35

Summary Report on Transit Planning and System Development Alternatives

RECEIVED
MASS TRANSIT
SEP 26 10 53 AM '75

MASS TRANSIT FILE COPY

HONOLULU RAPID TRANSIT PROJECT
PRELIMINARY ENGINEERING & EVALUATION PROGRAM
PHASE II

DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU

MASS TRANSIT FILE COPY

DMJM

DANIEL, MANN, JOHNSON, & MENDENHALL

AR00053237

SUMMARY REPORT

ON

TRANSIT PLANNING

AND

SYSTEM DEVELOPMENT ALTERNATIVES

HONOLULU RAPID TRANSIT PROJECT
PHASE II

Prepared For

DEPARTMENT OF TRANSPORTATION SERVICES

CITY & COUNTY OF HONOLULU

Preparation of this report was financially aided from a grant from the United States Department of Transportation under Section 9, of the Urban Mass Transportation Act of 1964 as amended.

SEPTEMBER 1975

DANIEL, MANN, JOHNSON, & MENDENHALL

AR00053238

TABLE OF CONTENTS

CHAPTER		Page
I	INTRODUCTION	
	A. Purpose of Report	I-1
	B. History of Transportation & Transit Planning	I-4
II	BASIS FOR TRANSPORTATION PLANNING	
	A. Goals, Objectives, and Criteria	II-1
	B. Population and Employment Forecasts	II-7
	C. Present and Future Land use	II-11
	D. Travel Forecasts	II-15
III	FUTURE TRANSPORTATION NEEDS AND SOLUTIONS	
	A. Island-Wide Development and Travel Characteristics	III-1
	B. Characteristics of the Urban Honolulu Corridor	III-5
	C. Study of Transportation Alternatives	III-7
	D. Study of Travel Demand Based on Alternative Development Policies	III-10
	E. Conclusions and Recommendations	III-14
IV	MANAGEMENT OF EXISTING TRANSPORTATION SYSTEM	
	A. General	IV-1
	B. Management of Existing Street and Highway System	IV-2
	C. Improvement of Existing Bus System	IV-5
	D. Measures to Reduce Vehicular Traffic	IV-8
	E. Summary and Conclusions	IV-9
V	RAPID TRANSIT ROUTE LOCATION ANALYSIS	
	A. General	V-1
	B. Basis for Route Evaluation	V-3
	C. Route Planning Analysis	V-8
	D. Conclusion and Recommendations	V-17
VI	ALTERNATIVE SYSTEMS EVALUATION	
	A. Background of Transit Planning Studies	VI-1
	B. PEEP I Alternatives Studied	VI-2
	C. Alternatives Selected for Detailed Study	VI-6

AR00053239

CHAPTER		Page
VI	D. Comparative Evaluation of Alternatives	VI-12
	E. Summary of Conclusions and Recommendations	VI-22
VII	ALTERNATIVE LENGTHS EVALUATION	
	A. General	VII-1
	B. Assumptions and Methodology	VII-2
	C. Analysis of System Networks	VII-3
	D. Analysis of Qualitative Measures	VII-5
	E. Analysis of Quantitative Measures	VII-10
	F. Comparative Evaluation	VII-17
	G. Conclusion and Recommendation	VII-20
	REFERENCES	R-1

AR00053240

LIST OF TABLES

CHAPTER II		Page
II-1	Goals, Objectives and Criteria	II-6
II-2	Population Forecast Summary	II-8
II-3	Employment Forecast Summary	II-9
II-4	Historical Employment Growth and Unemployment Rates	II-10
II-5	Land Use Classification Changes	II-12
II-6	Historic and Projected Average Cars Per Household	II-17
II-7	1995 Travel Projections - Trip Purpose Distribution	II-20
CHAPTER III		
III-1	Central Honolulu Share of Population and Employment	III-5
III-2	Major Urban Employment Areas	III-6
III-3	Screenline Volume to Capacity Analyses	III-11
III-4	Projected Transit Trips for Alternative Development Policies	III-13
CHAPTER V		
V-1	Route Evaluation Factors	V-5
V-2	Weighting of Non-Cost Factors in PEEP I Route Planning	V-7
V-3	Rapid Transit Alternative Route Alignments and Station Locations	V-10
CHAPTER VI		
VI-1	Summary of Alternatives Analysis - PEEP I	VI-3
VI-2	Summary of Design Assumptions	VI-9
VI-3	Summary of Analytical Results	VI-11
VI-4	Comparison Matrix for Alternative Systems	VI-15
VI-5	Summary of Rankings	VI-21
CHAPTER VII		
VII-1	Comparative Evaluation Matrix	VII-6
VII-2	Annual Costs	VII-12
VII-3	Cost Per Trip	VII-14
VII-4	Cost Per Trip at Varying Escalation and Interest Rates - 1985 Vol.	VII-15
VII-5	Comparison of Immediate and Deferred Investment for 14-Mile System	VII-18
VII-6	Summarized Comparison Matrix	VII-22

AR00053241

LIST OF FIGURES

CHAPTER II

II-1 Island of Oahu
II-2 Island-Wide Population Growth
II-3 Island-Wide Population Distribution
II-4 Island-Wide Employment Distribution
II-5 Generalized Model Relationships for Transit Patronage Forecasts

CHAPTER III

III-1 Island-Wide Population and Employment Growth Distribution
III-2 Highway Network - Island of Oahu
III-3 Preliminary Roadway Capacity and Volume
III-4 OTS Rapid Transit Corridor

CHAPTER IV

IV-1 Major Improvements to Existing Bus Operations
IV-2 Trend in Passengers on the Bus

CHAPTER V

V-1 Transit Corridor Segments

CHAPTER VI

VI-1 Busway Transit System
VI-2 Light Rail Transit System
VI-3 Fixed Guideway Transit System

CHAPTER VII

VII-1 Alternative Segment Lengths
VII-2 Land Use and Activity Centers in the Kaimuki Community
VII-3 14-Mile Fixed Guideway System

AR00053242

CHAPTER I

INTRODUCTION

A. PURPOSE OF REPORT

The purpose of this report is to present, in one document, the processes followed and the technical conclusions reached regarding a rapid transit system for Honolulu. It has been prepared in specific response to the U. S. Department of Transportation's policy on making "Major Urban Mass Transportation Investments", as published in Draft Form in docket 75-04 of the Federal Register of August 1, 1975.

In preparing this report, it is recognized that planning for rapid transit in Honolulu has taken place over a period of time, beginning with a major Island-wide transportation study in 1967. Throughout the course of this work, political leaders, business leaders, and citizen groups have continually participated in the studies and have, in various ways, indicated support and endorsement of the technical conclusions reached. However, at the outset, it should be pointed out that while numerous public meetings have been held during the course of the program on these technical conclusions, final decisions must await acceptance of an Environmental Impact Statement and the outcome of final public hearings.

While many questions have, of course, been addressed during the last eight years, four principle questions have received particularly close study in successively more detailed form. These questions are:

1. Does Honolulu need a fixed facility rapid transit system and, if so, when?

2. Where should it be located?

3. What type of rapid transit system would best serve the area's needs and desires?

4. How extensive should the initial system be?

Well documented and plausible answers to these questions are required by decision-makers in the City and County of Honolulu, the State of Hawaii, and the U. S. Department of Transportation, in order for the rapid transit program--the largest single public works program ever undertaken in Honolulu--to move forward. In answering these questions, Honolulu has thoroughly analyzed all feasible alternatives to each question, both in terms of cost-effectiveness as transportation solutions; and in terms of the non-quantifiable measures of effectiveness toward strengthening attainment of the Island's social, environmental, and community goals. These analysis were conducted with a view toward both the short range impacts (1985) and the long range impacts (1995).

AR00053244

Hopefully, this report captures the 10-year history of analyzing these questions. The remaining portion of Chapter I outlines the history of transportation and transit planning on the Island in order to give the reader some perspective of the detailed processes followed.

Chapter II provides an overview of current and future growth on the Island, both in terms of people and their transportation needs. This chapter also attempts to lay out in summary form the generally accepted land use and transportation goals of the Island as a framework within which public officials have made and will make decisions regarding alternative courses of transportation and related actions.

Chapter III presents a documentation of the analysis of the existing transportation system to meet current and future travel needs. It also describes and compares the alternative courses of action which could lead to solutions of this problem. These courses are principally to construct additional freeways, to considerably upgrade the existing bus transit system, or to do some combination of these. The conclusion documented in this chapter, both in terms of cost-effectiveness, and in terms of reinforcing established and future development, and community acceptance, would be to construct a high level rapid transit system in urban Honolulu as a backbone for a greatly improved Island-wide transit system.

Chapter IV builds on this case by illustrating the steps which have been taken in recent years by local and state governments to continue to maximize the use and effectiveness of the present street, highways, and bus system. Despite this action, the gap between demand and capacity continues to widen.

Given this condition, Chapter V analyzes various alternative locations for a backbone rapid transit system in terms of both transportation service and compatibility with other community goals. It concludes with a recommendation which is believed to provide a sound balance between maximum transportation service, minimum residential and non-residential dislocation, and maximum support of established development goals.

Chapter VI then looks at a series of alternative transit vehicle systems which by proper design might be able to satisfy the transportation requirements of the Island within the context of its non-transportation goals. Various alternative transit systems are screened and three are fully analyzed with respect to service and cost-effectiveness within the context of these goals. A selection of a vehicle system is documented.

Chapter VII assesses the short-term requirements regarding the length of the system. The effect here is to document the results of studies

AR00053245

conducted primarily to assure the cost-effectiveness over time of transit investments. This chapter concludes with a recommended length of the fixed guideway system over the short-term (1985) with a description of the supplemental line haul bus system which more nearly match near-term service requirements, yet are convertible to a higher level of service at minimum cost over the long run.

Great care has been exercised in this report to summarize a process which has occupied the time of public officials, citizens, and technicians over a number of years. In order to make the report coherent and concise, many details have been omitted, and while every effort has been made to produce a report which can stand on its own merits on the major points, substantial use is made of reference material which has been prepared over this long period of time. These references are all on file in Honolulu and with UMTA in Washington.

AR00053246

B. HISTORY OF TRANSPORTATION AND TRANSIT PLANNING

Since World War II it has been relatively clear that Oahu's population density and geography would require new high capacity transportation services. Studies conducted by the Hawaii Department of Highways in the late 1940's and 1950's concluded that three high capacity freeways would provide substantial relief through the 1970's (H-1, H-2 and H-3). These eventually became the principle elements in Hawaii's Interstate Highway Program. In the 1960's, however, as construction got underway for these facilities; as the impacts of such construction became clearer from experiences in San Francisco and elsewhere, and as the population growth began to exceed official forecasts, both the State and the City, with the financial support of the Federal government began a series of concentrated studies of the situation. Beginning with the preparation of the General Plan of the City and County of Honolulu, studies were initiated which began to show the need and value of an alternative to the expanded highway system. Adopted by the City Council after considerable public discussion and debate, the General Plan laid the foundation for further studies of the transportation system and established some general principals and goals which should guide the development of such a system.

In the mid-1960's, the State and the City, again with Federal financial assistance, undertook the Oahu Transportation Study, partly to satisfy Federal transportation planning requirements but mostly to begin the detailing of the parameters of a long term solution to the Island's transportation problems. This program re-examined the population and employment growth potential of the Island and based on new forecasts of such activity, prepared a comprehensive assessment of the present and projected transportation deficiencies on the Island. It concluded that additional transportation capacity would be needed in the 1980's to satisfy these deficiencies.

This study evaluated two basic alternatives, one an all-bus system operating in mixed traffic over an expanded freeway system, and the other a fixed-guideway system of the "trunkline/feeder" type. It also defined a feasible corridor and set some preliminary limits of the system at Pearl City on the west and Hawaii Kai on the east. Alternative technologies and alignments were not explored in detail.

With respect to timing, it concluded that a grade-separated fixed-guideway system should be developed as a long-term solution and that expansion of the existing bus system should be undertaken in the short term. Basically the high costs of an expanded highway system and its social and environmental consequences led to such a recommendation. Accordingly, additional studies of a high-capacity public transit system began in 1971, by which time the City and County of Honolulu began acquisition of private bus carriers and

AR00053247

embarked on a substantial expansion and modernization program.

At the same time, studies proceeded on the fixed guideway program. The Preliminary Engineering Evaluation Program, Phase I (PEEP I) included evaluation of mode, technology, corridor, length, and alignment alternatives. As in OTS, the need for a high-capacity system was demonstrated in the urban corridor. The line-haul/feeder was tentatively selected as the most appropriate technology in light of the volumes anticipated by 1995. Other technologies, however, were studied in some depth and included bus-on-busway and waterborne vehicles operating offshore and in canals with a feeder bus system.

Alternative corridors were looked at again and included a makai and mauka corridor in the urban area and a trans-Koolau corridor to Windward Oahu. The makai (near the sea) corridor was selected in preference to the mauka (inland) corridor, and patronage and cost estimates showed that only one of two could be justified. The trans-Koolau corridor did not prove to be justified in light of high costs and limited patronage.

Length of corridor was again re-tested in several alternatives, the longest of which extended from Kailua on the Windward side, around Koko Head, through the urban area, branching at Waiawa, with one branch extending to Wahiawa and the other to Waianae on the Leeward side of the Island. The shortest segment was 12 miles in length from Halawa to University, and the network selected was a single line in contrast to the branched line recommended by OTS. The selected technology was a rubber-tired, high-platform, medium-sized trainable transit car on a grade-separated fixed guideway with on-line stations supplemented with feeder and express buses.

An additional evaluation was made of alternatives involving the PEEP I system, bus-on-busway, waterborne, and an automatic small-vehicle system with off-line stations. With respect to the busway system, a number of operating alternatives were considered, including platooning and station bypassing. With respect to the automatic small-vehicle system, a network was designed to serve the same corridor but in a way which capitalized on the unique features of such systems. The system consisted of 33 miles of two-way guideway and 77 stations. An independent analysis of patronage was employed to compare the automatic system with the PEEP I recommendations. In addition to providing a means for comparing the two systems, this estimate of patronage also confirmed the estimates made by the regional travel and modal split models in PEEP I.

AR00053248

Thus, by early 1972, a broad spectrum of alternatives had been evaluated ranging over several corridors, technologies, system configurations, alignments, and lengths. A draft environmental impact statement, prepared at the conclusion of PEEP I, had been published, and comments had been received from numerous agencies, organizations, and individuals. The recommended system at that time was the rubber-tired, high-platform, fixed guideway with on-line stations and a supplementary bus network of local, feeder, and express routes covering the entire island of Oahu. The fixed guideway was proposed to extend from Pearl City to Hawaii Kai, a total length of 22 miles. Even so, there were a number of organizations and individuals who believed that other technologies could be used either as the primary system or as supplementary sub-systems.

Additionally, although the PEEP I study had evaluated many detailed alignment alternatives, the number of relocations required by the proposed alignment was high in light of the shortage of low- and moderate-cost housing in Honolulu. Accordingly, Phase II of the Preliminary Engineering Evaluation Program (PEEP II) examined a greater range of system lengths and alignments, the feasibility of off-line stations, and mixed-mode systems. The supplementary systems vary in some details but provide comparable levels of service in terms of schedule frequency, coverage, and travel time. As a result of PEEP II, several previous decisions on general locations, length, and vehicle system were verified. In addition, a more precise alignment was established which minimized relocation and disruption. This alignment was engineered in a preliminary way, stations were located and designed, and relocation, management and financial plans were prepared. An initial program to satisfy the Island's short range needs was determined. These were presented to both the City Council and the State Legislature for endorsement. General endorsement was forthcoming and preliminary applications were made in early 1975 for Federal financial assistance for final engineering, right-of-way acquisitions and construction.

AR00053249

CHAPTER II

BASIS FOR TRANSPORTATION PLANNING

A. GOALS, OBJECTIVES, AND CRITERIA

1. Introduction

As pointed out in Chapter I, planning for transportation and transit has been actively pursued in a comprehensive manner in Honolulu for some 10 years. Early in this program, a research was conducted of various planning documents containing specific goals and objectives reflecting the area's policy to ensure coordinated physical development of the Island.[1/] Recognizing that planning is a rational process for formulating and meeting objectives, the objectives chosen by the area should be used in development, testing, and evaluation of alternative transit decisions.

The physical development of an area is normally guided by a master plan of the city or region which is based upon economic, employment, and population studies of the area. The plan reflects estimates of future population based on economic and employment evaluations, allocation of land uses, determination of community facility needs, and transportation demands for the area. The land use element of the plan allocates land to various uses in compliance with the zoning code and the transportation element is not only planned to serve but to promote the land use pattern.

