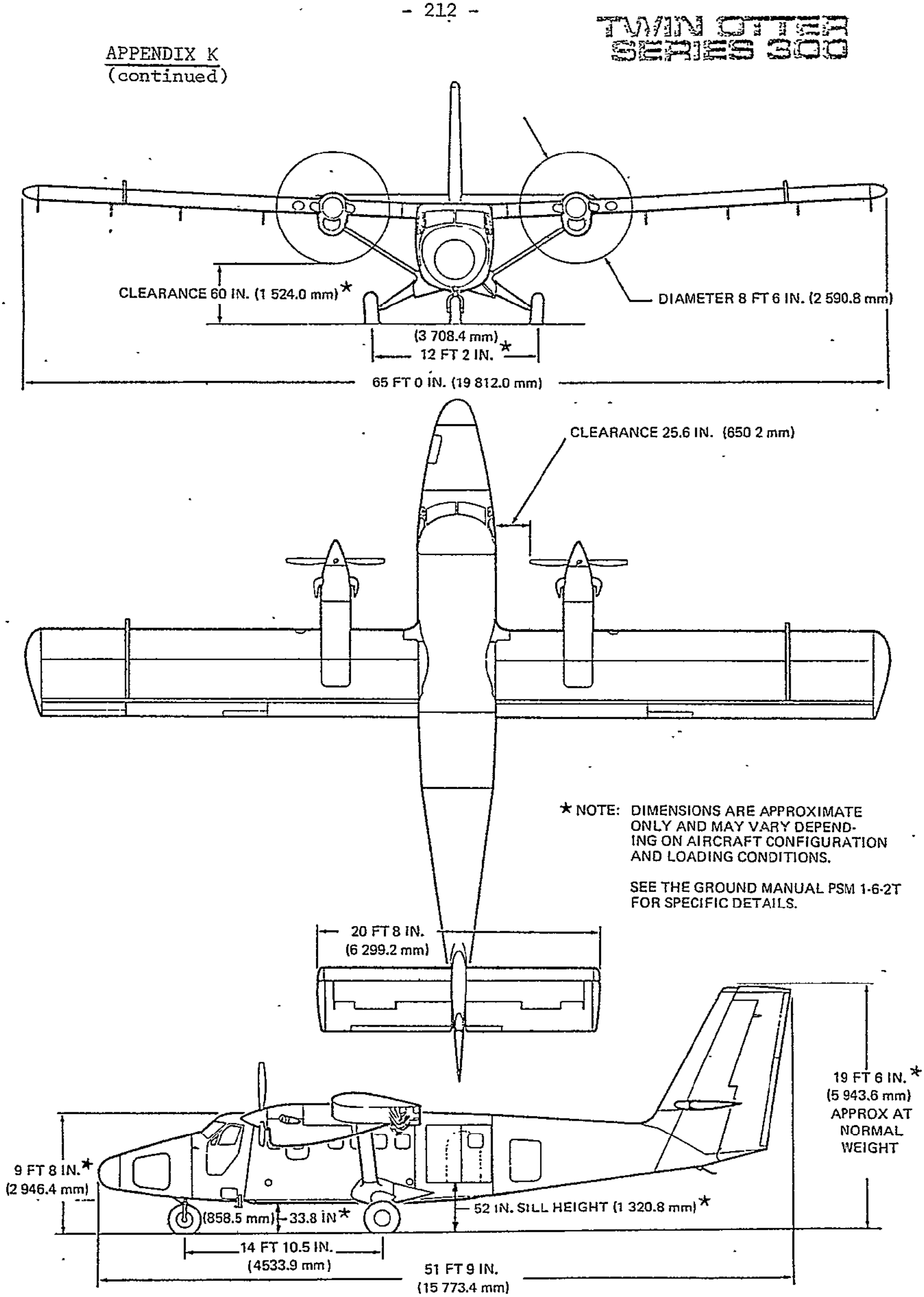
($ Thousands)

a. Modified Aircraft Engine GFE

b. Modified Aircraft Engine(s) Purchased

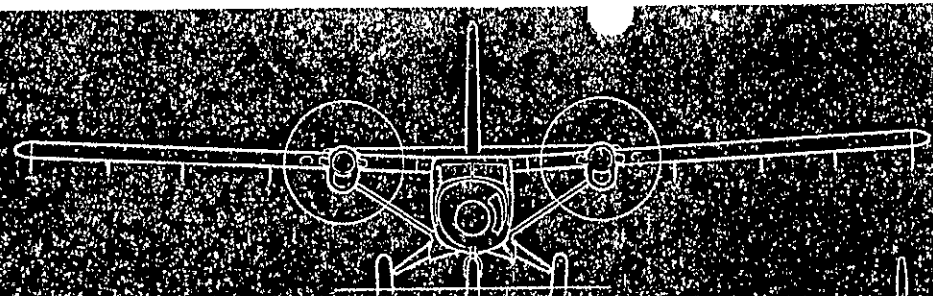
	DHC-6 1A/C	
	a	b
Basic Airframe(s) Modified Engineering included	627	925
A/C Operating Cost	136	136
Total Airframe Costs	763	1,061
Pilot Cost (Salary Ins. 18 Mo.)	36	36
Landing Site Prep & Priv. Rental	38	38
Ground Attendants, Staff Support Site Security	67	67
Ground Support Equip. Rental Office Rental & Personnel Processing Data & Pblsg.	55	55
ARF Personnel	120	120
Accounting, Audit, Legal	54	54
Travel & Per Diems	48	48
Allow for Possible Added Ins. & Misc.	36	36
Total Support Costs	454	454
Total Excluding Barges	1,217	1,515
Barge Sites (5)	262	262
Total Including Barges	1,479	1,777
Airframes, If Not GFE Add	400	400
Preliminary Total Program Costs	1,879	2,177

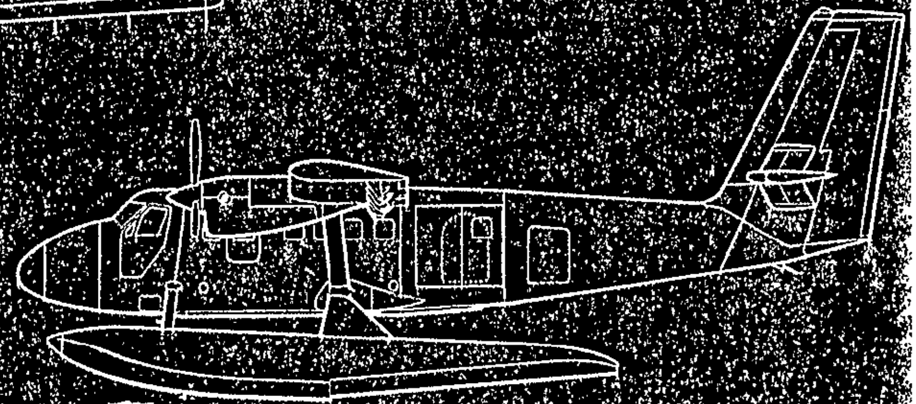
APPENDIX K
(continued)

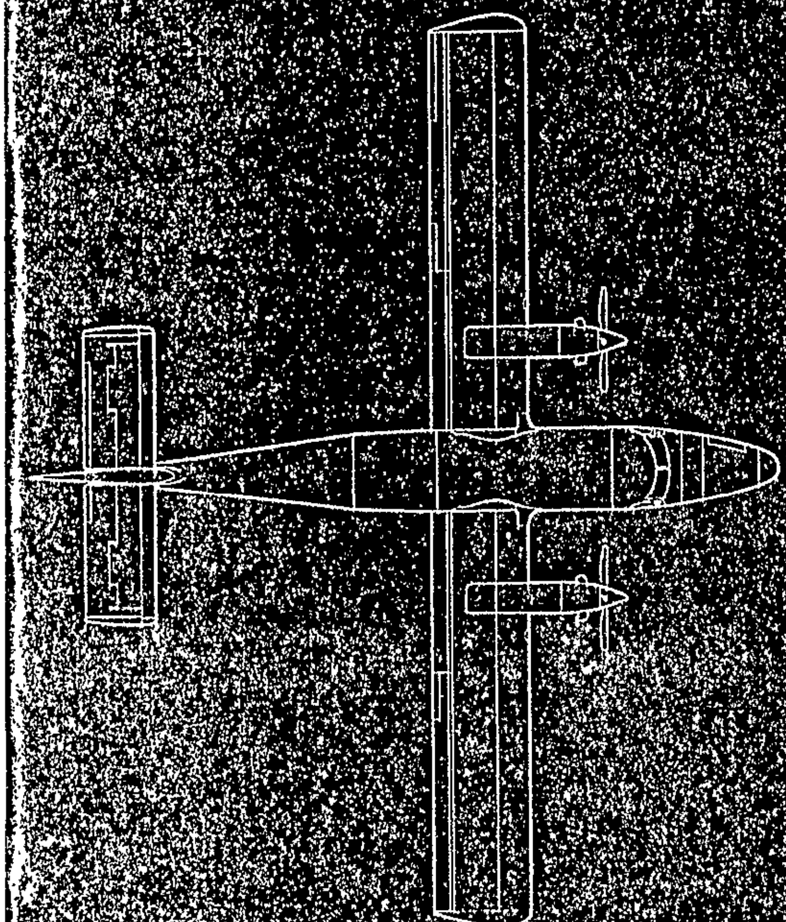


Three-View, Standard Wheelplane

APPENDIX K
(continued)