The specific objectives are usually listed separately for land use and transportation planning purposes. However, it should be emphasized that land and transportation are interdependent; and, therefore they cannot be separated. The separate listing of the specific objectives is done only for convenience of organization and presentation.

In the development of a transportation system, some measures must be applied in order to test the feasibility of a particular plan. Test and evaluation normally involve quantitative and qualitative evaluation of the degree to which a plan meets development objectives or criteria. Through this process, alternative transportation plans can be tested and evaluated such that a comparison can be made to aid in the selection of the most feasible and desirable alternative.

The purpose of this section is to outline those basic goals and objectives adopted by the area and define more specific transportation and transit development objectives together with a set of criteria relatable to each objective. These criteria are then used to facilitate their application in the decision-making process.

AR00053251

2. Goals and Objectives for Oahu

General goals and objectives for Oahu have been formulated through many studies and programs conducted by public and private agencies and organizations in the recent past with the aid of various community and citizen groups. The General Plan of the City and County of Honolulu adopted in 1964 included a statement of objectives.[2/] Transportation goals and objectives were developed and used in 1967 in the Oahu Transportation Study.[3/] General goals were prepared in the same year and recommended to the State of Hawaii by the Citizen's Advisory Committee. In 1970 the Advisory Committee of the Governor's Conference on the Year 2000 submitted general goals for the whole state in the decades ahead. In the publication, "Issues, Goals and Objectives for the Seventies and Beyond",[4/] the Mayor of the City and County of Honolulu outlined the administration's goals for the future.

In May of 1970 the Oahu Development Conference, a private organization, proposed Transportation Goals and Policies for Oahu dealing with both general and specific transportation objectives. In October of the same year the City Planning Department in a Status Report of The General Plan Revision Program[5/] reviewed the effectiveness of Objectives, Sub-Objectives, Standards and Principles of the General Plan of 1964 and suggested alternative definitions of objectives at the highest level of the program structure hierarchy. In general, each of those programs has produced consistent sets of goals and objectives for Oahu.

The relevant sets of goals and objectives used in guiding development on the island are summarized as follows:

a. General Goals of the Oahu General Plan: The General Plan of the City and County of Honolulu, adopted in 1964, which, together with its subsequent amendments forms the basis of this study, sets forth the City's policy for the long-range comprehensive physical development of Oahu. The General Plan consists of a map of Oahu and a statement of development objectives, standards, and principles with respect to the most desirable use of land, soil, density of population, the transportation system, public facilities and utilities, public housing projects, and such other matters which may be of benefit to the City. The plan is based upon studies of physical, social, economic and governmental conditions and trends.

AR00053252

The General Plan is designed to assure the coordinated development of the City and County of Honolulu and to promote the general welfare and prosperity of its people. The broad goals of the General Plan are set forth as follows:

1) To develop a wholesome, convenient, and attractive living environment.

2) To preserve and maintain significant historic sites, scenery and natural assets of the Island of Oahu.

3) To foster and create a favorable economic climate in agriculture, commerce, industry, defense and tourism.

4) To establish this island as a unique showplace of democracy, where all ethnic and social groups live together graciously and harmoniously in a "Spirit of Aloha".

5) To promote better citizen understanding in the planning program and participation in the planning process.

b. Transportation Objectives of the Oahu General Plan: The transportation objectives set forth in the General Plan are primarily concerned with a balanced transportation system to provide a set of facilities for convenient, safe, quick and economic movement of people and goods between various points within Oahu in harmony with the various land use patterns it serves. The transportation development objectives as adopted are stated as follows:

1) These facilities should enable a person to travel from any point in the region to any other point within reasonable travel time by one or more modes of transportation.

2) The entire system should be a combination of facilities which will provide the greatest efficiency and service to the community with the least overall expenditure of the resources.

3) The systems should be designed to prevent accidents as much as possible.

4) The systems should be designed as an integral part of and complementary to land use patterns.

AR00053253

c. The Oahu Transportation Study: Working within the framework of goals for comprehensive planning as set forth in the General Plan, the Oahu Transportation Study applied these basic goals in the development of a transportation plan for Oahu. The specific objectives adopted for the transportation plan were formulated through the efforts of technical and citizen advisory committees involving various citizen and business group participation in the decision-making process.

The Oahu Transportation Study identified major transportation planning objectives which are summarized as follows:

1) Ease of Movement

2) Integration of the Transportation System with Land Use

3) Availability of Variety of Modes of Travel

4) Preservation of Oahu's Beauty and Amenities

5) Safety

6) Balanced Transportation System

d. Supplemental Goals and Objectives of the City and County: In "Issues, Goals and Objectives for the Seventies and Beyond", the Administration of the City and County of Honolulu has identified various issues confronting the City. Transportation is included as one of the central issues with the goal for the development of an efficient, balanced transportation system that will offer alternative choices for the transportation of individuals and goods that will be consistent with the other elements and goals of the community in design and function.

Under that broad goal, the following specific objectives are outlined with programs already underway towards accomplishing certain objectives:

1) An efficient and safe street and highway system.

2) A convenient island-wide transit system that will encourage all people to use it and which should eventually be fare-free - beginning first for senior citizens and students, then for everyone.

AR00053254

3) A modern, highly attractive rapid transit system that will provide service to major centers of employment, education and recreation in urban areas.

4) Substantial reduction of the traffic accident rate.

5) Reduction of the vehicle ownership growth rate.

6) Participation of industry and community groups and partnership with the State and Federal governments in planning, financing and implementation.

All of the state goals and objectives of the State and City and County agencies as well as community and civic groups continually bring into focus the basic goals and objectives of the General Plan and the Oahu Transportation Study. They are primarily concerned with a balanced transportation system, improved mobility, reducing travel time and accident exposure, and minimizing costs and description effects upon communities and natural resources.

3. Use of Goals and Objectives in the Transit Planning Process

As stated previously, the purpose of researching the area's goals and objectives was to assist in developing a framework within which various alternatives regarding public transit could be compared so that recommendations on technical basis could be made.[1/] The obvious parallels in the goals and objectives established at various periods and by various governmental levels and private groups with respect to transportation, clearly set the stage for such a framework. However, to relate these to the current transit program and to facilitate their application to the development, testing, and evaluation of alternative transit decisions, requires a set of measurable criteria relating to each goal and objective.

Table II-1 presents in summary form the general framework which was used. It first presents the list of major goals and objectives, then presents the criteria used to measure relative attainment of these by various alternatives, and then illustrates the selected criteria used for evaluation of specific set of alternatives. Within the framework of this table, more detailed discussions are presented in later chapters.

AR00053255

TABLE II-1: GOALS, OBJECTIVES AND CRITERIA

Transportation Goals Oahu General Plan	Transportation Goals Oahu Transportation Study	Transit Development Objectives PEEP I and II	Transit Development Criteria for Alternatives Analysis	Applicable Criteria for Specific Alternative Analysis		
				Route Location	System Type	System Length
1. Provide transportation facilities to enable travel from any point in the region to any other point within reasonable travel time by one or more modes	1. *Provide transportation facilities for ease of movement throughout Oahu; and provide a variety of modes of travel which will best serve the different requirements of the community	1. Improve accessibility by serving and interconnecting existing and future urbanized areas of Oahu	a. Availability & coverage	—	✓	✓
			b. Average trip time	✓	✓	✓
			c. Service reliability	—	✓	✓
			d. Rider convenience	✓	✓	✓
			e. Rider comfort	✓	✓	✓
2. A transportation system which will provide the greatest efficiency and service to the community with the least overall expenditure of resources	2. Provide a balanced transportation system which will result in optimum service with the least public expenditure	2. *Provide a balanced transportation system of transit and highways	a. System patronage	✓	✓	✓
			b. System capacity	✓	✓	✓
		3. *Minimize expenditure of resources and disruption to community	a. Consumption of land	—	✓	✓
			b. Displacement of residents	✓	✓	✓
			c. Displacement of businesses	✓	✓	✓
			d. Reduction of comm. amenities	✓	✓	✓
			e. Disruption to future dvlpmt.	✓	✓	✓
			f. Disruption to local circulation	✓	✓	✓
			g. Disruption - constr. activity	—	✓	✓
			h. Savings in energy	—	✓	✓
			i. Technical risk	—	✓	✓
3. A transportation system to be designed as an integral part of and complementary to land use policies	3. Integration of the transportation system with land use	4. Support land use and development policies	a. Support regional development	✓	✓	✓
			b. Support comm. development	✓	✓	✓
4. *Preserve and maintain significant historic sites, scenery and natural assets of Oahu	4. Preserve Oahu's beauty and amenities	5. Preserve environment	a. Reduction air pollution	✓	✓	✓
			b. Noise level	✓	✓	✓
			c. Visual intrusion	✓	✓	✓
			d. Vistas	✓	✓	✓
			e. Historic sites	✓	✓	✓
5. Safety	5. Safety	6. Safety	a. Reduce accident exposure	—	✓	✓
			b. Security	—	✓	✓
6. **Provide a transportation system which will provide the greatest efficiency and service to the community with the least overall cost	6. **Provide a balanced transportation system which will result in optimum service at the least cost to the public	7. Provide the most economical system which best meets all other objectives	a. Total annual cost	✓	✓	✓
			b. Cost per trip	—	✓	✓
			c. Benefit-cost ratio	—	✓	—
*Stated as one of the general goals **Stated separately from 2 to differentiate between expenditure of resources and least cost	*Combines Goals 1 & 3 of OTS **Stated separately from 2 to differentiate between expenditure of resources and least cost	*Goal 2 stated as two separate objectives				

AR00053256

B. POPULATION AND EMPLOYMENT FORECASTS

The unique geography and topography of the Island of Oahu have, throughout the island's history, greatly influenced land use development including residential and economic growth and the transportation network. Development of Oahu has been conditioned largely by the geographic constraint imposed by the Koolau and Waianae Mountain Ranges and the constraint on urbanization imposed by the State's land use law. Urban developed has been restricted primarily to a relatively narrow level area along the southern Leeward Coast of the Island as shown in Figure II-1. This area has developed considerably higher in density in the past several decades, creating a need for more intensive transportation facilities. The following discussion describes the assumptions and methodology used to prepare population and employment forecasts which were used as the basis for patronage projections for the rapid transit and other alternative systems.

1. Assumptions and Methodology

The Honolulu Rapid Transit Program incorporates various policy directives and assumptions agreed to by the Oahu Transportation Planning Process representing the planning and transportation agencies of the City and County of Honolulu and the State of Hawaii and advised by the Citizens and Technical Advisory Committees. The Citizens Advisory Committee is made up of representatives from professional business and civic organizations and the Technical Advisory Committee is made up of members from various City and State agencies. Among the most significant policy directives and planning assumptions which were agreed upon by this process was:

a. That the year 1995 would be utilized as the base projection year for transportation purposes.

b. That medium range population forecasts and employment forecasts developed by the State Department of Planning and Economic Development (DPED) in 1971 for the year 1995 would be utilized for transportation planning purposes.

2. Population Forecasts

The DPED forecasts were used as the basis from which to assess the urban and environmental planning opportunities and patronage associated with the development of a refined transit system. The DPED long term growth projections were prepared in 1971 and are based upon medium growth assumptions; that is that population trends on Oahu will gradually converge with "Series D" national fertility projections and the same level

AR00053257

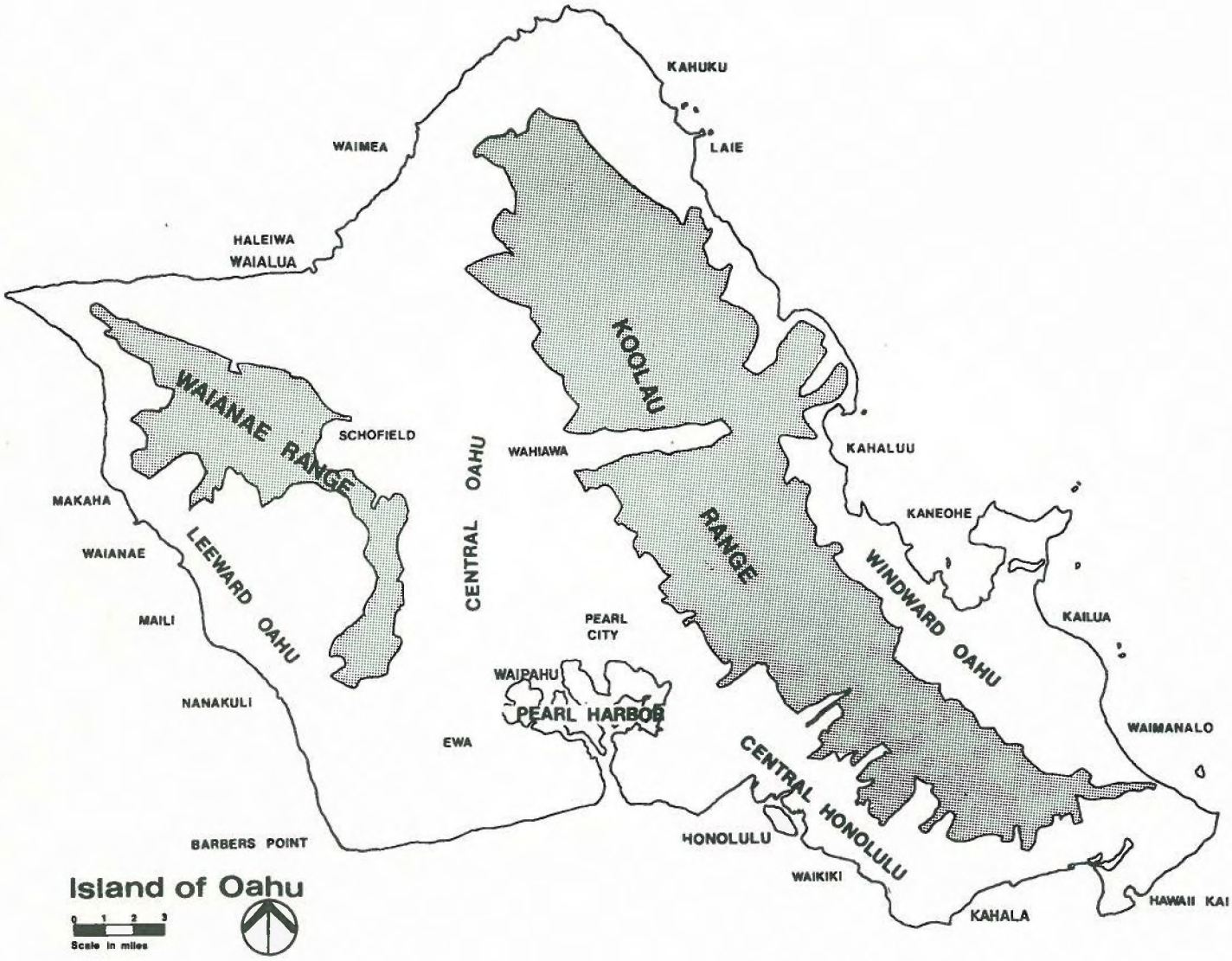

KAHUKU
LAIE
WAIMEA
HALEIWA
WAIALUA
KOOLAU
RANGE
WAIANAE RANGE
SCHOFIELD
CENTRAL OAHU
WAHIAWA
KAHALUU
MAKAHA
KANEOHE
WAIANAE
LEEWARD OAHU
WINDWARD OAHU
MAILI
PEARL CITY
KAILUA
WAIPAHU
PEARL HARBOR
NANAKULI
EWA
WAIMANALO
CENTRAL HONOLULU
BARBERS POINT
HONOLULU
WAIKIKI
KAHALA
HAWAII KAI
Island of Oahu
0 1 2 3
Scale in miles

FIGURE II-I

of net in-migration as in the 1970-1970 period.[6] These long range projections for the City and County of Honolulu are summarized in Table II-2.

TABLE II-2

POPULATION FORECAST SUMMARY

YEAR	POPULATION
1970	630,500
1975	680,000
1980	735,000
1985	795,000
1990	859,000
1995	924,000
2000	990,000

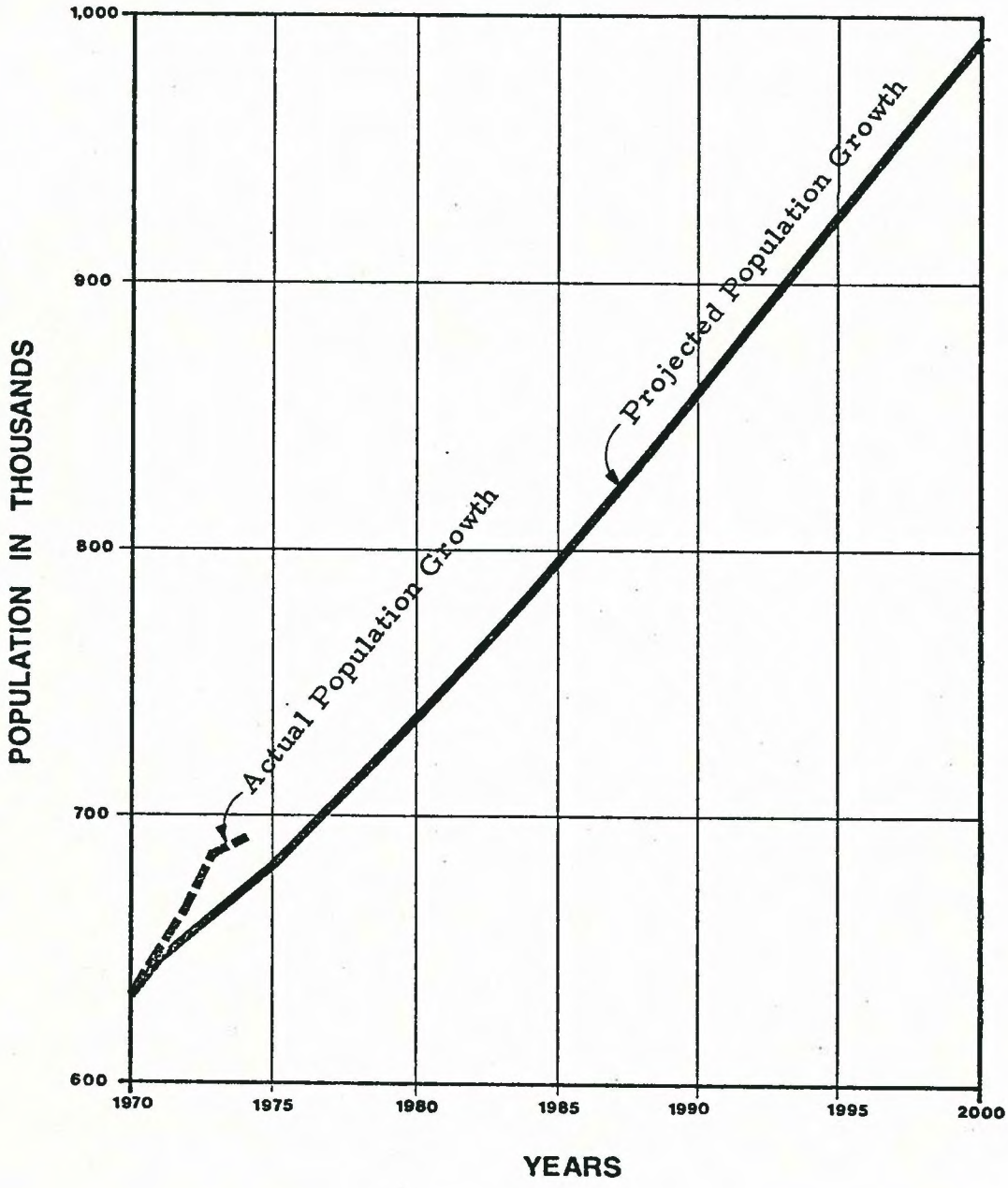
3. Comparison of Population Forecasts and Experience

Although DPED projections forecasted population growth rates on Oahu to gradually approach those of the nation, in fact, since Statehood, Hawaii's population growth rate has been about twice that of the nation and approximately 94% of the new residents have located on Oahu.[7]

The City and County of Honolulu had an estimated resident population of 691,200 as of July 1974, compared with 680,000 which was forecasted for 1975. (See Figure II-2) Between 1970 and 1974, population increased 9.6% and the housing inventory increased 15.8%. By district, recent population growth has been most rapid in Ewa (19%) and slowest in urbanized Honolulu; i.e. the area between Red Hill and Makapuu Point. Increases in the housing inventory by district followed a similar pattern, ranging from 10% in Waialua and 11% in Honolulu to 33% in Ewa.[8] These estimates were based on 1970 census statistics, official population estimates by county for the post censal years and official records of construction and demolition for 1970-1974.

Population projection updates prepared by DPED similarly document the rapidity of population growth in Hawaii and they confirm that population projections which were prepared in earlier years are conservative. The most recent DPED projections, prepared in 1974, indicate that by 1995, the population of Oahu may well approach 965,000 versus the 924,000 projected in 1971 and used in this study.

AR00053259



ISLANDWIDE POPULATION GROWTH

FIGURE II-2

Therefore, the observed growth rate and recent projections indicate that the transportation demand and transit patronage forecasts used in this program based on the 1971 projections should prove to be conservative.

4. Employment Forecasts

Employment projections used in this study were also developed by DPED through application of their economic model. In order to specify the required levels of economic activity, the economic planning model simulates, through a series of mathematical expressions, the key relationships among the many components of the economy and thereby "recreates" the primary forces that affect the pattern and nature of the economy's growth. These basic (or structural) relationships, which themselves are assumed to change over time, provide the basis for predicting the future required growth pattern.

An important output of the model is a projection of employment stratified by standard industrial classification code for 5 year increments. This data, together with population and dwelling unit projections is input to the land use model. The results of the DPED forecast of employment produced for this study are summarized in Table II-3 below.

TABLE II-3

EMPLOYMENT FORECAST SUMMARY 9/

YEAR	TOTAL EMPLOYMENT
1970	315,780
1975	333,000
1980	375,000
1985	419,000
1990	464,700
1995	515,700

5. Comparison of Employment Forecasts and Experience

Rapid population growth has occurred primarily because of expansion in three of Hawaii's basic economic sectors; tourism, military expenditures and Federal non-defense grants which, in turn, have stimulated growth throughout the rest of the economy. As indicated in the table below, the State has experienced fairly rapid growth in employment and has maintained relatively low unemployment rates. But competition for jobs, especially professional jobs is becoming increasingly intense.

AR00053261

TABLE II-4

HISTORICAL EMPLOYMENT GROWTH AND UNEMPLOYMENT RATES[10/]

Years	Annual Growth Rate of Employment (Percent Increase)	Unemployed as Percent of Total Labor Force
1965-70	5.4	2.6 min - 3.5 max
1970-71	2.3	5.0
1971-72	2.1	5.9

Recognizing this historical growth rate, the projections used in this study which reflect an average annual growth of approximately 2% between 1970 and 1995 appear reasonable. They also reflect a slight increase in labor participation rate, a trend that is also historically correct.

AR00053262

C. PRESENT AND FUTURE LAND USE

1. Assumptions and Methodology

It is a generally accepted fact that there is a complex relationship between transportation and future land use. Regional transportation facilities will influence the patterns, types, and densities of future land uses within the entire region and vice versa, and transportation facilities must be planned and designed to reflect existing and projected land use.

In recognition of these inter-relationships a Land Use Model was developed by the Oahu Transportation Study. The model is currently maintained and operated by the Oahu Transportation Planning Program and was used to project future land uses for this study. The Land Use Model takes the outputs of the Economic Model described earlier and allocates new jobs and population to census tracts. Employment is allocated depending on its type and on the land use allowed under the General Plan. Thus, allocations are made to census tracts which have land available for the specific purpose. Dwelling units and population are similarly assigned by the Land Use Model. The model provides 29 items of information for each census tract in five-year increments. Input to the Land Use Model was derived from the 1964 General Plan.

The following section discusses the land use inputs to the model and evaluates their validity in light of the land use classification changes which have occurred in Oahu since 1964.

2. Land Use Model

The land use planning basis for the development of patronage forecasts of the Honolulu Rapid Transit Program is the General Plan of 1964 of the City and County of Honolulu. Since 1964 two major factors have influenced the development of the General Plan. They are the State Land Use District classification system and the General Plan Revision Program.

Land uses designated in the General Plan were based upon the State of Hawaii Land Use Districts as designated in August 1964. This land use classification system designates all land in the State into urban, rural, agricultural or conservation lands. In the City and County of Honolulu, changes in the General Plan follow changes in

AR00053263

State Land Use Districts. The table below summarizes the State land use classification changes which have occurred since 1964, on Oahu:

TABLE II-5

LAND USE CLASSIFICATION CHANGES 1964-1975[11/]
(Acres)

	Urban	Rural	Agricultural	Conservation	Total
August 1964	75,700	0	158,200	151,400	385,300
August 1969 (After completion of 5-year Comprehensive Review)	82,592.9	0	145,906.1	156,801.0	385,300
March 1974	84,093.4	0	144,285.7	156,920.9	385,300
February 1975 (After completion of 2nd 5-year Comprehensive Review)	85,186.5	0	145,205.9	154,907.6	385,300

This summary of land use classification changes indicates that few new areas have been redesignated for urban use since 1964; this in turn suggesting that land use projections used in this study, produced in 1971 and based on the 1969 data, are still essentially reliable in 1975.

3. Future Land Use

The other major influence on the reliability of the Land Use Model is the current City and County of Honolulu General Plan Revision Program (GPRP). As part of the City's GPRP, three basic alternative growth policies have been developed. The three basic development policies are described below:

- Intensive Development - Characterized by the restriction of future development to within the present urban boundary as defined by the General Plan adopted in 1964 and as revised since that date. This restriction would have the effect of

AR00053264

limiting or slowing both the population and economic growth of the island. Under this policy, it is assumed that Central Honolulu would continue to be the primary employment and government center of the island.

- Moderate Expansion - Characterized by the restriction of development within the present urban boundary with the possible exception of providing land outside the urban boundary to meet the housing needs of low and moderate income families. The employment pattern remains essentially the same as in the Intensive Development alternative with Central Honolulu being the primary employment and governmental center.

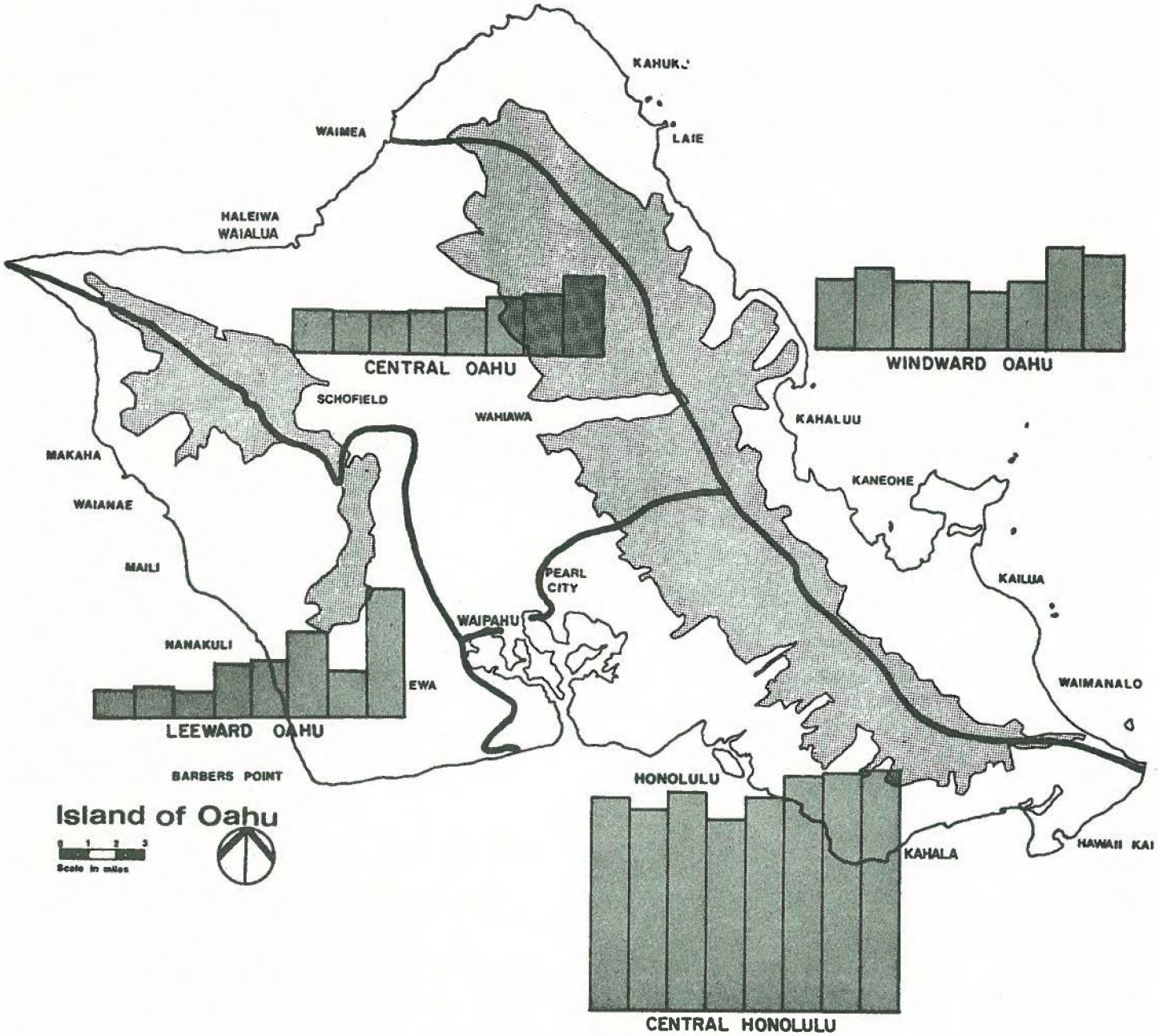
- Directed Growth - Characterized by the requirement that sufficient capacity be provided for residential and non-residential urban uses in programmed developments. These developments can occur through the expansion of the urban boundary. The amount of agricultural land released for urban use is dependent upon the programmed development of these new communities. These new communities are for all families of all income levels. The critical characteristics of this alternative is that non-residential land which could support substantial employment centers is provided.

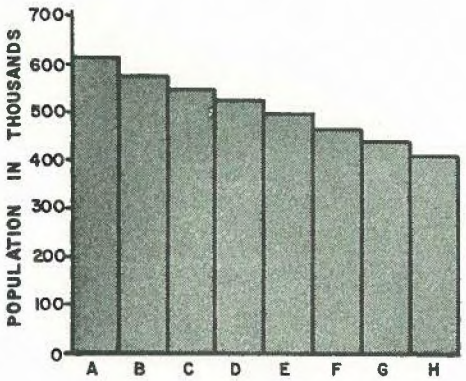
Under each of the basic policies, variations in the development pattern were defined and considered for various levels of population which essentially determine holding capacity of the development patterns. The island-wide population levels considered ranged from 924,000 to 1,398,000.

The alternative selected by the Chief Planning Officer of the City and County and recommended by him for adoption is the policy of "Directed Growth." In that alternative, future growth would be directed into the Ewa-Pearl City-Aiea-Central Honolulu corridor.