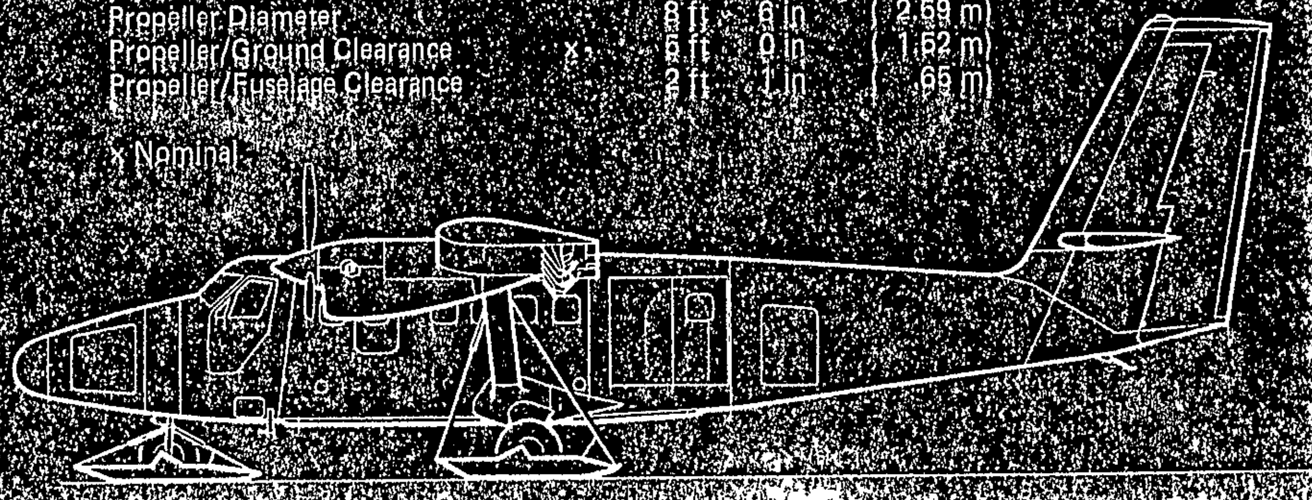




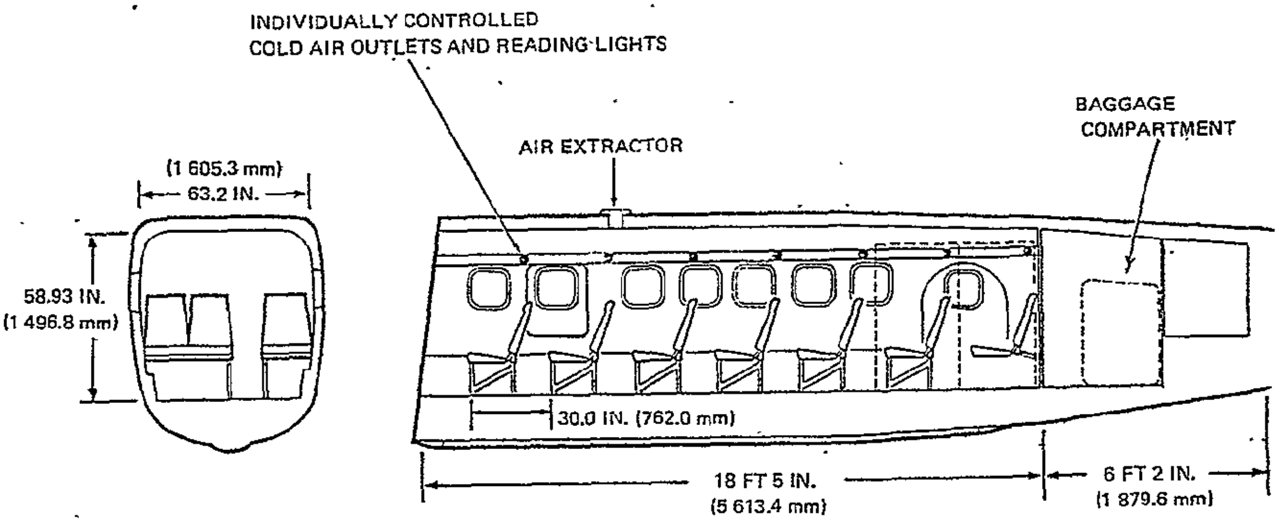
dimensions

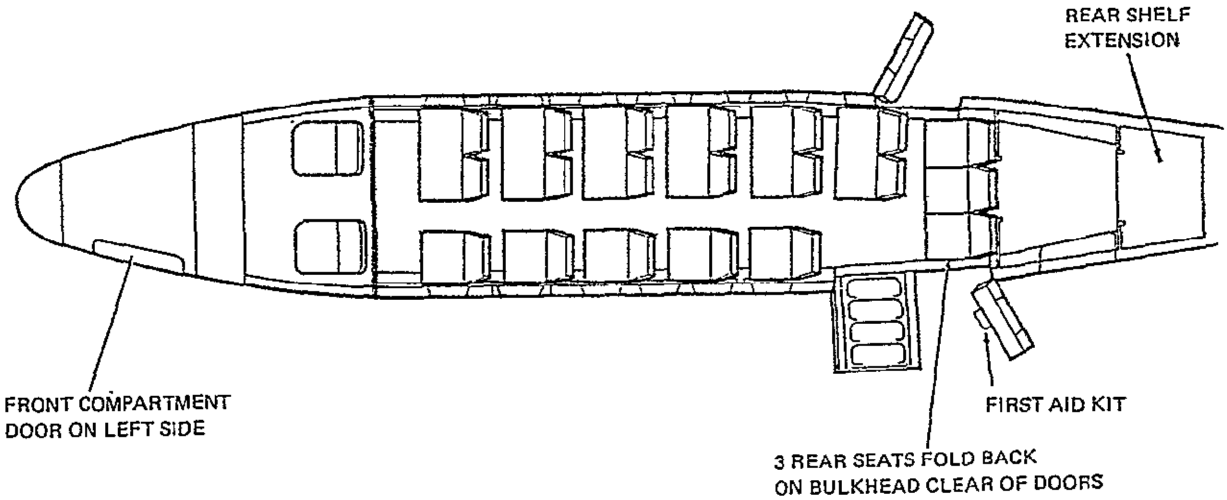
Wing Span			65 ft	0 in	(19.81 m)
Length	Landplane		51 ft	9 in	(15.77 m)
	Seaplane		49 ft	6 in	(15.08 m)
Overall Height	Landplane	x	19 ft	6 in	(5.94 m)
	Seaplane	x	19 ft	10 in	(6.04 m)
Cabin Floor Height		x	4 ft	4 in	(1.32 m)
Track	Landplane	x	12 ft	2 in	(3.70 m)
	Seaplane		13 ft	4 in	(4.05 m)
Wheel Base		x	14 ft	10.5 in	(4.53 m)
Fuselage/Ground Clearance		x	2 ft	9.8 in	(.85 m)
Propeller Diameter			8 ft	6 in	(2.59 m)
Propeller/Ground Clearance		x	5 ft	0 in	(1.52 m)
Propeller/Fuselage Clearance			2 ft	1 in	(.65 m)

x Nominal



APPENDIX K
(continued)

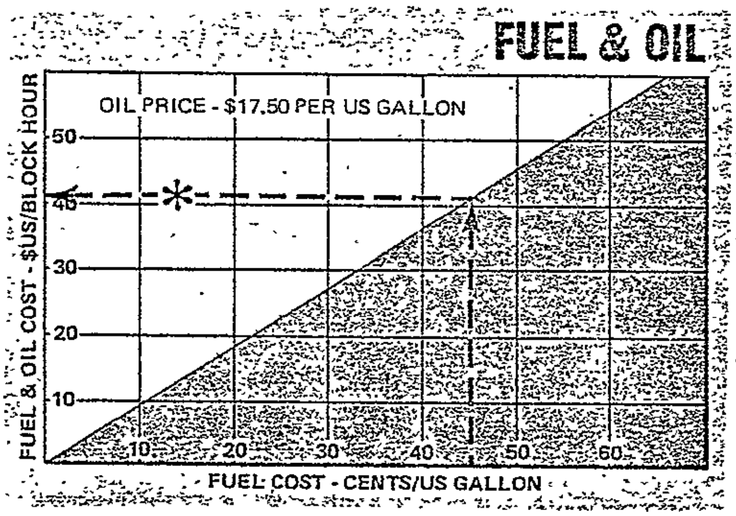


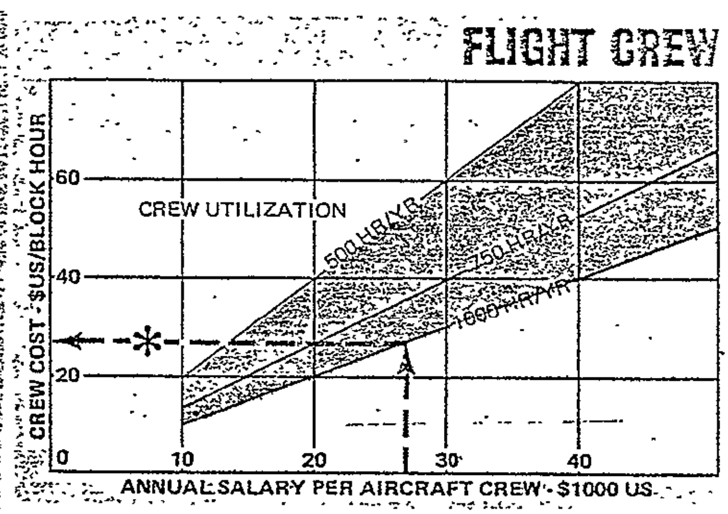


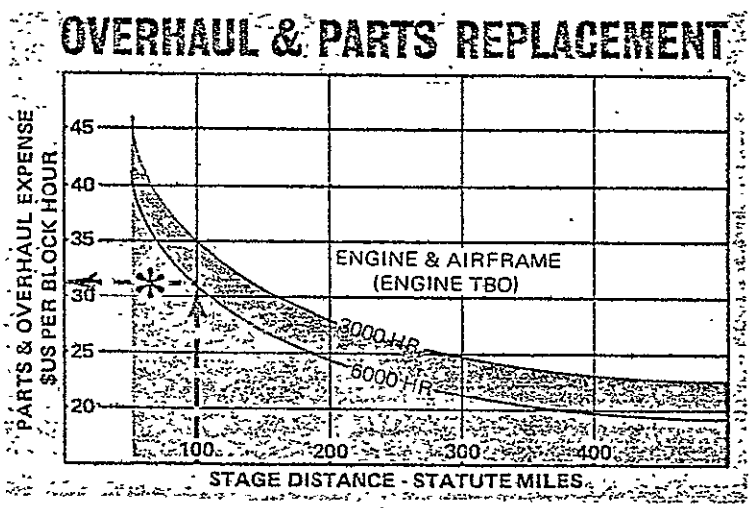
Cabin Layout - Commuter Interior

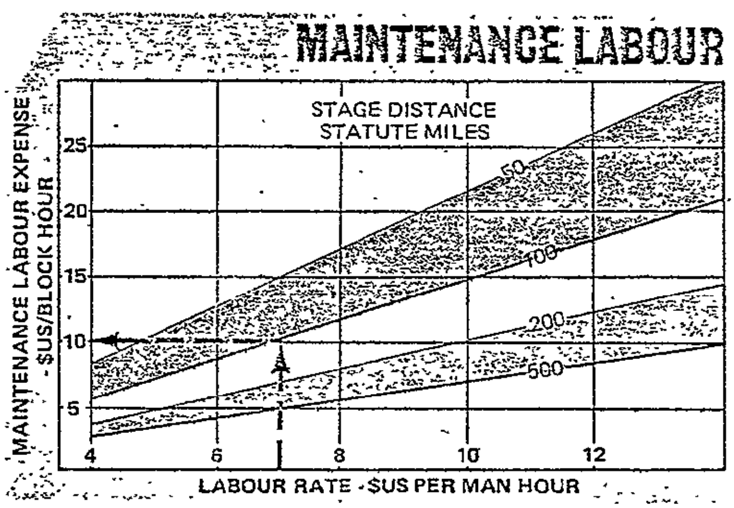
TWIN OTTER

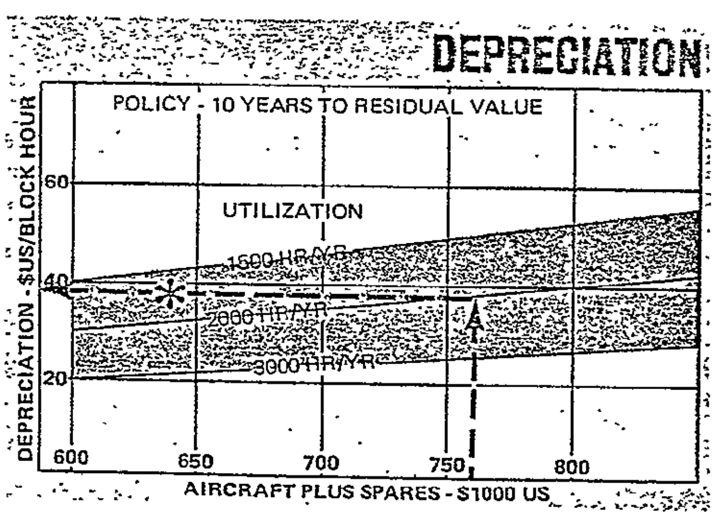
OPERATING COSTS[12]