While these land use policy changes may in fact have great significance over the long term on the future shape of development on Oahu, up to the 924,000 population level, any of the three basic development alternatives emphasizes development in existing urbanized areas. This emphasis can be seen in Figures II-3 and II-4 which shows the distribution of the projected population and employment for the various alternative policies developed by the Department of General Planning[12/] and the distribution of the 1995 projections used in the PEEP study.[13/] In comparing the GPRP and PEEP projections at the 924,000 population level, there would be a slight shifting of population into the Ewa district with the implementation of either the "Moderate Expansion" or "Directed Growth alternative policies, but the location of employment areas would

AR00053265





A. 1995 PEEP
(924,000 POPULATION LEVEL)

B. INTENSIVE DEVELOPMENT, SCHEME A
(924,000 POPULATION LEVEL)

C. INTENSIVE DEVELOPMENT, SCHEME B
(924,000 POPULATION LEVEL)

D. MODERATE EXPANSION
(924,000 POPULATION LEVEL)

E. DIRECTED GROWTH
(951,000 POPULATION LEVEL)

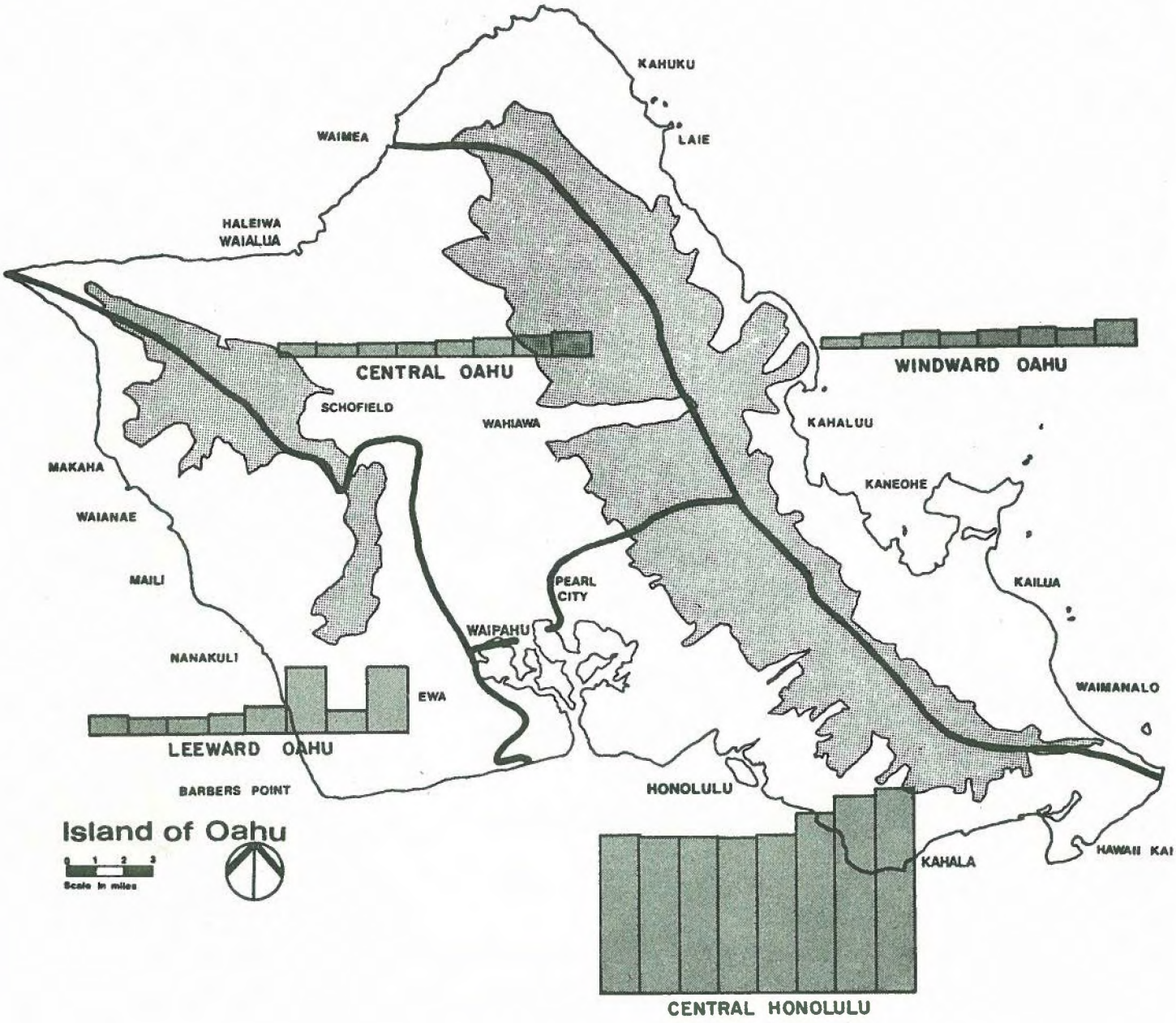
F. DIRECTED GROWTH
(1,157,000 POPULATION LEVEL)

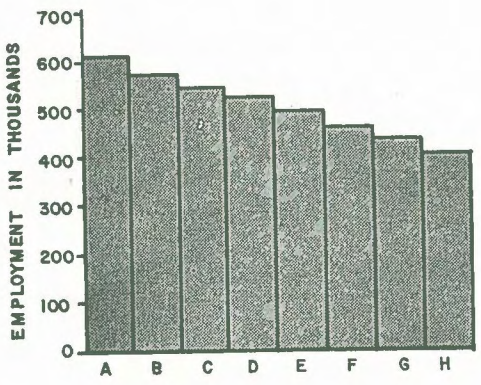
G. INTENSIVE DEVELOPMENT
(1,158,000 POPULATION LEVEL)

H. DIRECTED GROWTH
(1,398,000 POPULATION LEVEL)

ISLAND-WIDE POPULATION DISTRIBUTION
BASED ON ALTERNATIVE DEVELOPMENT POLICIES

FIGURE II-3





A. 1995 PEEP (924,000 POPULATION LEVEL)

B. INTENSIVE DEVELOPMENT, SCHEME A (924,000 POPULATION LEVEL)

C. INTENSIVE DEVELOPMENT, SCHEME B (924,000) POPULATION LEVEL)

D. MODERATE EXPANSION (924,000 POPULATION LEVEL)

E. DIRECTED GROWTH (951,000 POPULATION LEVEL)

F. DIRECTED GROWTH (1,157,000 POPULATION LEVEL)

G. INTENSIVE DEVELOPMENT (1,158,000 POPULATION LEVEL)

H. DIRECTED GROWTH (1,398,000 POPULATION LEVEL)

ISLAND-WIDE EMPLOYMENT DISTRIBUTION
BASED ON ALTERNATIVE DEVELOPMENT POLICIES

FIGURE II-4

remain the same, concentrated in the urban Central Honolulu area. At higher population levels, both population and employment is projected to increase in this Central Honolulu region. The major thrust of the General Plan, therefore, continues to be complete development of the existing urbanized corridor with gradual diversification of jobs and population into the outer areas of Oahu. Furthermore, all of these development policies retained the importance of the existing urban area of Central Honolulu. As will be seen in Chapter III, if the proposed transit improvements through this area are warranted at the 924,000 population level projected for use in this study, they will be even more important under any of the development patterns if a higher population is obtained.

The emphasis of rapid transit planning is to provide increased mobility to and within the highly urbanized core from all areas of the Island of Oahu. Increased urbanization within this core in the short term and gradual development of outer areas over the long term are in conformance with the expressed policies of the Honolulu Rapid Transit Program and with all planned transportation facilities associated with it.

AR00053268

D. TRAVEL FORECASTS

1. Assumptions and Methodology

The overall travel forecasts and subsequent patronage estimation procedures employ conventional sequential modeling techniques which take into account population and employment characteristics together with locational factors, land use, and characteristics of the transportation system. The total process involves seven (7) major models: Economic; Land Use; Car Ownership; Trip Generation; Trip Distribution; Modal Split; Assignment. Figure II-5 illustrates the sequencing of these models, basic input data and the output of each.

The models were developed in conjunction with the Oahu Transportation Study (OTS).[3/] They are, with the exception of the Economic Model, currently maintained and operated by the Oahu Transportation Planning Program (OTPP) as successor to OTS. The Economic Model is maintained and operated by the State Department of Planning and Economic Development (DPED). These agencies made the models available for this study and provided much of the input information.

The Economic and Land Use models which produced the population, employment and land use data crucial to transportation planning have previously been discussed. From the transportation planning aspects, the important facts relative to their output are:

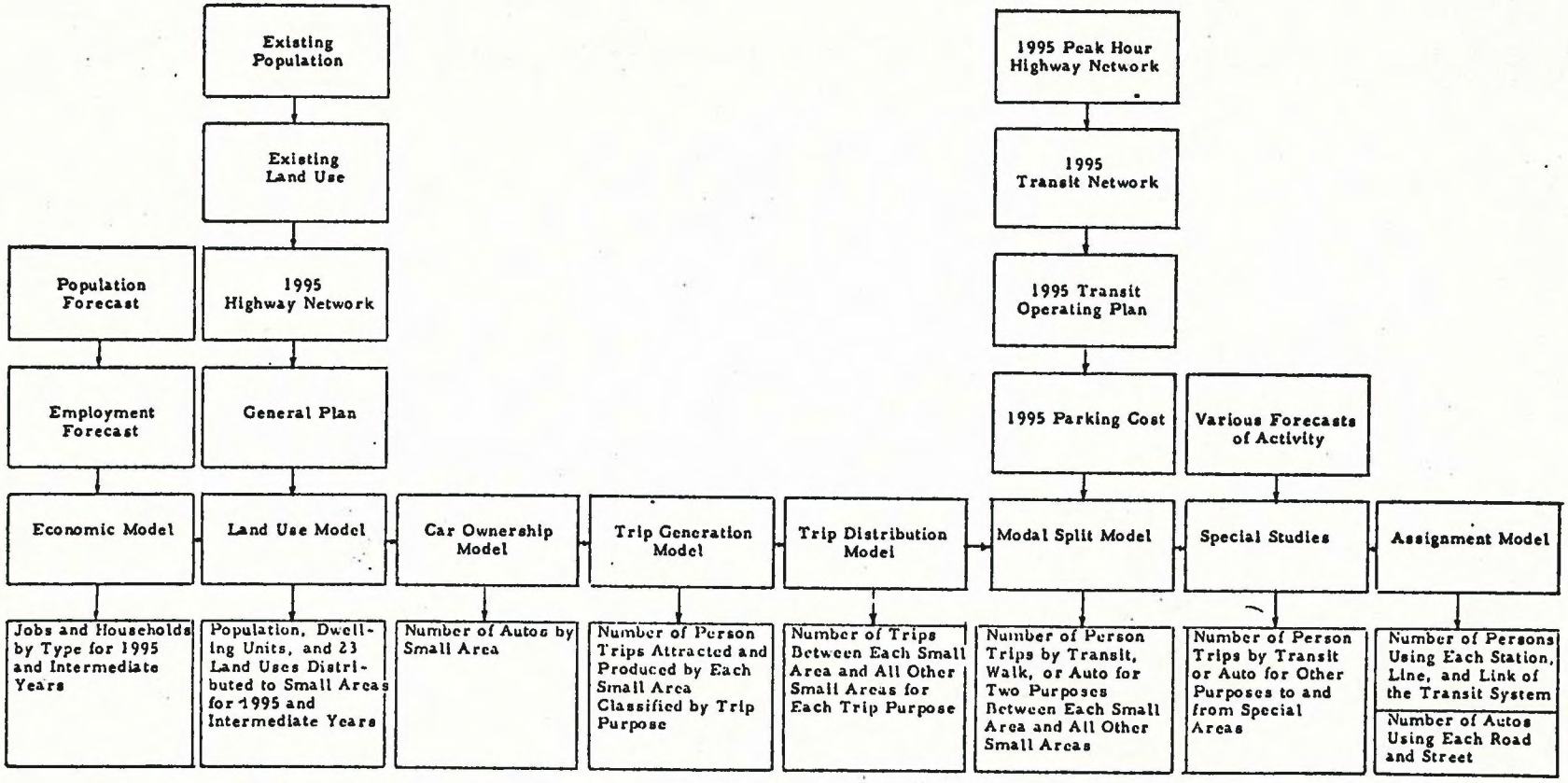
a. They reflect not only present trends of development but the specific long range policies of the study area in terms of land use, and

b. that the population and employment projections used, if anything, may be considered conservative when compared to actual observed growth rates in the immediate past.

The net result of these facts is that resulting trip distribution patterns reflect both policy decisions and current patterns and that the total future trip generation market (population and employment) is not overstated.

The following discussion describes the transportation aspects of this model sequence and the basic underlying assumptions and data. Important assumptions made in this portion of the process include:

AR00053269



GENERALIZED MODEL RELATIONSHIPS FOR TRANSIT PATRONAGE FORECASTS

FIGURE II-5

a. The street and highway system would include all existing and committed facilities including completion of H-1, H-2, and H-3. The resulting highway network was used in patronage estimating for all alternatives.

b. Kalanianaole Highway would not be further widened in the section between Kahala Mall and Hawaii Kai Drive. This assumption limited the capacity of that route to a definable and constant value and dictated the further assumption that all person trip movements in this corridor which could not be accommodated within the resulting capacity limit would use transit.

c. Manoa Campus of the University of Hawaii would be limited to an enrollment of 25,000 and Waikiki would be limited to a total of 27,000 hotel rooms. These assumptions placed limiting values on certain trip types to be analyzed in special studies.

2. Forecasts

After determining economic, demographic and land use variables and projections, determination of total person trips and their distribution between geographic areas was the next step in the transportation planning sequence. This involved 3 of the models illustrated in Figure II-5: car ownership, trip generation; and trip distribution.

a. Car Ownership: Access to or availability of an automobile is a significant variable in both the number of total person trips made (trip generation) and the mode of travel used (mode split). In the person-trip generation equations developed by OTS, car ownership appears as an independent variable in nearly all homebased trip productions. Therefore, it is necessary to be able to forecast future car ownership.

The OTS developed a car ownership model based on origin-destination studies which related car ownership to household income. For this study, OTPP operated the OTS model to project car ownership for 1980 and 1995 in each census tract based on the projected number of households in each of three income ranges forecasted by the Land Use Model. Table II-6 shows the result of that forecast and the historical trend of cars per household.

AR00053271

TABLE II-6

HISTORIC & PROJECTED AVERAGE CARS PER HOUSEHOLD

Year	Cars Per Household	
	Honolulu Urban Area	Non-Urban Areas
1960	1.01	1.11
1970	1.15	1.11
1980	1.27	1.21
1995	1.30	1.32

While these values indicate that auto-ownership will continue to increase, they appear reasonable when compared to observed mainland conditions. Columbus, Ohio in 1960 showed auto-ownership of 0.97 while Los Angeles County, a heavily auto oriented region, showed ownership of 1.42 in 1967. The projections for Honolulu appear in the mid-range of these observed conditions.

b. Trip Generation: The Trip Generation Model forecasts the number of daily trips produced in and attracted to each census tract. Because of the variation of land uses in each census tract and of trip production and attraction rates by trip purpose, trip generation was also stratified by purpose and each purpose calculated separately.

The Trip Generation Model was developed by OTS using statistical regression analysis techniques applied to socio-economic and land use characteristics related to the number of trip productions and attractions determined by origin-destination studies for specific trip purposes. In their development of the generation equations, all identifiable variables that could logically be related to the frequency of trip production or attraction by trip purpose were tested. Only those which had a significant effect on the generation were retained in the final equations. Trips were stratified by six (6) trip purposes:

- Home-based work
- Home-based shopping
- Home-based social-recreation
- Home-based school
- Home-based other
- Non-Home-based

AR00053272

In this program, OTPP operated the OTS model and the output was analyzed for conformance to results of recent home interview studies on Oahu and to results of similar studies on the mainland. In the OTS study and in the 1971 home interview, the ratio of 1.30 trips per job was found---a ratio which conforms to findings of Mainland studies. This consistent ratio of trips to jobs thus enabled the results of the Trip Generation Model to be checked. It was concluded that the model had over-predicted work trips by a relatively small amount and the results were therefore adjusted downward. With the adjustment, the total trips and trips per capita appeared reasonable, and no further adjustments were made.

c. Trip Distribution: The concluding step in the forecast of total travel was the determination of total person trip interchange between geographic areas, or trip distribution. The Trip Distribution Model is a gravity-type model developed and calibrated for Oahu by OTS. Primary model inputs are the productions and attractions produced by the trip generation model and an empirically derived time factor expressing the separation of zones. The model deals with each trip purpose separately and was calibrated by OTS on the basis of origin-destination studies. The model as calibrated produced excellent correlation between observed and predicted trip interchange values by trip purpose.

Prior to input into the Trip Distribution Model, trip totals as forecasted by the trip generation model on a census tract base were further refined to traffic analysis zones. These traffic analysis zones are subdivisions of census tracts and were used to provide more precise allocations of trips to the highway and transit networks in subsequent steps. There are 159 such zones. The model distributes the trips to these zonal pairs on the basis of person trips and produces what is called a person trip table, one for each trip purpose. The OTS model was operated by OTPP for this study producing trip tables for 1980 and 1995. These trip tables represent the basic travel forecasts and were used in subsequent testing of each transit alternative.

Again, because of the somewhat conservative nature of the population and employment forecasts, the direct relationship of land use projections to policy and current trends, and the excellent results obtained in the calibration of the travel forecasting models, the resulting trip tables may be accepted as representing the future trip distribution and demand with a high degree of confidence. If anything, the total travel demand forecast may be conservative.

AR00053273

Table II-7 presents a summary of daily and peak hour projections for 1995 by purpose.