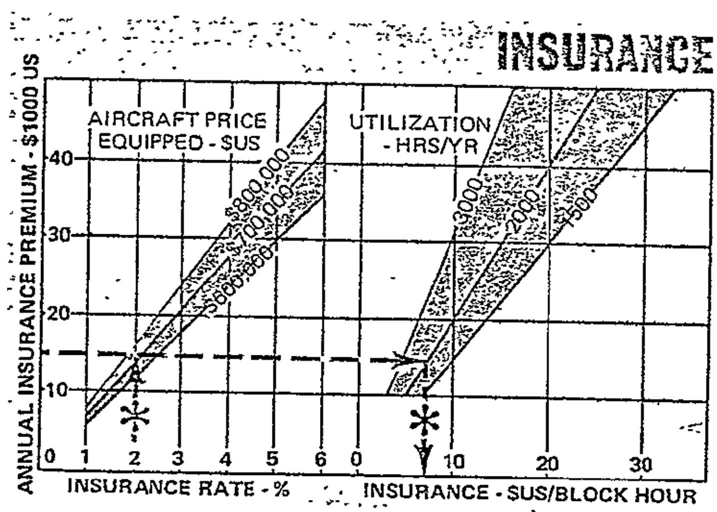








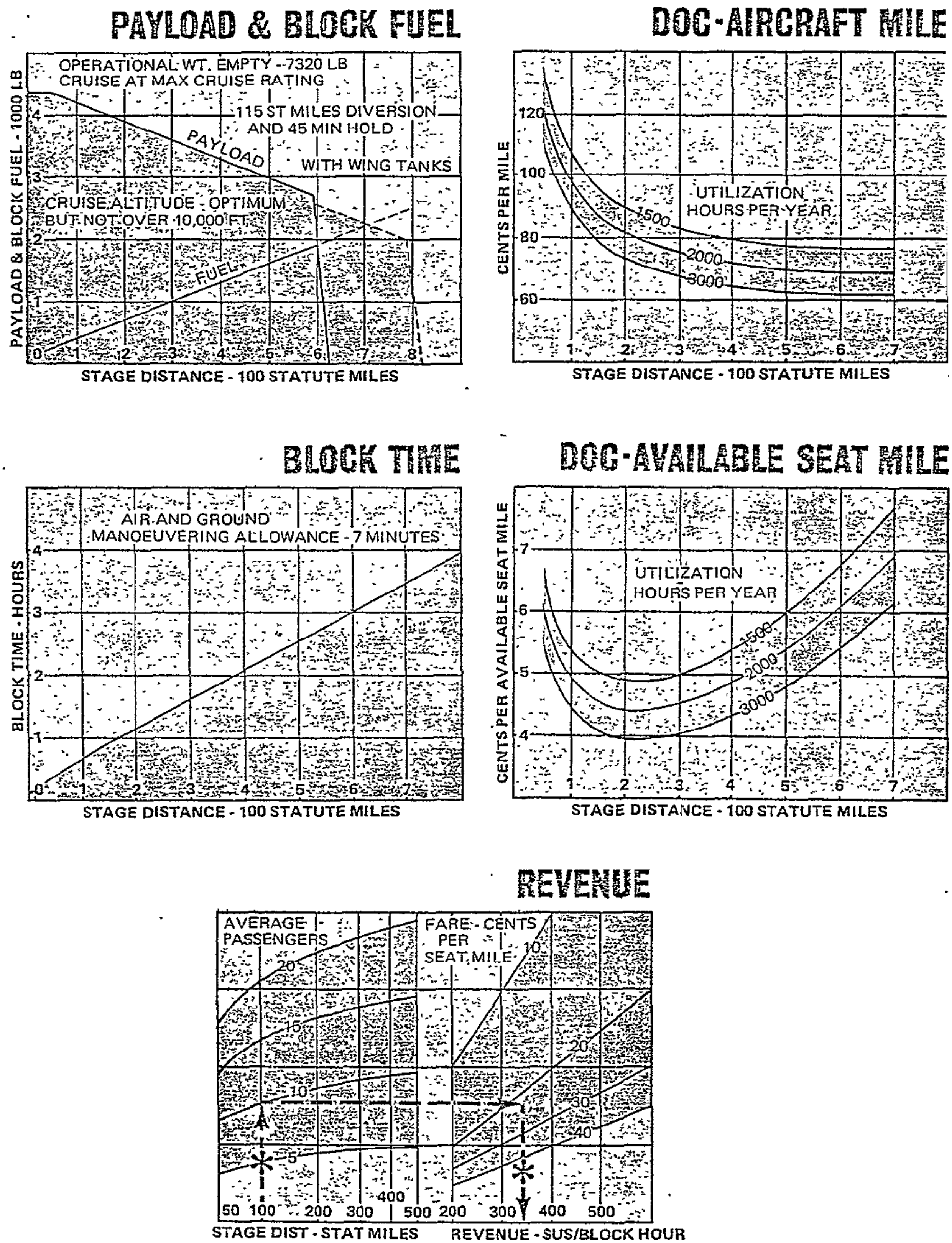




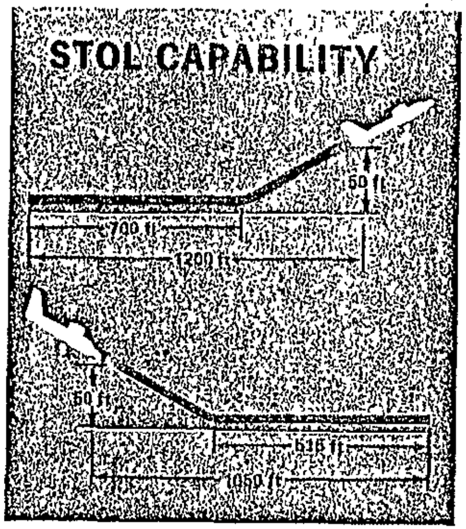
APPENDIX K
(continued)

TWIN OTTER

OPERATING COSTS

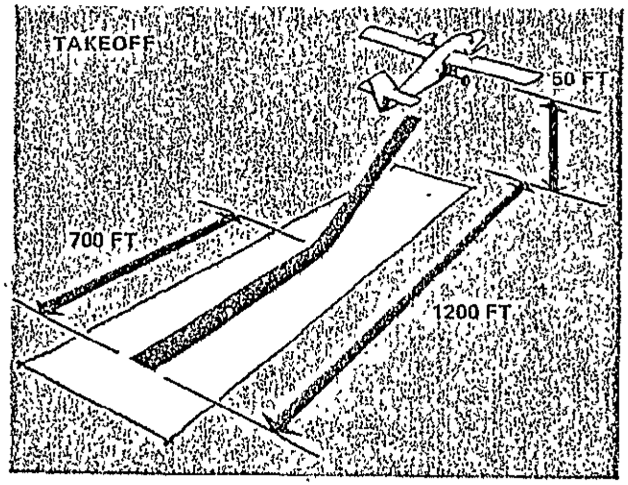


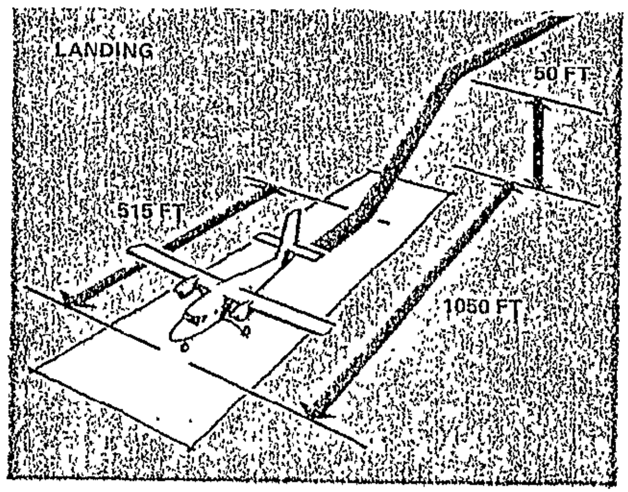
APPENDIX K
(continued)



TWIN OTTER

STOL capability





TWIN OTTER

basic data

POWERPLANT

Engines	Pratt & Whitney PT6A-27
Propellers	Hartzell 8 ft 6 in. diameter, Reversing
Fuel	JP-1, JP-4 or JP-5

Ratings (Sea Level, Static)

Takeoff	620 SHP to 91°F (+32°C)
Max. Continuous	620 SHP to 91°F (+32°C)
Max. Climb	620 SHP to 69°F (+21°C)
Max. Cruise	620 SHP to 69°F (+21°C)

WING AREA

420 sq ft (39 sq m)

WING LOADING (12,500 lb)

29.8 lb/sq ft (145.3 kg/sq m)

WEIGHTS (LANDPLANE)

Maximum Takeoff	12,500 lb	(5,670 kg)
Maximum Landing	12,300 lb	(5,580 kg)
Basic (20 Seat "Commuter")	6,878 lb	(3,120 kg)
Fuel Capacity - Standard	2,583 lb	(1,172 kg)
- With Wing Tanks	3,190 lb	(1,447 kg)

PERFORMANCE AT MAXIMUM WEIGHT (LANDPLANE)

SEA LEVEL, ISA	CAR-3 (U.S. F.A.R. Part 23)	STOL CAPABILITY
Takeoff Distance (Sea Level, ISA)		
Ground Run	860 ft (262 m)	700 ft (213 m)
Distance over 50 ft	1,500 ft (457 m)	1,200 ft (366 m)
Landing Distance (Sea Level, ISA)		
Ground Run	950 ft (290 m)	515 ft (157 m)
Distance over 50 ft	1,940 ft (591 m)	1,050 ft (320 m)
SFAR-23 Accelerate Stop (to full stop)	2,280 ft (695 m)	
Stalling Speed (Power Off)		
Flaps Retracted	74 knots EAS (137 km/hr)	
Flaps Extended	58 knots EAS (107 km/hr)	
Rate of Climb (Sea Level, ISA)		
Two Engines	1,600 ft/min (8.1 m/sec)	
One Engine	340 ft/min (1.7 m/sec)	
Service Ceiling (R/C = 100 ft/min, ISA)		
Two Engines	26,700 ft (8,138 m)	
One Engine	11,600 ft (3,535 m)	
Maximum Cruise Speed (ISA)		
Sea Level	170 knots TAS (315 km/hr)	
5,000 ft (1,524 m)	181 knots TAS (335 km/hr)	
10,000 ft (3,048 m)	182 knots TAS (337 km/hr)	

Payload - Range
20 seat Commuter (refer page 4)
ISA, 45 min fuel reserve

	RANGE	PAYLOAD
Standard Tanks	100 nm (185 km)	4,350 lb (1,973 kg)
	775 nm (1,435 km)	2,530 lb (1,148 kg)
With Wing Tanks	985 nm (1,824 km)	1,923 lb (872 kg)

APPENDIX L

EXAMPLE

ALTERNATIVE III COST ANALYSIS

Total Passenger 9504 Pass/Day

Air Distance mile traveled 966 mile/day

Average mile traveled 25.42 mile

BT	14.35	minutes
ET	7	minutes
Util	6	hours
LF	.5	
SC	20	

$$DFR = \frac{9504}{(.5 \times 20)} = 951/\text{day}$$

$$FLPA = \frac{6(60)}{14.35 + 7} = 17/\text{day}$$

$$FLSZ = \frac{951}{17} = 56 \text{ aircraft}$$

Construction Cost

Construction Cost Alternative I	$\$35.0 \times 10^6$
3 New STOL ports	$\$30.0 \times 10^6$
	$\$65.0 \times 10^6$

STOL Port annual recovery cost

$$(65.0 \times 10^6 \times .11746) = \$7.64 \times 10^6$$

Air Frame Cost

$$56 \text{ aircraft at } \$1.2 \times 10^6 = \$67.2 \times 10^6$$

APPENDIX L
(continued)

Total Operating Cost

$$\underset{20.2}{TOC} = \frac{1.87}{100} (-4.4 (\ln ATL) + 33.813) \; SM$$

$$\underset{20.2}{TOC} = \frac{1.87}{100} \; (-4.4 (\ln 17.25) + 33.813 \; SM$$

$$SM = (951 \times 20 \times \frac{966}{56}) \; 260$$
$$= 85.3 \times 10^6$$

$$\underset{20.2}{TOC} = \$33.95 \times 10^6$$

Air Fare Revenue Expected

Base $2.00 + (.1D x 1.15)

2.00 + 2.08 = 4.08 4.50 minimum

Air fare revenue = (9504 x 4.50 x 260)

= $\$11.2 \times 10^6$

Results

A.	Total operating cost	$\$33.95 \times 10^6$
B.	STOL Port annual recovery cost	7.64×10^6
	TOTAL	$\$41.59 \times 10^6$

Total yearly cost of the operation = $(41.59 \times 10^6 - 11.2 \times 10^6)\ (15.94)$

= $\$484.42 \times 10^6$

APPENDIX M

BAYESIAN DECISION THEORY

APPENDIX M

BAYESIAN DECISION THEORY

To a large extent urban transportation investments are made sequentially over long periods of time. Through the various construction phases the transportation planner can monitor the performance of implemented projects and using this information analyze future investments. Another trait common to transportation investments is that they are generally made under conditions of uncertainty regarding future demands, costs of construction, and costs of operation.

The importance of uncertainties associated with transportation investment is emphasized in a report on transportation planning, published by the Organization for Economic Cooperation and Development and further elaborated on in Principles of Urban Transportation Systems Planning by B. G. Hutchinson;

> Foremost among the obstacles to orderly innovation (in urban transport services), however, has been the element of uncertainty and risk which surrounds the introduction of major changes in transportation systems.
>
> Risk is always present in ushering innovative ideas, but it is particularly acute in the field of transportation. Massive resources will be required for research and development to carry new transportation systems from concepts to operational prototypes, to test them, refine their design and produce working operational systems. As with any untried technology, there will be uncertainty about actual construction and operation costs, and engineering performance. There will be uncertainties about the new systems' environmental side effects, their effects on property values and their compatibility with existing transportation networks. Most importantly, there will be uncertainties about the degree of public acceptability, passenger response and the resulting magnitude of the market for the new transportational service.