3. Mode Choice and Network Assignment

The concluding steps in the transportation planning process were the determination of choice of mode (mode split) and the travel volume on each portion of the respective transportation system (assignment). These steps are a function of the total travel forecast and the relative attractiveness of competing modes. Each of the transit alternatives considered was subjected to these steps in the analysis and the resulting output used to evaluate each alternative. Since these steps are sensitive to the specific combination of modes expressed as system networks, only the general and common factors will be discussed here. Each alternative and its results will be discussed in more detail in subsequent sections.

A primary assumption necessary to perform these steps for the alternatives was that the street and highway system including travel speed and capacity would be the same for all alternatives regardless of transit system. This assumption has the distinct advantage of producing transit performance forecasts on a directly comparable basis since each system to be examined and evaluated would compete with alternatives on an equal basis. The only variable being the relative attractiveness of the transit system itself.

a. Mode Split: The mode split (or mode choice) model developed by OTS is a post-distribution, interchange type model which forecasts transit use as a percentage of total trips based on the independent variables of autos per dwelling unit at the production end, the travel time difference by transit for the interchange and average 9-hour parking cost at the destination end. As in prior models, calibration was based on observed mode split determined by origin-destination surveys.

Autos per dwelling unit input to the model uses the output of the car ownership model described earlier. The travel time difference is equal to the "equivalent" transit time* minus the auto time

---

*Equivalent transit time includes time spent walking, waiting or transferring (termed "excess time") and estimated running time. In calculating this factor, "excess time" is kept separate from "running time" and multiplied by 2.5 because people tend to "weight" the excess time heavily in their selection of mode. The 2.5 value has been determined through analysis of origin-destination studies in such places was Washington, D.C. and Calgary, Ontario by statistical linear regression techniques which related the proportion of total trips by transit to identifiable variables including running time and excess time. These calibrated equations indicated that "excess time" was from 2.5 to 3.0 times as important as running tim

AR00053274

TABLE II-7 1995 TRAVEL PROJECTION[14/]
TRIP PURPOSE DISTRIBUTION

PURPOSE	DAILY TOTAL PERSON TRIPS	DAILY % OF TOTAL TRIPS	P.M. PEAK HOUR PEAK HOUR PERSON TRIP	P.M. PEAK HOUR % OF TOTAL TRIPS
HOMEBASE WORK	673,600	20.4	108,580	29.5
HOMEBASE SHOP	456,200	13.8	53,020	14.4
HOMEBASE SOCIAL/ RECREATIONAL	857,400	25.9	90,400	24.6
HOMEBASE OTHER	383,700	11.6	41,150	11.2
SCHOOL	288,000	8.7	28,840	7.8
UNIVERSITY OF HAWAII	33,400	1.0	3,610	1.0
NON-HOMEBASE	615,700	18.6	42,350	11.5
TOTAL	3,308,000	100.0	367,950	100.0

AR00053275

between origin-destination pairs and is determined by summing the various network link times for travel between zone pairs. Thus, this variable is a direct function of the transit and highway systems as specified in the respective networks.

Parking cost variables were determined initially on the basis of the number of parking stalls available, the 9-hour parking rate and the occupancy rate for each type of parking available. Since this is an important variable in the mode-split estimation, special care was exercised in developing 1980 and 1995 parking costs for this study. In addition to the original parking cost surveys conducted by the original OTS, recent studies of parking cost in selected areas for 1972 and 1973 were used. Costs determined in these various studies was plotted against employment and a linear relationship identified generally similar in any employment area. Because of the linearity of this historical plot, it was assumed to continue in the future and parking costs were adjusted accordingly.

The other variable entered into the model was the person trip table. The trip tables outputted by the distribution models were combined into two basic tables each with distinct differences in propensity to use transit. These were Home-based work and Home-based non-work (a combination of Home-based shopping, Home-based social-recreation and Home-based other). Home-based school and Non-Home-based trips have unique transit related characteristics and were handled independent of the mode-split model as part of the special studies step. Special analyses were made for school trips, trips to and from the Manoa Campus of the University of Hawaii, and for Punahou School. Model output consists of the modal split for (1) home-based work trips and (2) home-based non-work trips. Thus, the model produces four trip tables--two for transit trips and two for auto trips.

Transit and auto trip tables were created with the results of the mode split runs. Average daily transit and auto trip tables were formed by combining the respective trip tables for each purpose into one table for each mode. The peak-hour trip tables were developed by multiplying the daily trip table for each directional trip purpose by appropriate peak period factors. Each trip purpose was further disaggregated into home-to-destination and destination-to-home trips to enable application of the appropriate directional peak-period factor.

AR00053276

b. Assignment and Network Coding: The highway and transit systems largely determine how trips are made and what routes are taken. Thus, it was necessary to develop the 1980 and 1995 highway and transit system and describe their operating characteristics. The 1980 and 1995 highway systems were prepared by OTPP. They were assumed to be the same for all of the transit alternatives.

Computer processing requires that these transportation systems be encoded in a certain manner for use in both mode split and assignment. The method is to represent the system as a series of lines (links), points denoting intersections or stations (nodes), and centroids, denoting the approximate center of activity for each traffic analysis zone. Each link is described by its length, travel time or speed, and certain other characteristics. After network description is encoded for machine processing, the computer makes all necessary calculations to determine the travel time by transit and highway for the more than 25,000 zone-to-zone movements.

The daily and peak-hour trip tables were "loaded" onto their respective networks to obtain the trip assignments. The transit assignments form the basis of the patronage estimates of this report. The highway assignments were examined for overly-congested roadways which would require special analysis.

The resulting transit assignments for each alternative were then used to evaluate the performance of each and to determine the fleet requirements, operating costs, etc. Subsequent sections of this report deal in more detail with these individual results.

AR00053277

CHAPTER III

FUTURE TRANSPORTATION NEEDS AND SOLUTIONS

A. ISLAND-WIDE DEVELOPMENT AND TRAVEL CHARACTERISTICS

1. Development Characteristics

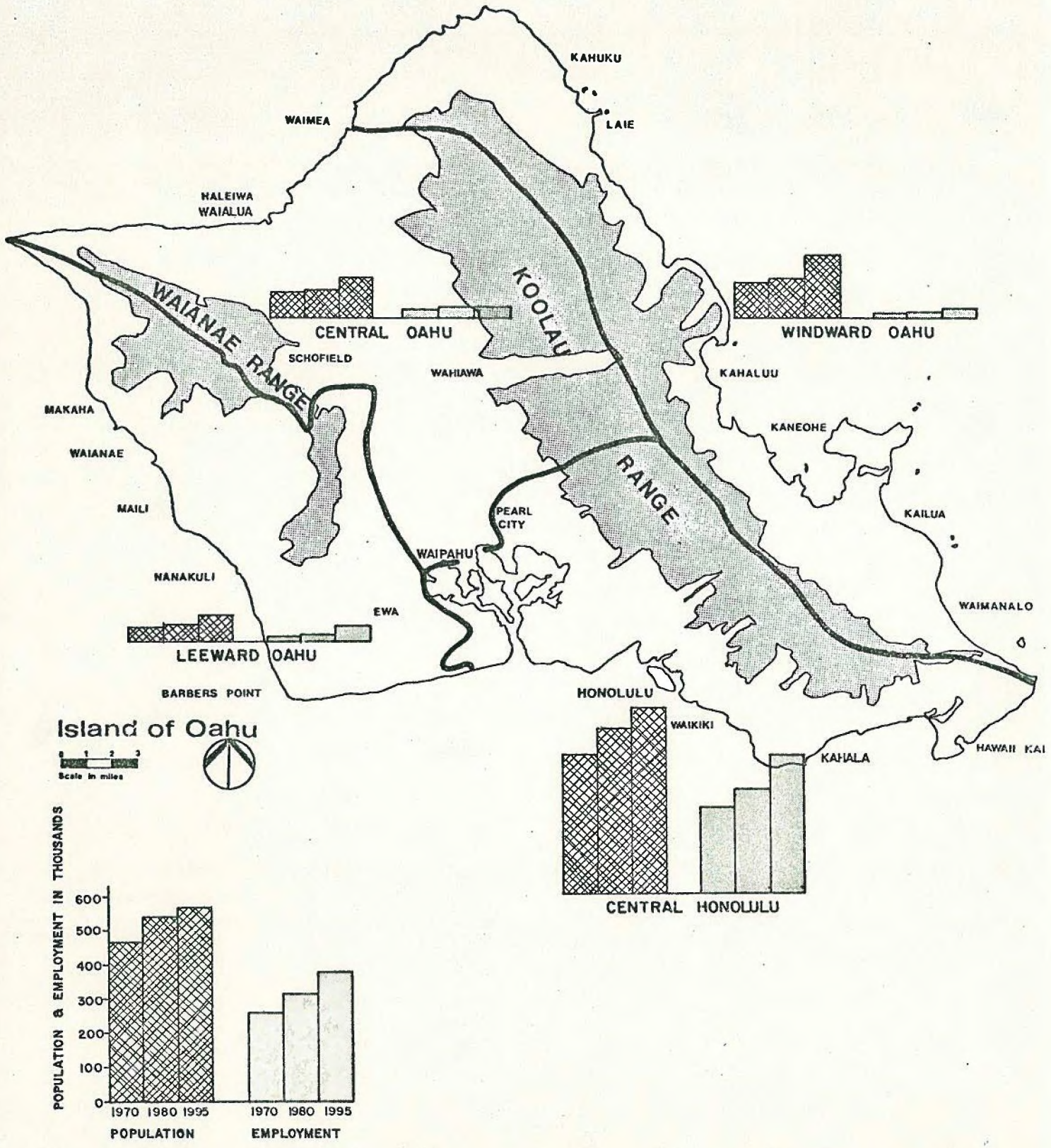
The Island of Oahu, due to its geography and topography, can be divided into four distinct regions; (1) Central Honolulu located on the leeward side of the Koolau Range, (2) Central Oahu located in the central plains between the Koolau and Waianae Ranges, (3) Windward Oahu located on the windward side of the Koolau Range, and (4) Leeward Oahu located on the leeward side of the Waianae Range. The development of the island has been greatly influenced by the geographic constraints imposed by the Koolau and Waianae Mountain Ranges and the constraints imposed by the State's land use law. Figure III-1 shows the 1970, 1980 and 1995 distribution of population and employment on the Island of Oahu. The highly urbanized Central Honolulu region is projected to continue as the center of population and employment on the Island of Oahu in the future.

The most densely urbanized district within Central Honolulu stretches from Pearl Harbor to Diamond Head. It is composed of many small urban concentrations which are strongly linked in function to the urban core of Honolulu. This dense urban district contains most of the island's industry, business, and government facilities and is the focus of major social, cultural, educational and recreational activities.

The urban district is approximately twelve miles long and two to three miles wide, with numerous developments extending into the valleys and ridges of the Koolau Range. It is characterized by a relatively narrow band of densely developed residential, commercial and industrial land uses. Development is generally most intense between the H-1 (Lunalilo) Freeway and the ocean, a distance of approximately one mile.

The suburban areas of the urban Honolulu district on the eastern end include developments adjacent to the Kalanianaole Highway extending to Hawaii Kai and on the western end developments in the Pearl City-Waipahu area, all located in the Central Honolulu region. In the outlying regions, the principal communities are located in the Leeward region from Ewa to Waianae, the Central region from Waipahu to Wahiawa, and the Windward region, including Kaneohe, Kailua and Waimanalo. Land use forecasts indicate that the pressures of continuing housing demand will intensify the development in the urban

AR00053279



ISLAND-WIDE POPULATION & EMPLOYMENT GROWTH DISTRIBUTION

FIGURE III-1

Honolulu as well as generate more new growth in the outlying regions.

2. Travel Patterns

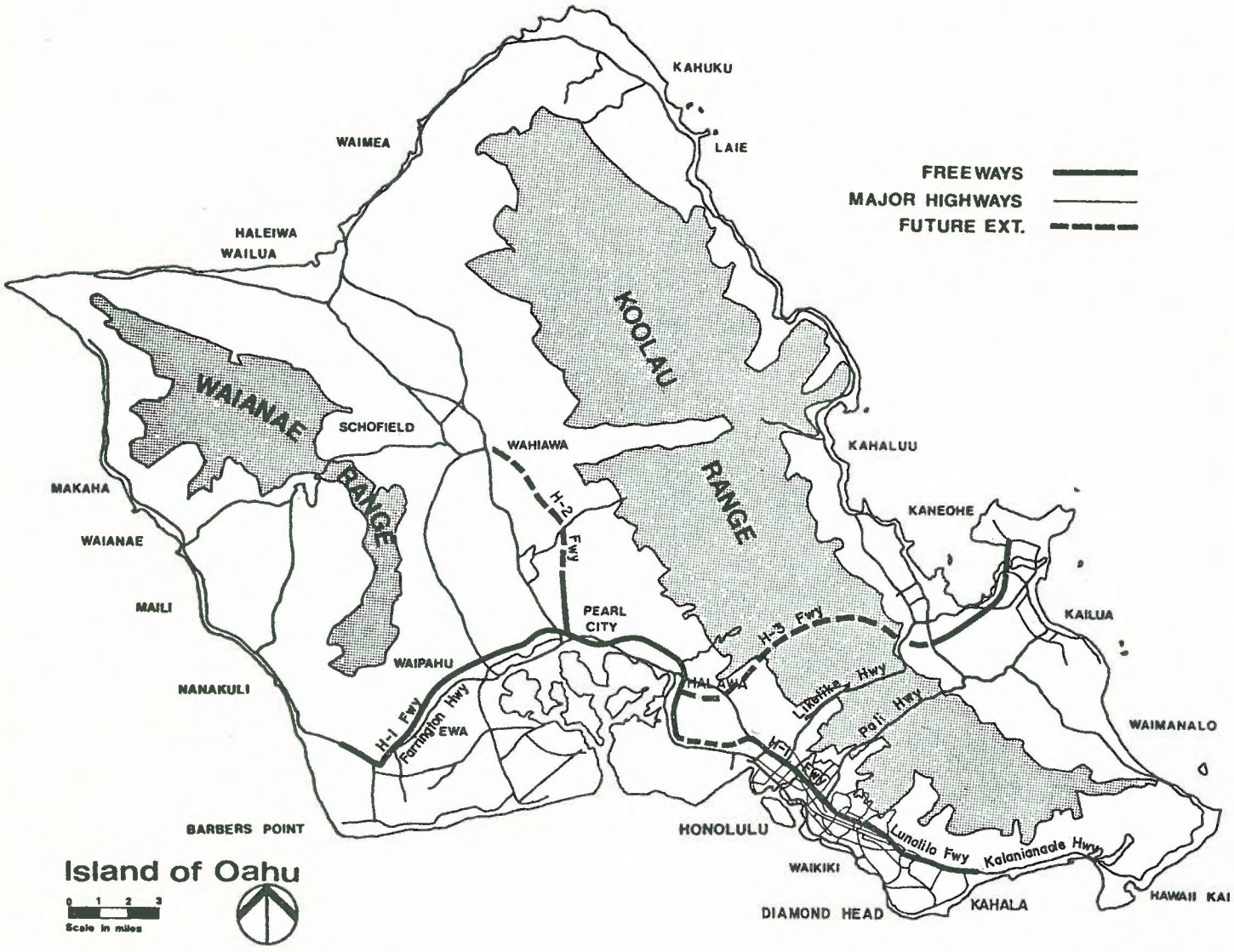
Development of Oahu, like that of most mainland urban regions, reflects the automobile orientation of the past several decades. The island was developed in relationship first, to the early road system, which was replaced by highways and ultimately by the interstate system.

In 1972 there were 1,230 miles of paved streets and highways on Oahu. The existing and planned Federal interstate highway system (H-1, H-2, H-3) which comprises approximately 52 miles of freeways on Oahu, is scheduled for completion by 1980. (See Figure III-2.) It will provide improved access to urban Honolulu from the Leeward, Central, and Windward regions of Oahu. With concentrations of government, commerce and tourism, located in urban Honolulu, the existing segment of the H-1 (Lunalilo Freeway) will be heavily used and will become the critical link in the interstate system. The H-2 freeway is presently under construction, and will extend from Pearl City to Wahiawa. The H-3 Freeway, when completed, will provide another link from the Kailua-Kaneohe area to urban Honolulu.