The Bayesian theory tells the decision maker to select an alternative which will minimize his expected loss. This expected loss is evaluated with respect to the prior distribution which is defined over the possible states of nature. For example, the basic structure of a Bayesian Decision problem is imposed through the following:

a.) the alternative terminal decisions open to a decisionmaker are d_1, d_2, . . .

b.) the possible states of nature, Θ_1, Θ_2, in that could occur.

c.) the possible experiments e_0, e_1, . . ., that could be performed prior to selection of a terminal decision in order to yield more information about the probability of occurrence of the states of nature.

d.) the possible experimental outcomes Z_1, Z_2, . . . that may be observed with an experiment.

e.) the values of U( ) which represent the decisionmaker's preferences for all e, z, d, Θ combinations relative to his objectives which is a scalar measure representing the relative value to the decision-maker.

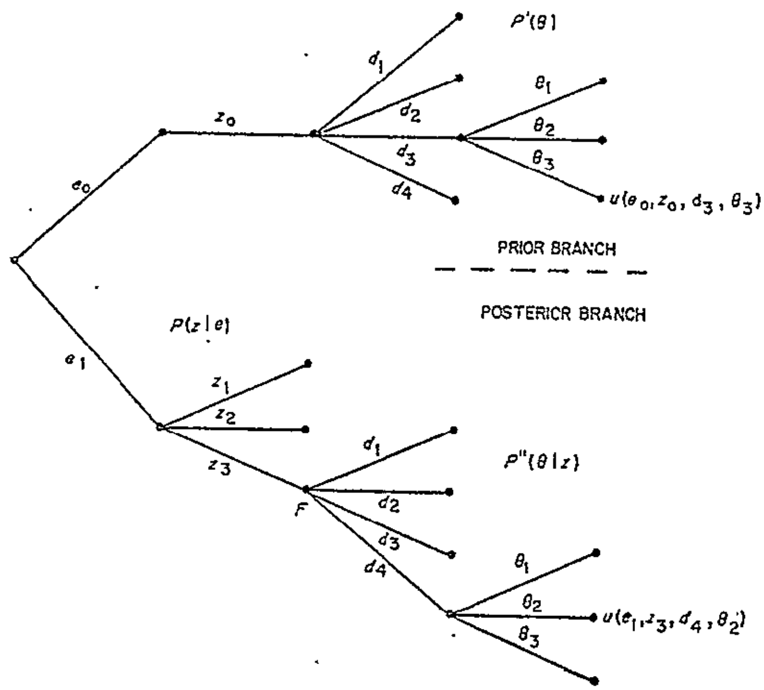
f.) the probabilities P which the decisionmaker assigns to the joint probability distribution of z, Θ for each of the potential experiments or analyses.

In essence, the evaluation scheme of these six components of a decision problem are most readily visualized in the form of a decision tree as shown in Figure 94. In this example, the upper branch of the tree shows the set of activities involved when a terminal decision is taken without any prior experimentation. This branch is called the 'prior branch.' Thus e_0 and z_0, are dummy experiment and outcome respectively concerning the experiment in order to make the flow of activities compatible with the posterior branch where experimentation does occur.

Note in the bottom branch a decision to employ a particular experiment, e_1, which results in outcomes z_1, z_2, z_3, which provide additional information on the probability of occurance of each of the states of nature. On the basis of the added information, an alternative d_1, d_2, d_3, d_4, is chosen, and is executed in the face of (in this case for d_4), Θ_1, Θ_2, Θ_3, the resulting states of nature. Before this experiment is performed there are three possible outcomes (z_1, z_2, z_3,) of the experiment e_1. For each one of these outcomes (z_i) there are four possible decisions (d_1, d_2, d_3, d_4). For each of these decisions (d_j) there are three possible states of nature. This results in 3 x 4 x 3 = 36 potential decision paths for e_1. The uncertainty regarding the states of nature after the new information has become available from the experiment is expressed in the probability distribution $P''(\Theta|z)$. Finally, $U(e_1, z_3, d_4, \Theta_2)$ is a utility, which is a scalar measure representing the relative value to the decision maker of a particular combination of experiment (e_1) an outcome (z_3), choosing a particular alternative (d_4), and having a particular state of outcome obtained (Θ_2).

Figure 94

BAYESIAN DECISION TREE



APPENDICES N AND O .

BAYESIAN COMPUTATIONAL DATA

APPENDIX N

BAYESIAN COMPUTATIONAL DATA

ROR METHOD

EXPERIMENT	OUTCOME	ACT	STATE	P(Z/E,S)	UTILITY
1	1	1	1	0.550	-10.990
1	1	1	2	0.300	-10.990
1	1	1	3	0.150	-10.990
1	1	1	4	0.000	-10.990
1	1	2	1	0.550	-9.290
1	1	2	2	0.300	-9.290
1	1	2	3	0.150	-9.290
1	1	2	4	0.000	-9.290
1	1	3	1	0.550	-6.370
1	1	3	2	0.300	-6.370
1	1	3	3	0.150	-6.370
1	1	3	4	0.000	-6.370
1	1	4	1	0.550	-6.240
1	1	4	2	0.300	-6.240
1	1	4	3	0.150	-6.240
1	1	4	4	0.000	-6.240
1	1	5	1	0.550	1.000
1	1	5	2	0.300	1.000
1	1	5	3	0.150	1.000
1	1	5	4	0.000	1.000
1	2	1	1	0.100	-10.990
1	2	1	2	0.150	-10.990
1	2	1	3	0.300	-10.990
1	2	1	4	0.450	-10.990
1	2	2	1	0.100	-9.290
1	2	2	2	0.150	-9.290
1	2	2	3	0.300	-9.290
1	2	2	4	0.450	-9.290
1	2	3	1	0.100	-6.370
1	2	3	2	0.150	-6.370
1	2	3	3	0.300	-6.370
1	2	3	4	0.450	-6.370
1	2	4	1	0.100	-6.240
1	2	4	2	0.150	-6.240

APPENDIX N
(continued)

ORIGINAL PAGE IS
OF POOR QUALITY

1	2	4	3	0.300	-6.240
1	2	4	4	0.450	-6.240
1	2	5	1	0.100	1.000
1	2	5	2	0.150	1.000
1	2	5	3	0.300	1.000
1	2	5	4	0.450	1.000
2	1	1	1	0.540	-10.990
2	1	1	2	0.310	-10.990
2	1	1	3	0.150	-10.990
2	1	1	4	0.000	-10.990
2	1	2	1	0.540	-9.290
2	1	2	2	0.310	-9.290
2	1	2	3	0.150	-9.290
2	1	2	4	0.000	-9.290
2	1	3	1	0.540	-6.370
2	1	3	2	0.310	-6.370
2	1	3	3	0.150	-6.370
2	1	3	4	0.000	-6.370
2	1	4	1	0.540	-6.240
2	1	4	2	0.310	-6.240
2	1	4	3	0.150	-6.240
2	1	4	4	0.000	-6.240
2	1	5	1	0.540	1.000
2	1	5	2	0.310	1.000
2	1	5	3	0.150	1.000
2	1	5	4	0.000	1.000
2	2	1	1	0.050	-10.990
2	2	1	2	0.150	-10.990
2	2	1	3	0.300	-10.990
2	2	1	4	0.500	-10.990
2	2	2	1	0.050	-9.290
2	2	2	2	0.150	-9.290
2	2	2	3	0.300	-9.290
2	2	2	4	0.500	-9.290
2	2	3	1	0.050	-6.370
2	2	3	2	0.150	-6.370
2	2	3	3	0.300	-6.370
2	2	3	4	0.500	-6.370
2	2	4	1	0.050	-6.240
2	2	4	2	0.150	-6.240
2	2	4	3	0.300	-6.240
2	2	4	4	0.500	-6.240
2	2	5	1	0.050	1.000
2	2	5	2	0.150	1.000
2	2	5	3	0.300	1.000
2	2	5	4	0.500	1.000
3	1	1	1	0.530	-10.990
3	1	1	2	0.320	-10.990
3	1	1	3	0.150	-10.990
3	1	1	4	0.000	-10.990
3	1	2	1	0.530	-9.290
3	1	2	2	0.320	-9.290
3	1	2	3	0.150	-9.290
3	1	2	4	0.000	-9.290
3	1	3	1	0.530	-6.370
3	1	3	2	0.320	-6.370
3	1	3	3	0.150	-6.370
3	1	3	4	0.000	-6.370
3	1	4	1	0.530	-6.240
3	1	4	2	0.320	-6.240

APPENDIX N
(continued)

ORIGINAL PAGE IS
OF POOR QUALITY

3	1	4	3	0.150	-6.240
3	1	4	4	0.000	-6.240
3	1	5	1	0.530	1.000
3	1	5	2	0.320	1.000
3	1	5	3	0.150	1.000
3	1	5	4	0.000	1.000
3	2	1	1	0.050	-10.990
3	2	1	2	0.150	-10.990
3	2	1	3	0.300	-10.990
3	2	1	4	0.500	-10.990
3	2	2	1	0.050	-9.290
3	2	2	2	0.150	-9.290
3	2	2	3	0.300	-9.290
3	2	2	4	0.500	-9.290
3	2	3	1	0.050	-6.370
3	2	3	2	0.150	-6.370
3	2	3	3	0.300	-6.370
3	2	3	4	0.500	-6.370
3	2	4	1	0.050	-6.240
3	2	4	2	0.150	-6.240
3	2	4	3	0.300	-6.240
3	2	4	4	0.500	-6.240
3	2	5	1	0.050	1.000
3	2	5	2	0.150	1.000
3	2	5	3	0.300	1.000
3	2	5	4	0.500	1.000
4	1	1	1	0.500	-10.990
4	1	1	2	0.350	-10.990
4	1	1	3	0.150	-10.990
4	1	1	4	0.000	-10.990
4	1	2	1	0.500	-9.290
4	1	2	2	0.350	-9.290
4	1	2	3	0.150	-9.290
4	1	2	4	0.000	-9.290
4	1	3	1	0.500	-6.370
4	1	3	2	0.350	-6.370
4	1	3	3	0.150	-6.370
4	1	3	4	0.000	-6.370
4	1	4	1	0.500	-6.240
4	1	4	2	0.350	-6.240
4	1	4	3	0.150	-6.240
4	1	4	4	0.000	-6.240
4	1	5	1	0.500	1.000
4	1	5	2	0.350	1.000
4	1	5	3	0.150	1.000
4	1	5	4	0.000	1.000
4	2	1	1	0.050	-10.990
4	2	1	2	0.150	-10.990
4	2	1	3	0.300	-10.990
4	2	1	4	0.500	-10.990
4	2	2	1	0.050	-9.290
4	2	2	2	0.150	-9.290
4	2	2	3	0.300	-9.290
4	2	2	4	0.500	-9.290
4	2	3	1	0.050	-6.370
4	2	3	2	0.150	-6.370
4	2	3	3	0.300	-6.370
4	2	3	4	0.500	-6.370
4	2	4	1	0.050	-6.240
4	2	4	2	0.150	-6.240

APPENDIX N
(continued)

4	2	4	3	0.300	-6.240
4	2	4	4	0.500	-6.240
4	2	5	1	0.050	1.000
4	2	5	2	0.150	1.000
4	2	5	3	0.300	1.000
4	2	5	4	0.500	1.000
5	1	1	1	0.490	-10.990
5	1	1	2	0.340	-10.990
5	1	1	3	0.140	-10.990
5	1	1	4	0.030	-10.990
5	1	2	1	0.490	-9.290
5	1	2	2	0.340	-9.290
5	1	2	3	0.140	-9.290
5	1	2	4	0.030	-9.290
5	1	3	1	0.490	-6.370
5	1	3	2	0.340	-6.370
5	1	3	3	0.140	-6.370
5	1	3	4	0.030	-6.370
5	1	4	1	0.490	-6.240
5	1	4	2	0.340	-6.240
5	1	4	3	0.140	-6.240
5	1	4	4	0.030	-6.240
5	1	5	1	0.490	1.000
5	1	5	2	0.340	1.000
5	1	5	3	0.140	1.000
5	1	5	4	0.030	1.000
5	2	1	1	0.050	-10.990
5	2	1	2	0.150	-10.990
5	2	1	3	0.300	-10.990
5	2	1	4	0.500	-10.990
5	2	2	1	0.050	-9.290
5	2	2	2	0.150	-9.290
5	2	2	3	0.300	-9.290
5	2	2	4	0.500	-9.290
5	2	3	1	0.050	-6.370
5	2	3	2	0.150	-6.370
5	2	3	3	0.300	-6.370
5	2	3	4	0.500	-6.370
5	2	4	1	0.050	-6.240
5	2	4	2	0.150	-6.240
5	2	4	3	0.300	-6.240
5	2	4	4	0.500	-6.240
5	2	5	1	0.050	1.000
5	2	5	2	0.150	1.000
5	2	5	3	0.300	1.000
5	2	5	4	0.500	1.000
6	1	1	1	0.530	-10.990
6	1	1	2	0.320	-10.990
6	1	1	3	0.100	-10.990
6	1	1	4	0.050	-10.990
6	1	2	1	0.530	-9.290
6	1	2	2	0.320	-9.290
6	1	2	3	0.100	-9.290
6	1	2	4	0.050	-9.290
6	1	3	1	0.530	-6.370
6	1	3	2	0.320	-6.370
6	1	3	3	0.100	-6.370
6	1	3	4	0.050	-6.370
6	1	4	1	0.530	-6.240
6	1	4	2	0.320	-6.240

APPENDIX N
(continued)

6	1	4	3	0.100	-6.240
6	1	4	4	0.050	-6.240
6	1	5	1	0.530	1.000
6	1	5	2	0.320	1.000
6	1	5	3	0.100	1.000
6	1	5	4	0.050	1.000
6	2	1	1	0.050	-10.990
6	2	1	2	0.100	-10.990
6	2	1	3	0.300	-10.990
6	2	1	4	0.550	-10.990
6	2	2	1	0.050	-9.290
6	2	2	2	0.100	-9.290
6	2	2	3	0.300	-9.290
6	2	2	4	0.550	-9.290
6	2	3	1	0.050	-6.370
6	2	3	2	0.100	-6.370
6	2	3	3	0.300	-6.370
6	2	3	4	0.550	-6.370
6	2	4	1	0.050	-6.240
6	2	4	2	0.100	-6.240
6	2	4	3	0.300	-6.240
6	2	4	4	0.550	-6.240
6	2	5	1	0.050	1.000
6	2	5	2	0.100	1.000
6	2	5	3	0.300	1.000
6	2	5	4	0.550	1.000
7	1	1	1	0.520	-10.990
7	1	1	2	0.330	-10.990
7	1	1	3	0.100	-10.990
7	1	1	4	0.050	-10.990
7	1	2	1	0.520	-9.290
7	1	2	2	0.330	-9.290
7	1	2	3	0.100	-9.290
7	1	2	4	0.050	-9.290
7	1	3	1	0.520	-6.370
7	1	3	2	0.330	-6.370
7	1	3	3	0.100	-6.370
7	1	3	4	0.050	-6.370
7	1	4	1	0.520	-6.240
7	1	4	2	0.330	-6.240
7	1	4	3	0.100	-6.240
7	1	4	4	0.050	-6.240
7	1	5	1	0.520	1.000
7	1	5	2	0.330	1.000
7	1	5	3	0.100	1.000
7	1	5	4	0.050	1.000
7	2	1	1	0.060	-10.990
7	2	1	2	0.090	-10.990
7	2	1	3	0.310	-10.990
7	2	1	4	0.540	-10.990
7	2	2	1	0.060	-9.290
7	2	2	2	0.090	-9.290
7	2	2	3	0.310	-9.290
7	2	2	4	0.540	-9.290
7	2	3	1	0.060	-6.370
7	2	3	2	0.090	-6.370
7	2	3	3	0.310	-6.370
7	2	3	4	0.540	-6.370
7	2	4	1	0.060	-6.240
7	2	4	2	0.090	-6.240

APPENDIX N
(continued)

7	2	4	3	0.310	-6.240
7	2	4	4	0.540	-6.240
7	2	5	1	0.060	1.000
7	2	5	2	0.090	1.000
7	2	5	3	0.310	1.000
7	2	5	4	0.540	1.000
8	1	1	1	0.400	-10.990
8	1	1	2	0.350	-10.990
8	1	1	3	0.250	-10.990
8	1	1	4	0.000	-10.990
8	1	2	1	0.400	-9.290
8	1	2	2	0.350	-9.290
8	1	2	3	0.250	-9.290
8	1	2	4	0.000	-9.290
8	1	3	1	0.400	-6.370
8	1	3	2	0.350	-6.370
8	1	3	3	0.250	-6.370
8	1	3	4	0.000	-6.370
8	1	4	1	0.400	-6.240
8	1	4	2	0.350	-6.240
8	1	4	3	0.250	-6.240
8	1	4	4	0.000	-6.240
8	1	5	1	0.400	1.000
8	1	5	2	0.350	1.000
8	1	5	3	0.250	1.000
8	1	5	4	0.000	1.000
8	2	1	1	0.050	-10.990
8	2	1	2	0.150	-10.990
8	2	1	3	0.350	-10.990
8	2	1	4	0.450	-10.990
8	2	2	1	0.050	-9.290
8	2	2	2	0.150	-9.290
8	2	2	3	0.350	-9.290
8	2	2	4	0.450	-9.290
8	2	3	1	0.050	-6.370
8	2	3	2	0.150	-6.370
8	2	3	3	0.350	-6.370
8	2	3	4	0.450	-6.370
8	2	4	1	0.050	-6.240
8	2	4	2	0.150	-6.240
8	2	4	3	0.350	-6.240
8	2	4	4	0.450	-6.240
8	2	5	1	0.050	1.000
8	2	5	2	0.150	1.000
8	2	5	3	0.350	1.000
8	2	5	4	0.450	1.000

APPENDIX O

BAYESIAN COMPUTATIONAL DATA

REV METHOD

EXPERIMENT	OUTCOME	ACT	STATE	P(Z/E,S)	UTILITY
1	1	1	1	0.550	310.000
1	1	2	1	0.550	195.000
1	1	3	1	0.550	230.000
1	1	4	1	0.550	115.000
1	1	5	1	0.550	425.000
1	1	1	2	0.300	310.000
1	1	2	2	0.300	195.000
1	1	3	2	0.300	230.000
1	1	4	2	0.300	115.000
1	1	5	2	0.300	425.000
1	1	1	3	0.150	310.000
1	1	2	3	0.150	195.000
1	1	3	3	0.150	230.000
1	1	4	3	0.150	115.000
1	1	5	3	0.150	425.000
1	1	1	4	0.000	310.000
1	1	2	4	0.000	195.000
1	1	3	4	0.000	230.000
1	1	4	4	0.000	115.000
1	1	5	4	0.000	425.000
1	2	1	1	0.100	310.000
1	2	2	1	0.100	195.000
1	2	3	1	0.100	230.000
1	2	4	1	0.100	115.000
1	2	5	1	0.100	425.000
1	2	1	2	0.150	310.000
1	2	2	2	0.150	195.000
1	2	3	2	0.150	230.000
1	2	4	2	0.150	115.000
1	2	5	2	0.150	425.000
1	2	1	3	0.300	310.000
1	2	2	3	0.300	195.000
1	2	3	3	0.300	230.000
1	2	4	3	0.300	115.000

APPENDIX O
(continued)

ORIGINAL PAGE IS
OF POOR QUALITY

1	2	5	3	0.300	425.000
1	2	1	4	0.450	310.000
1	2	2	4	0.450	195.000
1	2	3	4	0.450	230.000
1	2	4	4	0.450	115.000
1	2	5	4	0.450	425.000
2	1	1	1	0.540	310.000
2	1	2	1	0.540	195.000
2	1	3	1	0.540	230.000
2	1	4	1	0.540	115.000
2	1	5	1	0.540	425.000
2	1	1	2	0.310	310.000
2	1	2	2	0.310	195.000
2	1	3	2	0.310	230.000
2	1	4	2	0.310	115.000
2	1	5	2	0.310	425.000
2	1	1	3	0.150	310.000
2	1	2	3	0.150	195.000
2	1	3	3	0.150	230.000
2	1	4	3	0.150	115.000
2	1	5	3	0.150	425.000
2	1	1	4	0.000	310.000
2	1	2	4	0.000	195.000
2	1	3	4	0.000	230.000
2	1	4	4	0.000	115.000
2	1	5	4	0.000	425.000
2	2	1	1	0.050	310.000
2	2	2	1	0.050	195.000
2	2	3	1	0.050	230.000
2	2	4	1	0.050	115.000
2	2	5	1	0.050	425.000
2	2	1	2	0.150	310.000
2	2	2	2	0.150	195.000
2	2	3	2	0.150	230.000
2	2	4	2	0.150	115.000
2	2	5	2	0.150	425.000
2	2	1	3	0.300	310.000
2	2	2	3	0.300	195.000
2	2	3	3	0.300	230.000
2	2	4	3	0.300	115.000
2	2	5	3	0.300	425.000
2	2	1	4	0.500	310.000
2	2	2	4	0.500	195.000
2	2	3	4	0.500	230.000
2	2	4	4	0.500	115.000
2	2	5	4	0.500	425.000
3	1	1	1	0.530	310.000
3	1	2	1	0.530	195.000
3	1	3	1	0.530	230.000
3	1	4	1	0.530	115.000
3	1	5	1	0.530	425.000
3	1	1	2	0.320	310.000
3	1	2	2	0.320	195.000
3	1	3	2	0.320	230.000
3	1	4	2	0.320	115.000
3	1	5	2	0.320	425.000
3	1	1	3	0.150	310.000
3	1	2	3	0.150	195.000
3	1	3	3	0.150	230.000
3	1	4	3	0.150	115.000

APPENDIX O
(continued)

3	1	5	3	0.150	425.000
3	1	1	4	0.000	310.000
3	1	2	4	0.000	195.000
3	1	3	4	0.000	230.000
3	1	4	4	0.000	115.000
3	1	5	4	0.000	425.000
3	2	1	1	0.050	310.000
3	2	2	1	0.050	195.000
3	2	3	1	0.050	230.000
3	2	4	1	0.050	115.000
3	2	5	1	0.050	425.000
3	2	1	2	0.150	310.000
3	2	2	2	0.150	195.000
3	2	3	2	0.150	230.000
3	2	4	2	0.150	115.000
3	2	5	2	0.150	425.000
3	2	1	3	0.300	310.000
3	2	2	3	0.300	195.000
3	2	3	3	0.300	230.000
3	2	4	3	0.300	115.000
3	2	5	3	0.300	425.000
3	2	1	4	0.500	310.000
3	2	2	4	0.500	195.000
3	2	3	4	0.500	230.000
3	2	4	4	0.500	115.000
3	2	5	4	0.500	425.000
4	1	1	1	0.500	310.000
4	1	2	1	0.500	195.000
4	1	3	1	0.500	230.000
4	1	4	1	0.500	115.000
4	1	5	1	0.500	425.000
4	1	1	2	0.350	310.000
4	1	2	2	0.350	195.000
4	1	3	2	0.350	230.000
4	1	4	2	0.350	115.000
4	1	5	2	0.350	425.000
4	1	1	3	0.150	310.000
4	1	2	3	0.150	195.000
4	1	3	3	0.150	230.000
4	1	4	3	0.150	115.000
4	1	5	3	0.150	425.000
4	1	1	4	0.000	310.000
4	1	2	4	0.000	195.000
4	1	3	4	0.000	230.000
4	1	4	4	0.000	115.000
4	1	5	4	0.000	425.000
4	2	1	1	0.050	310.000
4	2	2	1	0.050	195.000
4	2	3	1	0.050	230.000
4	2	4	1	0.050	115.000
4	2	5	1	0.050	425.000
4	2	1	2	0.150	310.000
4	2	2	2	0.150	195.000
4	2	3	2	0.150	230.000
4	2	4	2	0.150	115.000
4	2	5	2	0.150	425.000
4	2	1	3	0.300	310.000
4	2	2	3	0.300	195.000
4	2	3	3	0.300	230.000
4	2	4	3	0.300	115.000

APPENDIX O
(continued)