The travel pattern of urbanized Oahu is similar in intensity to that of many intermediate sized metropolitan regions in the United States, in that, the primary urban travel corridors radiate from the urban core. In the eastern direction, the corridor follows Kalanianaole Highway to Hawaii Kai. In the northern direction, the trans-Koolau corridor serves the Windward region. In the western direction beyond Halawa, the H-1 Freeway-Kamehameha Highway corridor, extends to the Pearl City area, where it bifurcates into two corridors serving the Central and Leeward regions. These three primary corridors funnel all traffic flows into the relatively narrow east-west movement channel of the Honolulu urban core. Due to the preponderance of employment and major activity centers concentrated in the urban core 350,000 to 400,000 average daily auto trips are projected for this main corridor by 1995.

In this urban core, there are several destination points in addition to the Central Business District (CBD). The most significant destinations are the Ala Moana Center, the Waikiki area, and the Hickam-Pearl Harbor military complex, with considerable importance given to the other points such as the University of Hawaii and the Honolulu International Airport. These major destination points form a geo-

AR00053281



HIGHWAY NETWORK - ISLAND OF OAHU

FIGURE III-2

graphically linear corridor pattern, beginning with the military complex on the eastern corridor end, followed by the airport, the CBD and Civic Center, the Ala Moana center, and the Waikiki-University area as the corridor proceeds eastward.

The residential areas are characterized by density types: high density developments in the urban core, low-to-medium densities in the suburban areas and predominantly low density developments in the outlying districts. Within a ten mile radius of the CBD are located the major suburban communities of Hawaii Kai, Pearl City-Waipahu, and, in the Windward region, Kaneohe-Kailua. Within a radius of twenty to thirty miles are located the more distant communities of Wahiawa and Waianae in the Central and Leeward regions, respectively.

Travel on Oahu, as measured by automobile ownership and vehicle miles traveled has increased by about seventy-five percent during the past decade. Proportionally this is a much greater increase than the twenty percent increase in population. Due to the increase in labor participation rate, work trips have also increased more rapidly than the population. The very rapid increase in overall travel has created a great demand for additional street and highway capacities. The development patterns of urban Oahu and their transportation demands are beginning to overtax the principal travel corridors with the major impact on the critical high-volume corridor in the urban core.

3. Accessibility To Urban Honolulu

The outlying regions of Oahu are planned to be served by modern highways and freeways providing easy access to urban Honolulu. The H-1, H-2, and H-3 Freeways will serve the Leeward, Central, and Windward communities, respectively, and are all supplemented by one or more highways in the major travel corridors.

The Leeward and Central regions contain suburban and rural communities scattered over a large area. The rural communities are generally small and are typical of low density development. A relatively high percentage of the population in these communities fall into the lower income category.

In the Windward region are located the larger suburban communities of Kaneohe and Kailua. These communities are predominantly low to medium density developments for middle income families. On the southeastern end of this region is the semi-rural community of Waimanalo which has a relatively high percentage of lower income population.

AR00053283

With existing and committed highways and freeways providing fast and direct routes to central Honolulu, accessibility from these outlying regions is good and capacity is ample to accommodate future travel demands. As previously stated, these outlying regions have communities with higher percentages of low income households than is typical in other parts of Oahu. Consequently, there are more transit dependent households in these outlying communities but the dispersed pattern of development and its relatively small population poses certain economic constraints on the provision of more frequent service. The existing transit service provides bus routes to each of these low income areas with buses operating at minimum headways of 5-10 minutes during peak periods and at maximum headways of 20-30 minutes during off peak periods.

AR00053284

B. CHARACTERISTICS OF THE URBAN HONOLULU CORRIDOR

1. Land Use

In Chapter II, forecasts of growth in population, employment, and travel demand for the Island of Oahu which formed the basis for transit planning were presented. A more detailed review of the forecasted growth and changes in urban Honolulu is presented in the following section.

Within the Central Honolulu region, from Pearl City to Hawaii Kai which is the span of the proposed transit corridor, past and forecasted population and employment are shown in Table III-1.

TABLE III-1

CENTRAL HONOLULU SHARE OF POPULATION AND EMPLOYMENT

	Population	% of Total Island	Employment	% of Total Island
1970	407,600	65%	259,000	82%
1980	483,500	66%	309,000	82%
1995	545,500	59%	404,000	78%

The forecast indicates that there will be continued growth in both population and employment within urban Honolulu. However, in 1995, the percentage of population in urban Honolulu relative to the entire island drops from 65% to 59%. This percentage shift reflects the pressure for more urban land in the outlying areas as a result of both policy direction and the fact that the current urbanized area can accommodate increases only through reuse of existing developed land.

The employment forecasts indicate increased growth with only a slight decline in percentage of the total located in urban Honolulu. This forecast reflects the continued growth forecasted in government, tourism and service types of employment in the Honolulu core area. Notable increases in employment are forecasted to occur in the following locations:

AR00053285

TABLE III-2

MAJOR URBAN EMPLOYMENT AREAS

Districts	Employment 1970	1980	1995
CBD - Civic Center	52,400	64,400	83,100
Waikiki	18,800	23,700	39,800
Ala Moana-Ward	18,600	20,000	29,800
Kakaako	16,500	19,400	26,300
Kalihi-Iwilei	30,300	39,200	52,800
Airport	14,800	17,400	21,000
Pearl Harbor-Hickam	40,200	41,600	40,900

The above projected employment will reinforce the continued growth and importance of the urban core and the attendant increase in travel demand. Adequate transportation facilities which are required for the efficient movement of goods and people to support these activities is vital to the economic well being of the entire State.

2. Corridor Demand

The most critical transportation corridor on the Island of Oahu is the narrow east-west corridor spanning from Middle Street to the Diamond Head area. No new highways or freeways are contemplated and recent studies conducted under the TOPICS[15] and National Transportation Need Study[16] programs forecasted a serious deficiency in transportation capacity in this corridor.

Within this urban corridor, which continues to grow at a rapid rate, a comparison of traffic volumes versus capacity was made. An analysis of the screenlines on either side of the CBD-Civic Center area indicates an available capacity of some 280,000 vehicles per day on the western side and approximately 300,000 on the eastern side, based on a level of service "D". (See Figure III-3). The 1973 volumes through these screenlines are approaching or have reached their available capacities. Based on travel demand forecasts, in 1995 the volume will exceed capacity by approximately 80,000 to 100,000 autos per day. Converting the daily auto trips to peak hour auto trips would result in approximately 6,000 autos per hour in each direction; the equivalent of a new 6-lane freeway carrying 2,000 autos per hour per lane. It is clear from this analysis that, even today, congestion is heavy and will be more severe in the future and the question then is how to relieve this situation.

AR00053286

PRELIMINARY ROADWAY CAPACITY & VOLUME

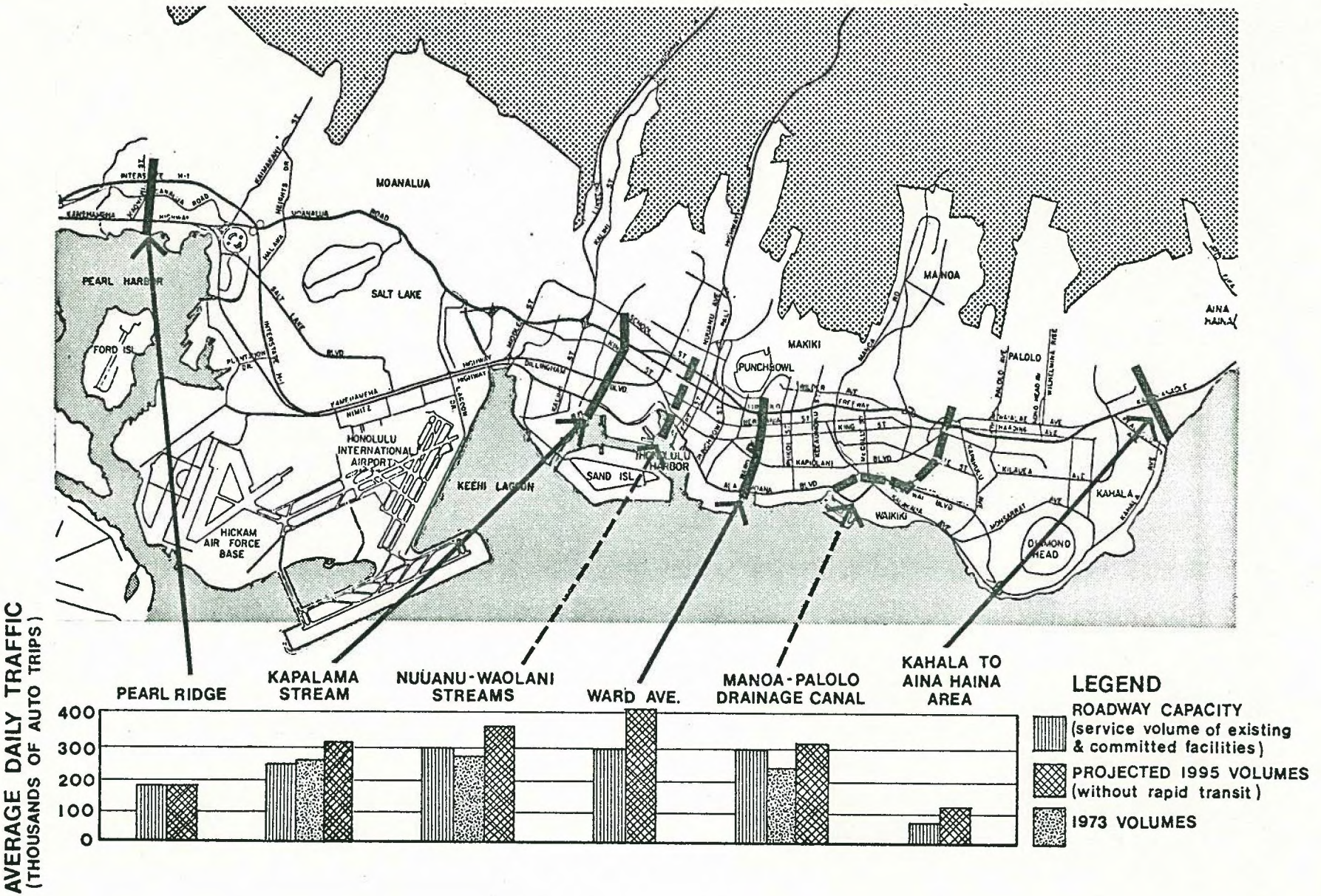


FIGURE III-3

C. STUDY OF TRANSPORTATION ALTERNATIVES

1. The Oahu Transportation Study

In 1967 a major step towards meeting the increasingly critical transportation needs on Oahu was made when the Oahu Transportation Study (OTS) was undertaken to establish a long range, comprehensive transportation planning process.[3/] This effort coordinated all other comprehensive planning efforts of the State and the City and County. In addition to the development of a transportation planning process, the study recommended a long range transportation plan, oriented toward relieving the heavily congested streets and highways on the island.

The OTS developed two basic alternative transportation systems for testing. One was oriented toward a fixed facility transit mode (System No. 1), as shown in Figure III-4, coupled with completion of the committed highway facilities. The other was oriented toward an all bus system operating on an expanded system of streets and highways (System No. 2). Route locations and service criteria were based upon the travel patterns and volumes indicated by a 1960 origin and destination study and projected 1985 travel.

An analysis of these two alternatives was conducted including a modal split analysis. The results of this analysis indicates nearly 340,000 daily passengers for the fixed facility system and some 280,000 daily passengers for the all bus system. The higher patronage volume of the fixed facility system required less streets and highway to meet future travel demand and hence resulted in less total transportation cost than the all bus system. Based on 1967 prices, the cost of the combined fixed facility transit system and planned streets and highway improvements was estimated at $580 million as compared to over $700 million for the all bus system alternative with its attendant requirement for additional streets and highways.

In addition to cost considerations, the study also analyzed various social, economic, and community factors relative to the two alternative systems. The result of this analysis was in support of System No. 1 or the fixed facility transit for the following reasons:

a. It produces a significantly higher level of service.

b. It has a much greater potential for influencing the shape and pattern of the future community.

AR00053288

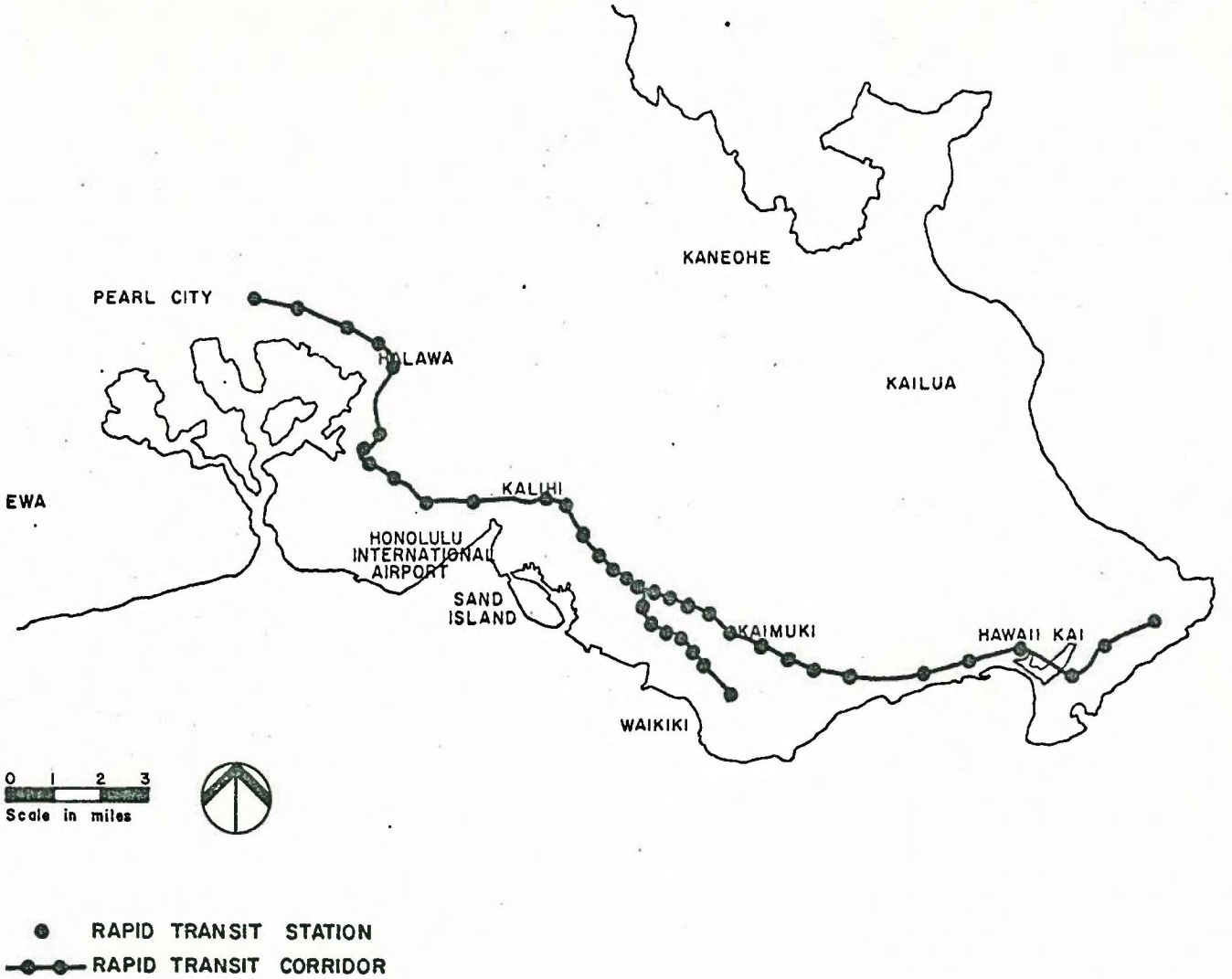


FIGURE III-4

OTS RAPID TRANSIT CORRIDOR

c. It affords a practical method of alleviating traffic congestion in the concentrated areas of Honolulu and is potentially a practical alternative to a second major freeway through an intensely developed area.

d. It affords the greatest potential for adequately accommodating the heavy tourist movements to and from the airport anticipated in the near future.

e. It provides the most predictable transportation mode in terms of travel time.

f. Coupled with existing highway facilities plus some improvement in the central areas, it affords a transportation capacity adequate to meet the estimated 1985 travel demands and beyond.

g. It provides an alternative to the requirement for extensive parking facilities in the urban areas and therefore promotes a more productive use of high value land area.

The Oahu Transportation Study concluded that the planned highway improvements should go forward and that plans should also be developed for an improved rapid transit system which would be required by 1985. It also concluded that rapid transit can attract large numbers of passengers which could influence the requirements for highways. The OTS had the foresight to conclude, as early as 1968, however, that a high-capacity roadway in Central Honolulu would not meet with general public accpetance. The study therefore recommended that a rapid transit system be adopted in all long-range plans for Oahu.