4	2	5	3	0.300	425.000
4	2	1	4	0.500	310.000
4	2	2	4	0.500	195.000
4	2	3	4	0.500	230.000
4	2	4	4	0.500	115.000
4	2	5	4	0.500	425.000
5	1	1	1	0.490	310.000
5	1	2	1	0.490	195.000
5	1	3	1	0.490	230.000
5	1	4	1	0.490	115.000
5	1	5	1	0.490	425.000
5	1	1	2	0.340	310.000
5	1	2	2	0.340	195.000
5	1	3	2	0.340	230.000
5	1	4	2	0.340	115.000
5	1	5	2	0.340	425.000
5	1	1	3	0.140	310.000
5	1	2	3	0.140	195.000
5	1	3	3	0.140	230.000
5	1	4	3	0.140	115.000
5	1	5	3	0.140	425.000
5	1	1	4	0.030	310.000
5	1	2	4	0.030	195.000
5	1	3	4	0.030	230.000
5	1	4	4	0.030	115.000
5	1	5	4	0.030	425.000
5	2	1	1	0.050	310.000
5	2	2	1	0.050	195.000
5	2	3	1	0.050	230.000
5	2	4	1	0.050	115.000
5	2	5	1	0.050	425.000
5	2	1	2	0.150	310.000
5	2	2	2	0.150	195.000
5	2	3	2	0.150	230.000
5	2	4	2	0.150	115.000
5	2	5	2	0.150	425.000
5	2	1	3	0.300	310.000
5	2	2	3	0.300	195.000
5	2	3	3	0.300	230.000
5	2	4	3	0.300	115.000
5	2	5	3	0.300	425.000
5	2	1	4	0.500	310.000
5	2	2	4	0.500	195.000
5	2	3	4	0.500	230.000
5	2	4	4	0.500	115.000
5	2	5	4	0.500	425.000
6	1	1	1	0.530	310.000
6	1	2	1	0.530	195.000
6	1	3	1	0.530	230.000
6	1	4	1	0.530	115.000
6	1	5	1	0.530	425.000
6	1	1	2	0.320	310.000
6	1	2	2	0.320	195.000
6	1	3	2	0.320	230.000
6	1	4	2	0.320	115.000
6	1	5	2	0.320	425.000
6	1	1	3	0.100	310.000
6	1	2	3	0.100	195.000
6	1	3	3	0.100	230.000
6	1	4	3	0.100	115.000

ORIGINAL PAGE IS
OF POOR QUALITY

6	1	5	3	0.100	425.000
6	1	1	4	0.050	310.000
6	1	2	4	0.050	195.000
6	1	3	4	0.050	230.000
6	1	4	4	0.050	115.000
6	1	5	4	0.050	425.000
6	2	1	1	0.050	310.000
6	2	2	1	0.050	195.000
6	2	3	1	0.050	230.000
6	2	4	1	0.050	115.000
6	2	5	1	0.050	425.000
6	2	1	2	0.100	310.000
6	2	2	2	0.100	195.000
6	2	3	2	0.100	230.000
6	2	4	2	0.100	115.000
6	2	5	2	0.100	425.000
6	2	1	3	0.300	310.000
6	2	2	3	0.300	195.000
6	2	3	3	0.300	230.000
6	2	4	3	0.300	115.000
6	2	5	3	0.300	425.000
6	2	1	4	0.550	310.000
6	2	2	4	0.550	195.000
6	2	3	4	0.550	230.000
6	2	4	4	0.550	115.000
6	2	5	4	0.550	425.000
7	1	1	1	0.520	310.000
7	1	2	1	0.520	195.000
7	1	3	1	0.520	230.000
7	1	4	1	0.520	115.000
7	1	5	1	0.520	425.000
7	1	1	2	0.330	310.000
7	1	2	2	0.330	195.000
7	1	3	2	0.330	230.000
7	1	4	2	0.330	115.000
7	1	5	2	0.330	425.000
7	1	1	3	0.100	310.000
7	1	2	3	0.100	195.000
7	1	3	3	0.100	230.000
7	1	4	3	0.100	115.000
7	1	5	3	0.100	425.000
7	1	1	4	0.050	310.000
7	1	2	4	0.050	195.000
7	1	3	4	0.050	230.000
7	1	4	4	0.050	115.000
7	1	5	4	0.050	425.000
7	2	1	1	0.060	310.000
7	2	2	1	0.060	195.000
7	2	3	1	0.060	230.000
7	2	4	1	0.060	115.000
7	2	5	1	0.060	425.000
7	2	1	2	0.090	310.000
7	2	2	2	0.090	195.000
7	2	3	2	0.090	230.000
7	2	4	2	0.090	115.000
7	2	5	2	0.090	425.000
7	2	1	3	0.310	310.000
7	2	2	3	0.310	195.000
7	2	3	3	0.310	230.000
7	2	4	3	0.310	115.000

APPENDIX O
(continued)

7	2	5	3	0.310	425.000
7	2	1	4	0.540	310.000
7	2	2	4	0.540	195.000
7	2	3	4	0.540	230.000
7	2	4	4	0.540	115.000
7	2	5	4	0.540	425.000
8	1	1	1	0.400	310.000
8	1	2	1	0.400	195.000
8	1	3	1	0.400	230.000
8	1	4	1	0.400	115.000
8	1	5	1	0.400	425.000
8	1	1	2	0.350	310.000
8	1	2	2	0.350	195.000
8	1	3	2	0.350	230.000
8	1	4	2	0.350	115.000
8	1	5	2	0.350	425.000
8	1	1	3	0.250	310.000
8	1	2	3	0.250	195.000
8	1	3	3	0.250	230.000
8	1	4	3	0.250	115.000
8	1	5	3	0.250	425.000
8	1	1	4	0.000	310.000
8	1	2	4	0.000	195.000
8	1	3	4	0.000	230.000
8	1	4	4	0.000	115.000
8	1	5	4	0.000	425.000
8	2	1	1	0.050	310.000
8	2	2	1	0.050	195.000
8	2	3	1	0.050	230.000
8	2	4	1	0.050	115.000
8	2	5	1	0.050	425.000
8	2	1	2	0.150	310.000
8	2	2	2	0.150	195.000
8	2	3	2	0.150	230.000
8	2	4	2	0.150	115.000
8	2	5	2	0.150	425.000
8	2	1	3	0.350	310.000
8	2	2	3	0.350	195.000
8	2	3	3	0.350	230.000
8	2	4	3	0.350	115.000
8	2	5	3	0.350	425.000
8	2	1	4	0.450	310.000
8	2	2	4	0.450	195.000
8	2	3	4	0.450	230.000
8	2	4	4	0.450	115.000
8	2	5	4	0.450	425.000

APPENDICES P AND Q

FREMONT LAND VALUE RELATIONSHIPS

APPENDIX P

FREMONT LAND VALUES

					(2x3x43,560)			(5x6x43,560)
		1	2	3	4	5	6	7
		Urbanized Land	Commercial Land	Value	Commercial Land Value	Industrial Land	Value	Industrial Land Value
	1975	13,802	634.9	5.50	150×10^6	3,420	2.50	372×10^6
State 1	1980	14,992	762.2	5.50	182.6×10^6	3,714	2.50	404.4×10^6
	1990	17,378	1,017.4	5.50	243.7×10^6	4,306.5	2.50	468.9×10^6
State 2	1980	14,941	759.5	5.50	181×10^6	3,701	2.50	403×10^6
	1990	17,223	1,008.3	5.50	241×10^6	4,267.8	2.50	464.7×10^6
State 3	1980	14,967	760.9	5.50	182×10^6	3,708	2.50	403.8×10^6
	1990	17,301	1,012.9	5.50	242×10^6	4,287	2.50	466×10^6

Average Land Value by Growth State

Growth State	Average Land Value ($\$ \times 10^6$)
Base Year Data (1975)	522
State 1	649.8
State 2	644.8
State 3	646.5

APPENDIX Q

EQUATIONS AND VALUES FOR LAND USE COMPONENT OF REWARD MATRIX

Value in (1,1) = 649.8 - 522 = 127

Value in (1,2) = 644.8 - 649.8 = -5

Value in (1,3) = 646.5 - 649.8 = -3.3

Value in (2,1) = 649.8 - 644.8 = 5

Value in (2,2) = 644.8 - 522 = 122.8

Value in (2,3) = 646.5 - 644.8 = 1.7

Value in (3,1) = 649.8 - 646.5 = 3.3

Value in (3,2) = 644.8 - 646.5 = -1.7

Value in (3,3) = 646.5 - 052.2 = 124.5

APPENDIX R

COMPUTER SOFTWARE LISTING

```
      INTEGER N,Z,A,Y,H,KK,C,D,B
      REAL MPROB,IDEN
      DIMENSION IDEN(25,25)
      DATA IDEN/625*0./
      REAL PIE
      INTEGER CNT,INDEX
      INTEGER SELCTD
      DIMENSION WINV(25,25),W2(25,25)
      DIMENSION SELCTD(25,2)
      DIMENSION SELCTV(25,2)
      DIMENSION PROBM(25,25)
      DIMENSION EXRWM(25,10)
      DIMENSION WI(25,25)
      DIMENSION WV1(25,1)
      DIMENSION WV2(25,1)
      DIMENSION VAL(25,1)
      DIMENSION FMT1(18)
      DIMENSION FMT2(18)
      COMMON/BLIST/MPROB(25,25,10),REW(25,25,10),PIE(25,10),
     1EXREW(25,10),TEST(25,10),VALUE(25,1),N,FMT(18),FMT3(18)
      DATA SELCTD/50*0/,SELCTV/50*0./
      READ (5,1) N,Z,A
      READ (5,8) FMT1
      READ (5,8) FMT2
    1 FORMAT (3I4)
      PRINT 2,N
    2 FORMAT('0','NUMBER OF SYSTEM STATES',2X,I4)
      PRINT 3,Z
    3 FORMAT('0','NUMBER OF ALTERNATIVES',2X,I4)
      PRINT 4,A
    4 FORMAT('0','MAXIMUM NUMBER OF ITERATIONS',2X,I4)
      READ (5,FMT1) (((MPROB(I,J,K),J=1,N),I=1,N),K=1,Z)
      READ (5,FMT2) (((REW(I,J,K),J=1,N),I=1,N),K=1,Z)
      READ (5,8) FMT
      READ (5,8)FMT3
    8 FORMAT (18A4)
      CNT=0
      INDEX=0
      DO 7 M=1,N
      IDEN(M,M)=1.0
    7 CONTINUE
      DO 20 K=1,Z
      IF (K.EQ.1) CALL PYE(K)
      IF (K.EQ.2) CALL PYE(K)
      IF (K.EQ.3) CALL PYE(K)
      IF (K.EQ.4) CALL PYE(K)
      IF (K.EQ.5) CALL PYE(K)
      IF (K.EQ.6) CALL PYE(K)
      IF (K.EQ.7) CALL PYE(K)
      IF (K.EQ.8) CALL PYE(K)
      IF (K.EQ.9) CALL PYE(K)
      IF (K.EQ.10) CALL PYE(K)
   20 CONTINUE
      DO 25 K=1,Z
      PRINT 26,K
   26 FORMAT('0','STEADY STATE PROBABILITIES,ALTERNATIVE',2X,I3)
      DO 27 I=1,N
      PRINT 28,I,PIE(I,K)
   28 FORMAT('0',2X,'STATE',2X,I3,4X,F9.6)
```

```
27 CONTINUE
25 CONTINUE
   DO 30 K=1,Z
   IF (K.EQ.1) CALL EXRWD(K)
   IF (K.EQ.2) CALL EXRWD(K)
   IF (K.EQ.3) CALL EXRWD(K)
   IF (K.EQ.4) CALL EXRWD(K)
   IF (K.EQ.5) CALL EXRWD(K)
   IF (K.EQ.6) CALL EXRWD(K)
   IF (K.EQ.7) CALL EXRWD(K)
   IF (K.EQ.8) CALL EXRWD(K)
   IF (K.EQ.9) CALL EXRWD(K)
   IF (K.EQ.10) CALL EXRWD(K)
30 CONTINUE
   DO 32 K=1,Z
   PRINT 33,K
33 FORMAT('0','EXPECTED REWARD,ALTERNATIVE',2X,I3)
   DO 34 I=1,N
   PRINT 35,I,EXREW(I,K)
35 FORMAT('0',2X,'STATE',2X,I3,4X,F11.4)
34 CONTINUE
32 CONTINUE
   CNT=0
   DO 39 I=1,N
   VALUE(I,1)=0.
   SELCTD(I,2)=1
   SELCTV(I,2)=0.
   DO 38 J=1,N
   PROBM(I,J)=MPROB(I,J,1)
38 CONTINUE
39 CONTINUE
31 INDEX=0
   CNT=CNT+1
   DO 40 K=1,Z
   IF (K.EQ.1) CALL POLICY(K)
   IF (K.EQ.2) CALL POLICY(K)
   IF (K.EQ.3) CALL POLICY(K)
   IF (K.EQ.4) CALL POLICY(K)
   IF (K.EQ.5) CALL POLICY(K)
   IF (K.EQ.6) CALL POLICY(K)
   IF (K.EQ.7) CALL POLIGY(K)
   IF (K.EQ.8) CALL POLICY(K)
   IF (K.EQ.9) CALL POLICY(K)
   IF (K.EQ.10) CALL POLICY(K)
40 CONTINUE
   PRINT 49,CNT
49 FORMAT('0','ITERATION NUMBER',2X,I3)
   DO 48 K=1,Z
   PRINT 47,K
47 FORMAT('0','TEST QUANTITY,POLICY IMPROVEMENT,ALTERNATIVE',2X,I3)
   DO 46 I=1,N
   PRINT 45,I,TEST(I,K)
45 FORMAT('0','STATE',2X,I3,4X,F11.4)
46 CONTINUE
48 CONTINUE
   Y=Z-1
   DO 99 I=1,N
   DO 98 K=1,Y
   H=K+1
```

```
      IF (TEST(I,K).GE.TEST(I,H)) GO TO 97
      SELCTD(I,1)=H
      SELCTV(I,1)=TEST(I,H)
      GO TO 93
   97 IF (TEST(I,K).EQ.TEST(I,H)) GO TO 96
      SELCTD(I,1)=K
      SELCTV(I,1)=TEST(I,K)
      GO TO 93
   96 IF (K.EQ.SELCTD(I,2)) GO TO 95
      IF (H.EQ.SELCTD(I,2)) GO TO 94
      SELCTD(I,1)=K
      SELCTV(I,1)=TEST(I,K)
      GO TO 93
   95 SELCTD(I,1)=K
      SELCTV(I,1)=TEST(I,K)
      GO TO 93
   94 SELCTD(I,1)=H
      SELCTV(I,1)=TEST(I,H)
      GO TO 93
   93 CONTINUE
   98 CONTINUE
   99 CONTINUE
      PRINT 43
      DO 44 I=1,N
      PRINT 19,I,SELCTD(I,1),SELCTV(I,1),SELCTD(I,2),SELCTV(I,2)
   19 FORMAT ('0',29X,I3,3X,I3,5X,F11.4,4X,I3,4X,F11.4)
   43 FORMAT ('0','POLICY IMPROVEMENT SUMMARY',2X,'STATE',3X,
     1'NEW ALT',3X,'NEW VALUE',3X,'OLD ALT',3X,'OLD VALUE')
   44 CONTINUE
      DO 50 I=1,N
      IF (SELCTV(I,1).GT.SELCTV(I,2)) GO TO 52
      GO TO 51
   52 SELCTV(I,2)=SELCTV(I,1)
      SELCTD(I,2)=SELCTD(I,1)
      INDEX=1
      GO TO 51
   51 CONTINUE
   50 CONTINUE
      IF (INDEX.EQ.0) GO TO 100
      IF (CNT.EQ.A) GO TO 101
      DO 60 I=1,N
      KK=SELCTD(I,2)
      DO 61 J=1,N
      PROBM(I,J)=MPROB(I,J,KK)
      EXRWM(I,1)=EXREW(I,KK)
   61 CONTINUE
   60 CONTINUE
      DO 72 I=1,N
      DO 71 J=1,N
      PROBM(I,J)=-(PROBM(I,J)-IDEN(I,J))
   71 CONTINUE
   72 CONTINUE
      DO 80 B=1,N
      DO 81 C=2,N
      D=C-1
      WI(B,C)=PROBM(B,D)
   81 CONTINUE
   80 CONTINUE
      DO 82 I=1,N
```

```
      WI(I,1)=1.0
   82 CONTINUE
      CALL LINV1F (WI,N,25,WINV,0,W2,IER)
      CALL VMULFF (WINV,EXRWM,N,N,1,25,25,VAL,25,IER)
      DO 89 C=2,N
      B=C-1
      VALUE(B,1)=VAL(C,1)
   89 CONTINUE
      VALUE(N,1)=0.
      PRINT 88,VAL(1,1)
   88 FORMAT ('0','SYSTEM GAIN,G',2X,F11.4)
      DO 87 I=1,N
      PRINT 86,I,VALUE(I,1)
   86 FORMAT ('0','STATE',2X,I3,3X,'VALUE',2X,F11.4)
   87 CONTINUE
      GO TO 31
  100 PRINT 102
  102 FORMAT ('0','POLICY VECTOR SOLUTION')
      GO TO 103
  101 PRINT 104
  104 FORMAT('0','MAXIMUM ALLOWABLE ITERATIONS')
      GO TO 108
  103 PRINT 107
  107 FORMAT ('0','STATE',3X,'POLICY VECTOR',4X,'VALUE VECTOR')
      DO 105 I=1,N
      PRINT 106,I,SELCTD(I,2),SELCTV(I,2)
  106 FORMAT ('0',2X,I3,9X,I3,8X,F11.4)
  105 CONTINUE
      GO TO 110
  108 DO 109 I=1,N
      PRINT 43,I,SELCTD(I,1),SELCTV(I,1),SELCTD(I,2),SELCTV(I,2)
  109 CONTINUE
  110 CONTINUE
 9999 STOP
      END
      BLOCK  DATA
      COMMON/BLIST/MPROB(25,25,10),REW(25,25,10),PIE(25,10),
     1EXREW(25,10),TEST(25,10),VALUE(25,1),N,FMT(18),FMT3(18)
      REAL MPROB
      DATA MPROB/6250*0./,REW/6250*0./,PIE/250*0./,EXREW/250*0./,
     1TEST/250*0./
      END
      SUBROUTINE PYE(SK)
      COMMON/BLIST/MPROB(25,25,10),REW(25,25,10),PIE(25,10),
     1EXREW(25,10),TEST(25,10),VALUE(25,1),N,FMT(18),FMT3(18)
      DIMENSION ALT(25,25),ALTT(25,25)
      REAL MPROB
      INTEGER SK
      REAL IDEN
      DIMENSION IDEN(25,25),COL(25,1),W1(25),ALTI(25,25)
      DIMENSION RESUL(25,1)
      DATA IDEN/625*0./,ALTT/625*0./,ALTI/625*0./
      WRITE (6,7) SK
    7 FORMAT ('0','TRANSITION PROBABILITY MATRIX FOR ALTERNATIVE',I3)
      WRITE (6,FMT) ((MPROB(I,J,SK),J=1,N),I=1,N)
      DO 15 K=1,N
      DO 16 L=1,N
      ALT(K,L)=MPROB(K,L,SK)
   16 CONTINUE
```

```
15 CONTINUE
   WRITE (6,8) SK
 8 FORMAT ('0','REWARD MATRIX FOR ALTERNATIVE',I3)
   WRITE (6,FMT3) ((REW(I,J,SK),J=1,N),I=1,N)
   DO 19 I=1,N
   DO 20 J=1,N
   ALTT(I,J)=ALT(J,I)
20 CONTINUE
19 CONTINUE
   DO 30 K=1,N
   IDEN(K,K)=1.0
30 CONTINUE
   DO 22 I=1,N
   DO 21 J=1,N
   ALTT(I,J)=ALTT(I,J)-IDEN(I,J)
21 CONTINUE
22 CONTINUE
   DO 17 K=1,N
   ALTT(N,K)=1.0
17 CONTINUE
   DO 40 K=1,N
   COL(K,1)=0.
40 CONTINUE
   COL(N,1)=1.0
   CALL LINV1F(ALTT,N,25,ALTI,0,W1,IER)
   CALL VMULFF(ALTI,COL,N,N,1,25,25,RESUL,25,IER)
   DO 18 K=1,N
   PIE(K,SK)=RESUL(K,1)
18 CONTINUE
   RETURN
   END
   SUBROUTINE EXRWD(SK)
   COMMON/BLIST/MPROB(25,25,10),REW(25,25,10),PIE(25,10),
  1EXREW(25,10),TEST(25,10),VALUE(25,1),N,FMT(18),FMT3(18)
   DIMENSION SM(25,25)
   DIMENSION SR(25,25),COL(25,1),SQ(25,1)
   REAL MPROB,EXREW,SM,SR,COL,SQ
   INTEGER SK
   DATA SQ/25*0./
   DO 33 L=1,N
   DO 32 M=1,N
   SM(L,M)=MPROB(L,M,SK)
   SR(L,M)=REW(L,M,SK)
32 CONTINUE
33 CONTINUE
   DO 35 J=1,N
   DO 34 K=1,N
   SM(J,K)=SM(J,K)*SR(J,K)
34 CONTINUE
35 CONTINUE
   DO 36 J=1,N
   COL(J,1)=1.
36 CONTINUE
   CALL VMULFF(SM,COL,N,N,1,25,25,SQ,25,IER)
   DO 38 K=1,N
   EXREW(K,SK)=SQ(K,1)
38 CONTINUE
   RETURN
   END
```

```
      SUBROUTINE POLICY(SK)
      COMMON/BLIST/MPROB(25,25,10),REW(25,25,10),PIE(25,10),
     1EXREW(25,10),TEST(25,10),VALUE(25,1),N,FMT(18),FMT3(18)
      DIMENSION MSMM(25,25)
      DIMENSION SR(25,1),PRD(25,1)
      INTEGER SK
      DO 40 I=1,N
      DO 41 J=1,N
      MSMM(I,J)=MPROB(I,J,SK)
   41 CONTINUE
   40 CONTINUE
      DO 42 J=1,N
      SR(J,1)=EXREW(J,SK)
   42 CONTINUE
      CALL VMULFF(MSMM,VALUE,N,N,1,25,25,PRD,25,IER)
      DO 44 I=1,N
      SR(I,1)=SR(I,1)+PRD(I,1)
   44 CONTINUE
      DO 43 J=1,N
      TEST(J,SK)=SR(J,1)
   43 CONTINUE
      RETURN
      END
```

BIBLIOGRAPHY

"A Bibliography on Air Travel and Associated Ground Transportation," Janet D. Kiernan, Institute for Defense Analysis, Arlington, VA, June 1970.

A Fortran Program to Calculate the STOL Penetration of other Travel Modes by City Pair. A Value of Time Approach, prepared by J. Nazareth and A. F. Toplis, Operations Analysis Group, The DeHavilland Aircraft of Canada, Limited, 2 April 1976.

A Perspective in the Assessment of Large-Scale Technology: The Case of the STOL Aircraft Transport System, A Progress Report, November 1971, by Todd R. LaPorte, Bayard Latron, John Forester, N. Mayer and Daniel Metlay, Institute of Governmental Studies, University of California, Berkeley, for Ames Research Center, NASA.

"Air Passenger Survey," San Francisco Bay Area, Metropolitan Transportation Commission, June 1976.

Air Transportation - Comparative Assessment of its Public Benefits, prepared by Civil Aviation Advisory Group, Aerospace Research Center, May 1976.

Airline View of STOL System Requirements, American Airlines, Inc., Feb. 1972, Final Report Prepared for D.O.T. Systems Development and Technology, DOT-OS-10075.

Alternative Policies for Effecting Intercity Energy use Reduction, Saul Sokolsky, The Aerospace Corporation, El Segundo, CA, October, 1974.

An Economic Analysis of Future Short-Haul Transportation, George C. Kenyon, et. al, Office of Advanced Research and Technology, Moffett Field, March 1971, N71-20114.

Bay Area Study of Aviation Requirements - Aviation Forecasts, prepared by Systems Analysis and Research Corporation, May 1970.

Bay Area Transportation Report, Bay Area Transportation Study Commission, Berkeley, California, May 1969.

City of Fremont, Commercial Activity Study, January 1976.

City of Fremont, Community Development Block Grant Program, Community Profile, 1975, Community/Economic Development Department.