2. Analysis of Expanded Bus Transit System

The previous section discussed the results of the OTS Study conducted on basic transportation alternatives consisting of an all-bus system operating on streets and highways and a high level rapid transit system. This study concluded that a rapid transit system is not only more cost-effective due to the reduced need for additional highway improvements but that it provided other social, environmental, and community benefits which the all-bus transit system could not match. This section presents a more detailed discussion of various implications related to an all-bus transit system.

In the earlier sections of this Chapter, the travel demands on an island-wide basis and for Central Honolulu were presented. The critical capacity

AR00053290

deficiency in the street and highway system on either side of the downtown area was shown to require a minimum 6-lane freeway by 1995. As early as 1967, the OTS pointed out that any new freeway in Central Honolulu would not be acceptable to the community. Today, it is recognized by government officials, professional planners, and citizens that Honolulu cannot afford such an environmentally disruptive facility as a new freeway in urban Honolulu. Both the State's and the City's recommended policy statements as contained in their respective General Plan Revision Program for Oahu reflect this view.

A vastly expanded bus service provided by over 700 buses operating in both mixed traffic and on reserved bus lanes was tested and found to attract over 60 million passengers in 1980 and increasing to 110 million passengers in 1995. The latter volume would not meet the basic transportation objective of providing a transit system capable of attracting up to 150 million passengers in order to reduce the need for additional new freeways.

In addition to the foregoing, the degradation of the downtown environment through increased air and noise pollution caused by several hundred buses operating on the streets would be significant. The further aggravation of the already congested streets would reach an intolerable level. Perhaps the most significant constraint placed on the expanded bus system is the physical limitation of the downtown streets. Based on a detailed analysis of street capacity and other studies,[17] an estimated upper limit of some 120 buses per hour are capable of being accommodated through the downtown streets as compared to nearly 200 buses per hour estimated for the expanded bus system in 1995. Thus both environmental considerations and physical constraint of downtown streets combine to limit the feasibility of continued expansion of the bus system as the long-term solution for Honolulu.

AR00053291

D. STUDY OF TRAVEL DEMAND BASED ON ALTERNATIVE DEVELOPMENT POLICIES

In the analysis of the "Benefits" and "Costs" to the community associated with each of the alternative development policies and their impact on the existing transportation facilities, the Department of General Planning in their General Plan Revision Program (GPRP) assumed an existing transportation system containing a highway network which included all primary facilities that exist today and H-1, H-2, and H-3 Freeways.[18] In addition, a high-capacity rapid transit facility between Pearl City and Hawaii Kai with supporting feeder and express bus service was assumed fully operational.

To investigate the impact of the alternative development policies on the highway network, several strategically located cordons or corridor "screenlines" were established and an auto volume to capacity analysis was conducted at these screenlines. The capacities or service volumes volumes used were based on level of service C or D.[19] Facilities in urban areas were generally assigned service volumes at the D level, while facilities in rural areas were assigned service volumes at the C level.

Each screenline volume was calculated by totaling the individual volumes projected for each roadway through which the screenline passes. The service volumes through each screenline were calculated similarly. A tabulation of the results of the volume versus capacity or service volume (V/C ratio) analysis for each of the six alternative development patterns (all with a high-capacity rapid transit system with attendant express and feeder bus service assumed operational) are given in Table III-3.

As can be seen in Table III-3, the street capacities are generally adequate at the 924,000 population level except in the Kalanianaole Highway corridor. Further it can be observed that streets in the urban core for populations greater than 1,000,000 would be highly congested and inadequate to meet the demand without additional facilities provided.

For population in excess of 1,157,000 and more specifically for 1,398,000 as tested, the development patterns under the Directed Growth policy shifts both population and employment to outer areas in order to develop holding capacity. While this policy naturally reduces travel demand in the critical central areas of Honolulu compared to the Intensive Development option at comparable population levels, travel demand is still substantially above that produced with the DPED projected population of 924,000 used in this study.

AR00053292

TABLE III-3: SCREENLINE VOLUME TO CAPACITY ANALYSES

Screenline	Service Volume (Autos)	924,000 Population Level: Intensive Development Scheme A* Volume (Autos)	V/C	Intensive Development Scheme B* Volume (Autos)	V/C	Mod. Expansion Volume (Autos)	V/C
Pearl Ridge	192,000	175,000	0.91	165,000	0.86	181,000	0.94
Liliha Street	278,000	251,000	0.90	254,000	0.91	251,000	0.90
Ward Avenue	369,000	324,000	0.88	340,000	0.92	323,000	0.88
Kahala-Aina Haina	60,000	83,000	1.38	71,000	1.18	72,000	1.20

Screenline	Service Volume (Autos)	1,157,000 Population Level: Intensive Development** Volume (Autos)	V/C	Directed Growth Volume (Autos)	V/C	1,398,000 Population Level: Directed Growth Volume (Autos)	V/C
Pearl Ridge	192,000	223,000	1.16	227,000	1.18	204,000	1.06
Liliha Street	278,000	332,000	1.19	290,000	1.04	315,000	1.13
Ward Avenue	369,000	441,000	1.20	381,000	1.03	403,000	1.09
Kahala-Aina Haina	60,000	96,000	1.60	79,000	1.32	84,000	1.40

*Scheme A consisted of meeting anticipated housing demand based on the maximum number of low density dwelling units. Scheme B consisted of the maximum number of high density dwelling units to meet housing demand.

**Housing demand would consist of the maximum number of high density dwelling units. Supply of low density residential land was insufficient to support the maximum number of low density dwelling units.

AR00053293

In addition to studies of projected vehicular traffic volumes, the Department of General Planning developed transit ridership volumes for both the rapid transit and feeder-express bus services. A compilation of these volumes for each of the defined alternatives is shown in Table III-4. It was estimated that the peak hour, peak link rapid transit volumes would vary between 20,000 to 30,000 passengers in one direction. The variation is basically due to the difference in population levels. The table indicates that, in general, the Intensive Development policy will place a somewhat heavier requirement upon both the arterial and highway network and mass transit systems through the urban corridor at comparable development levels.

In terms of the transportation policy analysis for the various development policies the findings were as follows:

- With a high capacity rapid transit system complementing the existing and planned streets and highways, the combined capacity would generally meet the demand of a population level of 924,000 for all three of the alternative development policies; Intensive Development, Moderate Expansion and Directed Growth.

- The travel demand is not significantly affected in the urban core by different development alternatives up to the population level of 924,000.

The recommended policy statement contained in the General Plan Revision Program is: "Demand for transportation services within the Central Honolulu, East Honolulu, and Pearl Harbor corridors should be met primarily through the provision of rapid transit services and feeder systems as appropriate, with limited highway improvements."[5/]

AR00053294

TABLE III-4

PROJECTED TRANSIT TRIPS FOR
ALTERNATIVE DEVELOPMENT POLICIES

	Total Daily Trips	Daily Transit Trips	Daily Rapid Transit Trips
Intensive Development			
Population Level I Scheme A	3,361,300	484,500	345,000
Population Level I Scheme B	3,361,300	497,000	348,200
Population Level II	4,194,350	597,300	424,100
Moderate Expansion			
Population Level I	3,361,300	489,400	343,900
Directed Growth			
Population Level II	4,196,600	583,050	393,300
Population Level III	4,994,500	644,500	417,900

Note: Population Level I - 924,000
PopulationLevel II - 1,157,000
Population Level III - 1,398,000

AR00053295

E. CONCLUSIONS AND RECOMMENDATIONS

Based on these studies, it is concluded that a high level rapid transit system would best meet the future travel demand in Central Honolulu. This conclusion is supported by the results of studies which considered the following:

- the ability of existing and planned facilities to satisfy present and future travel demands

- the ability of various forms of transit to attract patrons

- the ability of transportation systems to best meet land use and environmental goals of the area

First, from a total travel standpoint, the existing street and highway system is heavily congested, particularly in the urban core sections. Almost all major city streets and freeways are presently operating at a level of service "D" during peak hour in the urban core with no new freeways planned in those areas. Therefore, at the present time, there is a crucial need for additional transportation capacity in the urban core areas of Honolulu. The City and County and the State have cooperated in several traffic engineering, parking, and bus operational improvement programs to fully maximize the use of the present system. Despite this, the problem remains and it will worsen, of course, as time goes on.

Population was projected to rise by 17% by 1980 to a level of 735,000 and by 50% by 1995 to a level of 924,000 from the base year of 1970. Already in 1975, the forecast has been exceeded by nearly 5%. The same general situation exists in terms of employment. In terms of trip making and existing and planned transportation capacity, there is no question that new facilities are needed now, and that they will be increasingly utilized immediately when available. The density of population and resulting relocation problems, environmental problems, and energy considerations prohibit additional freeway capacity, a decision which was made locally, prior to the current general nationwide view on this matter.

The question then becomes, can some other mode of transportation accommodate the transportation needs? Our analyses have shown conclusively that transit can indeed satisfy this need. In early 1971 the City and County of Honolulu assumed bus transit operation on the island. The patronage on this system has increased dramatically since that time from 17 million annual passengers in 1971, to over 35 million passengers in 1974, and about 50 million expected in 1975, based on experiences so

AR00053296

far this year. These increases have been attributed to various innovative programs instituted by the City including express bus services, contra-flow bus lanes, reserved bus lanes, etc. Based on the conservative population and employment forecasts described above, we have projected greater transit ridership in 1985 and in 1995. Exclusive of tourist patronage, we conservatively estimate that a well located and designed high level rapid transit system can generate 100 million passengers a year by 1985, and nearly 150 million by 1995. This projection is quite consistent with the present experience with the bus system, when one accounts for the differences in levels of services, particularly as further congestion builds on the highway system.

These forecasted transit patronage volumes would match the expected travel demand which cannot be accommodated by the existing transportation system due to capacity limitations. Providing a system less than a high level rapid transit system, such as the expanded bus system which would attract about 100 million passengers in 1995, would not be sufficient to meet future demands without building additional new freeways.

Finally, we have talked earlier about the population and employment growth of the island. While many geographical features, such as mountain ranges and water tend to channel this growth into certain locations, the construction of a high level rapid transit system, in concert with present and future growth and development policies, will do much to ensure that this growth is served by adequate transportation and that the growth takes place at the proper locations.

There are other reasons as well why investments can safely be made, and should be made in rapid transit in Honolulu. Environmentally, Honolulu is a sensitive area which must be protected, both for its residents and for the sake of one of its principal industries--tourism. Investments in public transit such as those proposed will have a positive impact on air and noise pollution, and in addition, have less serious negative environmental impacts than major investments in new highway facilities. Then, too, from an energy conservation standpoint, which is especially crucial because of the geographical separation of Honolulu from energy sources, an investment in a sound rapid transit system will have impacts on energy conservation which would save the area over 10 million gallons of fuel per year.

Another important consideration is transit service to various national defense installations on Oahu. These facilities and supporting military housing areas are important generators of trips which were recognized in determining the system route. Improved transit service will benefit

AR00053297

not only the resident population working in defense facilities but alos military personnel and their dependents.

Without question, then, there is a demonstrated need for new transportation facilities in the urbanized areas of Honolulu at the present time. This need will increase significantly over time and it can be satisfied well by a high level rapid transit system. This system will attract significant patronage so that it would be a sound investment which is in accord with and promotes the land use and environmental goals of the Island. Honolulu has demonstrated through its existing bus system that it can and is indeed attracting high transit patronage at a level of about 50 trips annually per population unit, a level about that of Chicago. This high level is sufficient to justify a major expenditure in rapid transit now and over the long term.

AR00053298

CHAPTER IV

MANAGEMENT OF EXISTING TRANSPORTATION SYSTEM

A. GENERAL

An important element of effective urban transportation planning is the examination of the possibilities of using low-cost, short-term transportation actions to optimize use of existing systems. A conclusion of Chapter III was that all possible steps should be taken in this area. This is especially important when consideration is being given toward the commitment of a large amount of capital for a long-term project. Currently, the City is striving to optimize the use of its existing transportation capacity and is taking steps to reduce travel demands wherever possible.

For the purpose of discussion, improvements in the management of existing transportation systems are discussed in three broad categories:

- Management of Existing Street and Highway System
- Improvement of Existing Transit System
- Measures to Reduce Vehicular Travel

This chapter discusses the low capital, short-term transportation programs which have been attempted and are planned for the City and County of Honolulu. The magnitude of each project and their effectiveness is also discussed.

AR00053300

B. MANAGEMENT OF EXISTING STREET AND HIGHWAY SYSTEM

The City and County of Honolulu and the State of Hawaii have implemented several measures to improve total vehicular flow on Oahu. These measures have varied from minor signalization improvements at intersections to reserving lanes on freeways for high-occupancy vehicles.

1. Improved Signal System

The City and County of Honolulu have continually maintained a program of monitoring and upgrading its traffic signals. The traffic demand at major intersections is carefully reviewed to ensure that signal phasing and timing optimizes these facilities. This is especially true at the more complex intersections. The City and County has embarked on a program of signal modernization and upgrading of traffic control equipment which will encompass 203 intersections over a period of three years.

2. One-Way Streets, Reversible Lanes, Restricted On-Street Parking

Traffic engineering experience has indicated that there are several means of increasing street capacity within the existing right-of-way and without major capital expenditures. One of these which has been extremely successful is the one-way street program. The circulation pattern for the entire area from downtown to Waikiki is designed around the concept of one-way streets. The Waikiki area is an example with Kalakaua Avenue and Ala Wai Boulevard forming an east-west one-way couplet. All the mauka-makai (north-south) streets in this area are one-way streets. Because many of these streets are narrow, the one-way street system allows on-street parking without sacrificing street capacity.

A program of peak-hour parking restrictions has been implemented in Honolulu. This has increased the peak-hour capacity of streets without affecting the off-peak parking capacity of certain areas. This is especially important on streets which are in areas with a high concentration of commercial establishments and are important routes for commuters to the downtown and Waikiki areas.

A third major program is the use of reversible lanes. This has been implemented on two streets in Honolulu--Kapiolani Boulevard and Ward Avenue. The two center lanes on Kapiolani Boulevard between Kaimuki and South Street are used in this manner during peak hours allowing four lanes inbound (ewa) and two outbound (kokohead) during the AM peak and four outbound and two inbound during the PM peak.

AR00053301

This same concept is utilized on Ward Avenue between Kinau Street and Kapiolani Boulevard.

3. Ramp Metering and Freeway Surveillance

Consultants to the State of Hawaii Department of Transportation has recently completed a study[21] to evaluate the origin and destination of the users of the Lunalilo Freeway. This study was conducted to determine what measures could be implemented to monitor and control the volume of traffic on the freeway by ramp metering. This would help divert short trips off of the freeway and provide the long trip users with improved traffic flow. The results of this study are currently under review by the State.

4. Flexible Work Hours

The City and County of Honolulu allows its employees to vary their work hours in an effort to spread the peak period commuting over a greater period of time. City and County employees are allowed to start as early as 7:30 AM and as late as 8:30 AM with a corresponding variance at the end of the day to allow for an 8-hour work day. This is a program which would require more universal implementation (e.g., State and Federal employees) before it could significantly improve city-wide traffic conditions. The City program has been in existence since 1973 and affects 1,600 employees.

5. Bike Lanes and Bikeways

Accommodation of bicyclists on the streets and highways in Honolulu have been provided in certain areas. Bike lanes have been implemented on University Avenue, between Metcalf Street and Kapiolani Boulevard. Bike lanes have also been provided along Kalanianaole Highway, between Lunalilo Home Road in Hawaii Kai to Ainakoa Avenue near Kahala. These bike lanes have improved the safety of bicyclists and the operation of automobiles on these roadways by providing reserved lanes for bicycles and thereby reducing the conflicts between automobiles and bicycles.

Currently, a master plan of bikeways[22],[23] in Honolulu is being prepared by the City and County of Honolulu and State of Hawaii. This plan is primarily located in the central area of Honolulu. The plan is intended to provide a safe and convenient network of bikeways for Honolulu residents for work and school use as well as for recreation.

AR00053302

6. Other Improvements

Improved street illumination along major traffic arteries provides not only improved pedestrian safety but also greater comfort and convenience to traffic moving during hours of darkness. The City and County of Honolulu continually reviews existing street illumination levels to determine areas of deficiencies and non-conformance to current standards and criteria and implements programs to remedy these deficiencies. Such programs include the conversion of mercury vapor lamps to high pressure sodium lamps to increase the illumination levels at certain busy intersections along two major east-west arteries, King Street and Kapiolani Boulevard.