City of Fremont: Freeway Deletion Impact Study, August 1976, TJKM Planning and Transportation Consultants.

City of Fremont, The Fremont General Plan, 5/9/77.

Community Economic Profile for Fremont, Alameda County, California, prepared by the Fremont Chamber of Commerce, March 1977.

Commuter Airline and Aircraft Studies-Experimental Flight Program to Establish Public Acceptance Criteria, Research Aircraft Technology Office, NASA Ames Research Center, August 1976.

County Airport Design Manual, Division of Aviation, Ohio State University Airport, Columbus, Ohio.

Distribution of Primary Benefits and Costs of Intraurban Air Transportation in the San Francisco Bay Area, J. P. Stucker, prepared for NASA, October 1972, R-1076-NASA.

Dynamic Probabalistic Systems Volume I: Markov Models, Ronald A. Howard Stanford University, John Wiley & Sons, Inc., New York, London, Sydney, Toronto, 1971.

Dynamic Programming and Markov Processes, Ronald A. Howard, Mass. Institute of Technology, Technology Press of MIT and John Wiley and Sons, New York, London, 1960.

Effects of a V/STOL Commuter Transportation System on Road Congestion in the San Francisco Bay Area, T. F. Kirkwood, prepared for NASA, October 1972,R-1075-NASA.

Environment Project Phase I Report, BART Impact Program, prepared for U.S. Department of Transportation, June 1975.

Environmental Impacts of BART: Interim Service Findings, BART Impact Program, prepared for U.S. Department of Transportation, January 1976.

External Impacts of an Intraurban Air Transportation System in the San Francisco Bay Area - Summary Report, J. Y. Lu, J. R. Gebman, T. F. Kirkwood, P. T. McClure, and J. P. Stucker, prepared for NASA, October 1972, R-1074-NASA.

Frederick, John Hutchinson, Commercial Air Transportation, 4th ed., R. D. Irwin, 1955.

Fremont the Pathfinder City, Fremont Chamber of Commerce.

Fremont-Newark Climatological Summary, U.S. Department of Commerce, National Oceanic and Atmospheric Administration in cooperation with the Department of Water Resources, State of California.

Fremont's Exceptional Livability and its Importance to Business, Fremont Chamber of Commerce, 39737 Paseo Padie Parkway, Fremont, California 94538.

Forecasting the Demand Potential for STOL Air Transportation, Shing-Leung Fan, Robert Horonjeff, Adib Kanafani, and Abdollah Mogharabi, The Institute of Transportation and Traffic Engineering, University of California, prepared for NASA, February 1973, NASA CR 114572.

Further Studies in Short Haul Air Transportation in the California Corridor, Richard S. Shevell, July 1974, submitted to NASA-Ames Research Center, Contract No. NAS2-7199.

"Impact of BART on Transportation and Travel: Interim Service Findings," Interpretive Summary, Metropolitan Transportation Commission, July 1976.

Inter-Metropolitan STOL Evaluation: Final Report (Phase X); Development Engineering, Report #50, January 1970, American Airlines.

Locklin, Dr. Philip, Economics of Transportation, Richard D. Irwin, Inc. Homewood, Illinois.

Long-Run Effects of an Intraurban Air Transportation System On Residential Location and Commuting in the San Francisco Bay Area, J. P. Stucker, Report prepared for NASA, October 1972, R-1077-NASA.

Major Commercial Airport Location: A Methodology for the Evaluation of Potential Sites, Michael S. Bambiger, Hugo L. Vandersypen, The Transportation Center, Northwestern University, Evanston, Illinois, August 1969.

"Metropolitan Transportation Commission - 5 years of Progress, 1970-1975," prepared by Metropolitan Transportation Commission.

1976-81 Overall Work Program for the San Francisco Bay Area, Association of Bay Area Governments, Metropolitan Transportation Commission.

Official Airline Guide: North America Edition, March 1, 1975, Volume I, No. 11, Reuben H. Donnelley Publication.

Open Space Element of the General Plan, Community Development Department, Fremont, California, December, 1973.

Operational Evaluation of a Regional Air Transportation System for the San Francisco Bay Area, Stephen Eastwood, Geoffrey Gosling, Mark Waters, prepared for NASA Ames Research Center, September 1976, Grant No. NSG-2133.

Operational Evaluation of a Regional Air Transportation System for the San Francisco Bay Area, Stephen J. Eastwood, prepared for Ames Research Center, NASA, May 1976.

Present and Proposed Route Structures of California Certificated Air Carriers and Routes Operated by Cab Certificated Air Carriers, Transportation Division, Public Utilities Commission, State of California, January 1, 1976.

Proposed Transportation Control Plan for the San Francisco Bay Area, Air Quality Control Region, Metropolitan Transportation Commission, March 12, 1975.

Regional Airport Plan Update Program: Phase 1, Bruce Benzler, Chris Brittle, Walter E. Gillfilland, prepared for the Regional Airport Planning Committee of Metropolitan Transportation Commission and Association of Bay Area Governments, May 1976.

Regional Airport Plan Update Program: Phase I, Background Paper 1, The Impact of Energy Availability on Airport Planning, Walter E. Gillfillan, Association of Bay Area Governemnts, Metropolitan Transportation Commission, July 1975.

Background Paper 2 - Environmental Impact Assessment: Requirements and Trends, Bruce Benzler.

Background Paper 3 - Regional Airport and Airspace Capacities, Walter E. Gillfillan.

Background Paper 4 - Aviation Noise, Bruce Benzler.

Background Paper 5 - Bay Area Airport Land Use Commissions, Bruce Benzler.

Background Paper 6 - Airport Ownership and Finance, Walter E. Gillfillan.

Background Paper 7 - The Effect of Governmental Regulation and Programs on the Airport System, Walter E. Gillfillan.

Background Paper 8 - Airport Alternatives, Walter E. Gillfillan.

Background Paper 9 - Medium and High Speed Ground Transportation Systems for the California Corridor, Chris Brittle.

Background Paper 10 - New Technology, Chris Brittle.

Background Paper 11 - Airport Ground Access, Chris Brittle.

Background Paper 12 - Airport Utilization, Chris Brittle.

Background Paper 13 - Aviation Forecasts, Chris Brittle.

Background Paper 14 - Economic Impacts of Airports, Walter E. Gillfillan.

Background Paper 15 - Environmental Impacts of Airports, Walter E. Gillfillan.

Background Paper 16 - Effect of Aviation on Air Quality, Walter E. Gillfillan.

Background Paper 17 - Goals, Policies, and Plan Implementation, Chris Brittle and Walter E. Gillfillan.

Background Paper 18 - General Aviation, Walter E. Gillfillan.

Regional Transportation Plan, Metropolitan Transportation Commission, Summary and Maps.

Revenue Sources for Transit Support, Transportation Finance Task Force, Metropolitan Transportation Commission, Berkeley, California, January 12, 1976.

Safety Aspects of a V/STOL Commuter Transportation System in the San Francisco Bay Area, T. F. Kirkwood, prepared for NASA, October 1972, WN-7950-NASA.

"Service to Small Communities," Civil Aeronautics Board, Task Force on Service to Small Communities, May 18, 1976.

Short Haul Air Passenger Data Sources in the United States, Joan Al-Kazily, Geoffrey Gosling, Robert Horonjeff, prepared for NASA Ames Research Center, June 1976, Grant No. NSG-2127.

Short Haul Air Passenger Service in the San Francisco Bay Area 1969-1980, Cloyd J. Combs, The Institute of Transportation and Traffic Engineering, University of California, August 1970.

Short-Haul Airline System Impact on Intercity Energy Use - Final Report, S. Sokolsky, Air Transportation Group, May 31, 1974, prepared for Ames Research Center, National Aeronautics and Space Administration, Moffett Field, California, Contract No. NAS2-6473.

Social Change, Public Response, and Regulation of Large-Scale Technology--Questions in the Social Assessment of STOL Aircraft Transport, Second Annual Progress Report, Todd R. LaPorte, Principal Investigator, Institute of Governmental Studies, University of California, Berkeley, December 1972.

STOL Aircraft in Intraurban Travel, McDonnell Aircraft Company, McDonnell Douglas Corporation, St. Louis, MO June 1968.

Study of Aircraft in Intraurban Transportation Systems, by E. G. Stout, prepared by Lockheed-California Company for Ames Research Center, NASA, Washington, D.C. March 1972, NASA CR-1991.

Study of Aircraft in Intraurban Transportation Systems-San Francisco Bay Area, prepared by the Boeing Company for Ames Research Center, NASA, Washington, D.C. March 1972, NASA CR-2006.

Study of Aircraft in Intraurban Transportation Systems-San Francisco Bay Area, Boeing Company, Seattle, Washington, for National Aeronautics and Space Administration, NASA CR-114347, September 1971.

Study of Aircraft in Intraurban Transportation Systems-San Francisco Bay Area, The Boeing Company, Seattle Washington, September 1971, NASA Contract No. NAS2-5969.

Study of Aircraft in Short Haul Transportation Systems, Volumes 1 and 2 The Mission Analysis Division, Office of Advanced Research and Technology, NASA, Ames Research Center, Moffett Field, California, August, 1967, NAS2-3862.

Study of an Intraurban Travel Demand Model Incorporating Commuter Preference Variables, Holligan, Paul E., Coote, Malcolm A., Rushmer, Charles R., Fanning, Michael L., Boeing Company, Seattle, Washington, December 1971, NASA Contract NAS2-2969.

Study of Low Density Air Transportation Concepts, H. M. Webb, Prepared by the Aerospace Corporation for Ames Research Center, NASA, Washington, D.C. October 1972, NASA CR 2142.

Study of Quiet Turbofan STOL for Short-Haul Transportation - Final Report, Volume III Airports, June 1973, prepared under Contract No. NAS2-6994 for Advanced Concepts and Missions Division NASA, Moffett Field, California 94035 by Douglas Aircraft Company, Long Beach, CA.

Study of V/STOL Aircraft Implementation: Volume I, Summary, W. J. Portenier and H. M. Webb, prepared by the Aerospace Corporation for Ames Research Center, NASA, Washington, D.C. March 1973, NASA CR-2227.

Study of V/STOL Aircraft Implementation: Volume II: Appendices, prepared by A. Androsky, S. C. Miller, J. A. Neiss, W. S. Portenier, and H. M. Webb, prepared for Advanced Concpets and Missions Division, NASA, Moffett Field, California, November 1972, NASA CR-114518.

"Summary of MTC's Travel Demand Forecasting System"

Systems Evaluation of Low Density Air Transportation Concepts, R. W. Bruce and H. M. Webb, prepared for Advanced Concepts and Missions Division, NASA, Moffett Field, California, July 1972, NASA, CR 114484.

Technical and Economic Evaluation of Aircraft for Intercity Short Haul Transportation, Volumes I, II, III, McDonnell Aircraft Corporation St. Louis, MO April 1966, FAA Contract No. FA65WA-1246.

The Airport in MicroCity: A Study of its Usage and Significance in Six Small Minnesota Communities, Center for the Study of Local Government, St. John's University, Collegeville, Minn, September, 1968.

The Potential for Helicopter Passenger Service in Major Urban Areas, Jarir S. Dajani, Ralph G. Stortstrom, Dennis B. Warner, Department of Civil Engineering, Duke Environmental Center, School of Engineering, Duke University, Durham, N.C. March 1977.

Transportation and Travel Impacts of BART: Interim Service Findings, BART impact program, Metropolitan Transportation Commission, April, 1976.

Transportation Management Tactics for Air Quality Improvement, San Diego Air Quality Planning Report, prepared by Planning Environment International, 1100 Glendon Avenue, Los Angeles, California, April 1976.

Travis AFB Joint Use Economic Analysis, Economic Impact Assessment, October, 1976.

Work Program: Summary, Environmental Management Plan, San Francisco Bay Region, Association of Bay Area Governments, April 1976.

A State-of-the-Art Review of Transportation Systems Evaluation Techniques Relevant to Air Transportation, by Lonnie E. Haefner, August, 1975, NASA CR-137770.

Development of Air Transportation Evaluation Processes, by Lonnie E. Haefner, August 1975, NASA CR-137771.

Summary of Progress, Benefit-Cost Evaluation of an Intra-Regional Air Service in the Bay Area, by Lonnie E. Haefner, NASA Grant NSG-2170, January 3, 1977.