Also, the City endeavors to improve existing street capacity and operation through programs of re-channelization of major streets and intersections. Such programs include the re-striping of Dillingham Boulevard in the Kalihi-Palama area, Ward Avenue in the Kakaako area, and Kuhio Avenue in Waikiki, to provide left turn lanes and improve the flow of through traffic on these streets.

AR00053303

C. IMPROVEMENT OF EXISTING BUS SYSTEM

Improvements to the existing bus system can be categorized into two general areas: those improvements which are related to fares, routes, and schedules, and those which are related to improving the flow of buses on the streets and highways.

1. Fares, Routes, and Schedules

Despite increasing costs for the operation and maintenance of the system, the City and County of Honolulu has maintained its policy of a flat fare (25 cents), free transfer bus system. All discussions related to changes in fare policy have been directed toward the lowering of fares to a possible free-fare system. This philosophy of providing bus service at a low cost to passengers has been a significant factor in the continual increase in the patronage.

Several routes have been added since the integration of the system into an Island-wide bus system. The most significant additions include the Hawaii Kai Express, the Windward Express and the Wahiawa Express (See Figure IV-1). Schedules have been improved to the point of reducing headways on some heavily patronized routes to three minutes. The City and County of Honolulu Department of Transportation Services is continually monitoring and updating the transit plan to reflect changes in demand and usage. The improvement program, which is fully documented in the "Short-Range Bus Plan for Oahu (1975-1980 inclusive)"[24] includes the following elements:

- A substantial increase to the existing bus fleet from 250 buses currently to 350 by 1977.
- New bus routes and revisions to existing routes.
- Improvement of bus stops including benches, shelters, and signs.
- Provision for park-and-ride facilities in suburban areas.
- A positive marketing program to disseminate route and schedule information to the public.
- Modern coaches with air-conditioning and public address system.
- Provisions for reserved-lane bus service on major highways.

AR00053304

Major Improvements to Existing Bus Operations

- Express Bus from Hawaii Kai
- Express Bus from Windward
- Express Bus from Wahiawa

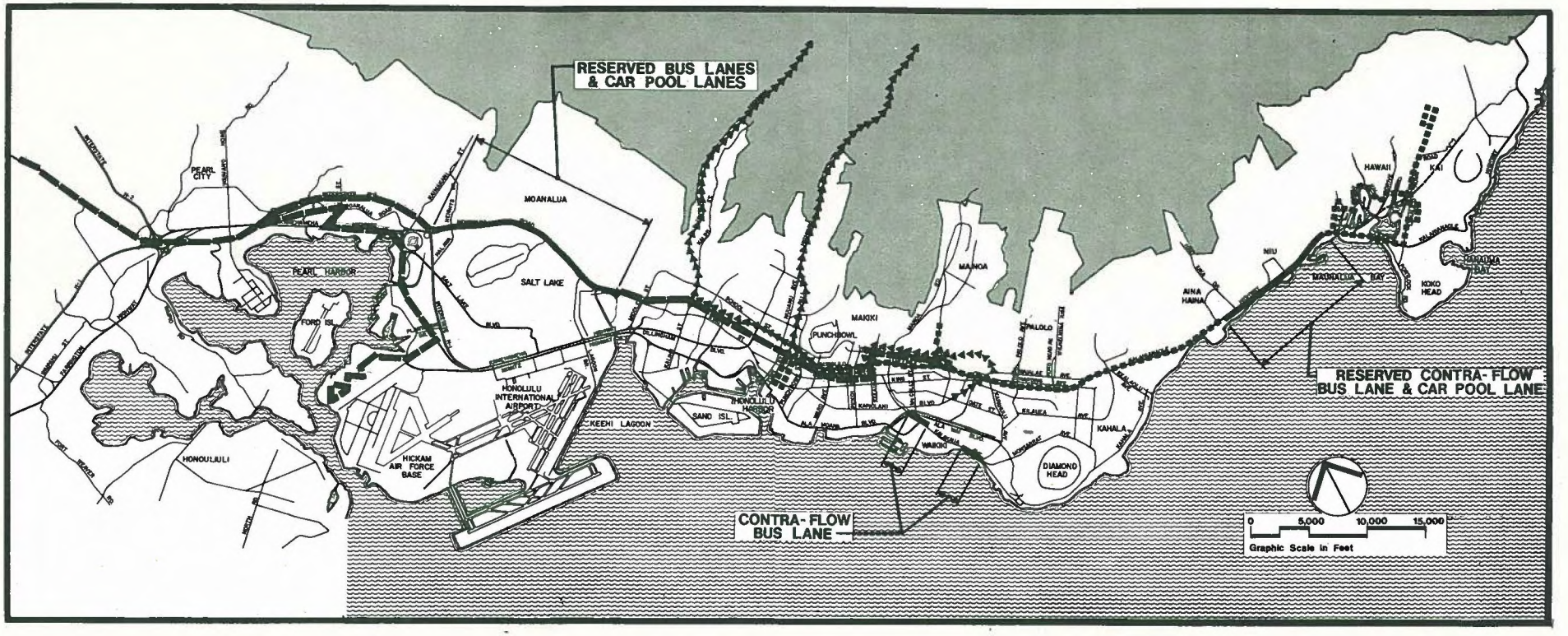


FIGURE IV-I

2. Improvements to Flow of Buses

The most notable improvement is the implementation of several express and semi-express bus routes. The Hawaii Kai express bus route was implemented by utilizing the concept of the contra-flow bus lane (see Figure IV-1). An outbound (kokohead) traffic lane on the Kalanianaole Highway is reserved for inbound (ewa) express buses during the AM peak period. The Hawaii Kai express has been in operation since 1973 and has a daily patronage of 1,300, very near its capacity based upon existing bus availability. Recently the use of the contra-flow bus lane has been expanded to include carpoolers.

Two other programs are currently being employed in Honolulu to improve the service provided by buses. These are:

- The use of contra-flow lane on a portion of Kalakaua Avenue between Kapahulu Avenue and Ala Wai Boulevard to allow local buses to travel ewa-bound. This affects 4 routes and 41 buses per hour during the peak hour. (See Figure IV-1).

- Reserving the center lane in each direction on Moanalua Freeway for buses and carpools between Halawa Heights Road and Puuloa Road. Currently the lane averages over 600 vehicles per hour during the two-hour peak period. (See Figure IV-1).

The short-range bus plan for Oahu includes an extensive system of bus lanes and busways to service the express and semi-express routes during the next six years. These include:

- Kalanianaole Highway from Lunalilo Home Road to Kahala Mall--possibly an at-grade one-way busway with median openings at ten major intersections and the use of signal preemptive devices aboard the buses to assure good signal progression.

- H-1 from Kahala Mall to Kapiolani Interchange--exclusive bus lanes.

- Pali Highway from Castle Junction to CBD--contra-flow bus lanes.

- TH-3 from Likelike Interchange to Halawa Interchange--bus lanes.

- H-1 from Waiawa Interchange to Halawa Interchange--exclusive bus lanes.

In addition to the above, a new route is planned to serve the primary transportation corridor in urban Honolulu and basically follows the proposed rapid transit route. The description of this route and required

AR00053306

improvements are as follows:

- Kamehameha Highway from Waiawa Interchange to Middle Street--exclusive bus lanes in outside lanes on each side of the highway. Bus bays will be constructed off-line to permit buses to pass stopped vehicles and preemptive devices aboard buses will improve signal progression.

- Dillingham Boulevard from Middle Street to North King Street-contra-flow bus lanes with use of signal preemptive devices.

- Hotel Street from River Street to Richards Street--exclusively for buses and commercial vehicles.

- King Street from Richards Street to Kapiolani Boulevard--exclusive bus lane in right-hand lane.

- Beretania Street from Alapai Street to Richards Street--exclusive bus lane.

- Kapiolani Boulevard from King Street to Kalakaua Avenue--exclusive bus lane in right-hand lane in peak-period direction during peak period.

AR00053307

D. MEASURES TO REDUCE VEHICULAR TRAFFIC

The City and County of Honolulu and the State of Hawaii have both implemented programs to reduce vehicular travel primarily by encouraging higher occupancy in existing modes. This includes greater bus usage and increasing passenger occupancy in private automobiles. Some of the measures are intended to reduce automobile traffic in specific areas. One such program is the limitation on the amount of public parking facilities provided in the downtown area to encourage use of buses and fringe lots. The program is designed to provide parking facilities outside of the downtown core to free these streets for pedestrians and buses.

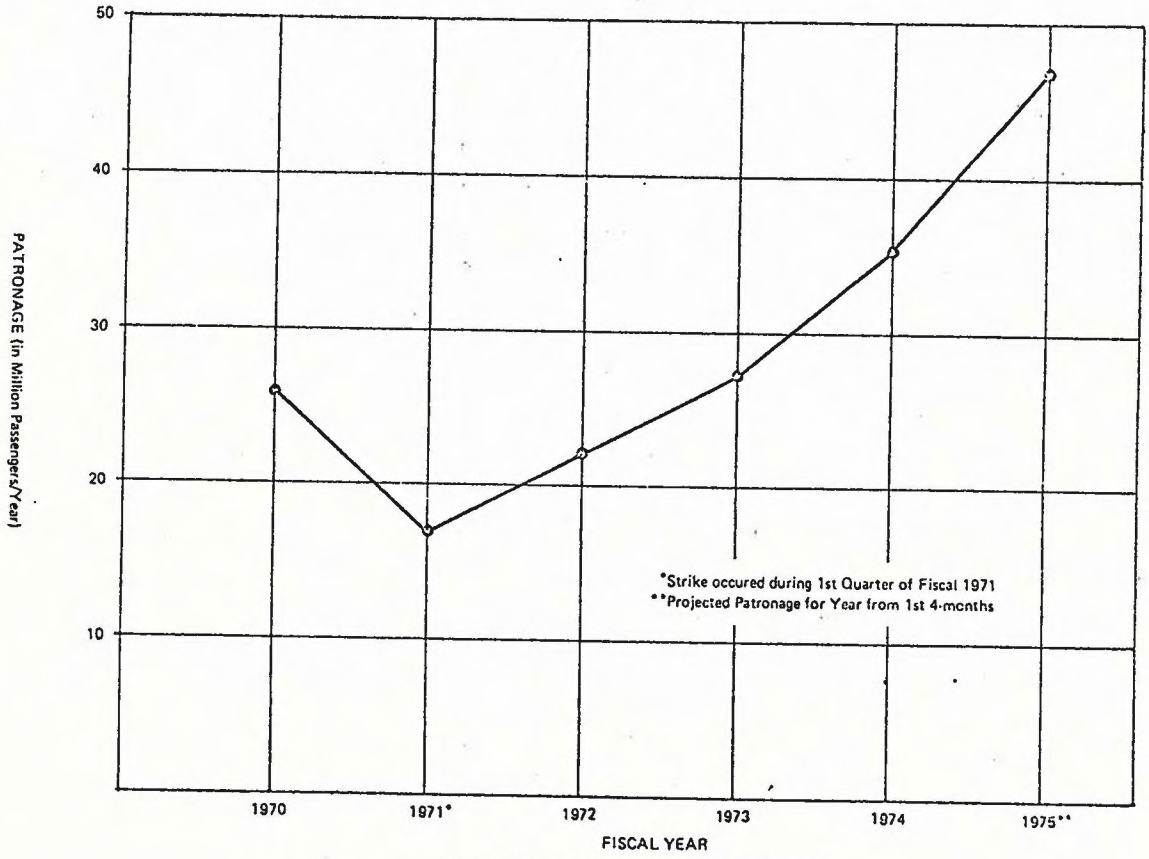
The other major program which has been attempted in Honolulu is the carpooling program. Early in 1974 the State of Hawaii Department of Transportation implemented a carpool matching program. Questionnaires were distributed throughout the Island of Oahu through banks, post offices, and other highly-frequented locations. For carpooling purposes the Island was divided into a grid pattern of zones. Anyone interested in participating in the carpooling program was asked to respond to the questionnaire and to indicate the location of his home, place of work, and the times when he traveled between these two points. Approximately 5,000 responses were received. Of these, only 150 were provided with the names of three persons whose work trip characteristics were compatible with their own. No follow-up was performed to determine how many of these 150 were successfully matched and formed a carpool.

AR00053308

E. SUMMARY AND CONCLUSIONS

It is difficult to determine precisely how successful any one of these programs have been because of the interrelationship between them. For example, a multitude of factors affect transit patronage and therefore make it impossible to estimate how much of the patronage increase on lines serving Waikiki can be attributed to the contra-flow bus lane on Kalakaua Avenue. The Hawaii Kai express is, of course, a definitive improvement since no such service existed prior to its implementation.

But nevertheless, three general conclusions can be drawn. First, in relation to transit patronage, the bus improvements have been generally successful. Figure IV-2 shows what has happened to transit patronage since the City and County of Honolulu took over the several private systems and began the program of improvements described herein. The 200% increase in transit patronage over a five year period of time is a basic reason why local officials are so confident that a fixed facility rapid transit system will be successful in Honolulu.



TREND IN PASSENGERS ON THE BUS

FIGURE IV-2

AR00053309

Regarding the street improvements, the situation is not as clear. About the best that can be said is that the improvements which have been made have kept pace with the general increase in vehicular traffic and that congestion has not worsened significantly.

Finally, it also seems clear that the use of the existing system, both the transit system and the street and highway system has been maximized with the improvements already implemented and those scheduled for implementation in the very near future. Without additional new transportation capacity, congestion can be expected to increase significantly in the future.

AR00053310

CHAPTER V

RAPID TRANSIT ROUTE LOCATION ANALYSIS

A. GENERAL

Having established in Chapter III that a high level, grade separated rapid transit system was needed in Honolulu, both in the near term and over the long term, the planning process now becomes one of generally locating the facility within the urban fabric of the city. Clearly to get the most usage, it should be located where the population and employment are located today. Then too, one must consider the development potential of the location and its ability to reinforce the declared development goals of the Island. These two factors must then be balanced by relocation, environmental problems and by cost factors. The objective, of course, is to find that location which represents a reasonable balance of all of these.

One of the initial steps in long-range transportation planning is the development of an area-wide system network which is compatible with future growth and land use policies, environmentally acceptable, and practical to implement. A long-range, island-wide transit network was defined to serve and interconnect the various urbanized regions of the island.[25] All outlying districts would have transit corridors located in existing highway corridors that feed into the primary Central Honolulu corridor. The basic transit network in Central Honolulu would consist of a single line that could meet the projected travel demand to 1995 and beyond. A second parallel line was identified on the urban core area to complement the initial single line system whenever it is justified by future demand.

The primary transportation corridor in Central Honolulu, from Pearl City to Hawaii Kai, is located in a narrow plateau constrained by the ocean on one side and the mountains on the other. Located within the corridor are all of the major activity and employment centers which are the primary traffic generators on Oahu. One of the basic requirements for a successful rapid transit system is to provide fast and convenient service to major destination areas of the region. The proposed rapid transit system should therefore be planned to serve as many of these activity centers as possible in the most direct manner with appropriately placed stations for ease of accessibility, consistent with land use and development goals, relocation and environmental factors, and with minimum cost.

Given the above, the first step in the route location process was an extensive data gathering program. Land use plans, zoning ordinances and maps, traffic data, development plans and studies, economic data, population and demographic data and any other pertinent data were collected and reviewed. This provided the basis for defining the limits of the rapid transit corridor and the identification of alternative routes. After an initial screening and elimination of least desirable alternatives, the remaining routes were subjected to a thorough comparative evaluation.

AR00053312

The evaluation of alternative route alignments, station locations, and auxiliary facility locations were accomplished in two phases, i.e. the two phases of the Preliminary Engineering and Evaluation Program (PEEP I and PEEP II). The first full-scale evaluation was conducted in PEEP I using a thorough and rigorous comparative evaluation methodology.[26] PEEP II studies later refined routes recommended in PEEP I and established more detailed route alignments and station locations. In fact the PEEP II refinement was successful in reducing by three quarters the relocations originally caused by the alignments first selected in PEEP I.

AR00053313

B. BASIS FOR ROUTE EVALUATION

The approach adopted for the evaluation of routes was to provide a balance between the tangible elements of cost and the intangible elements of community disruption, aesthetic qualities, convenience and comfort of service, etc. To provide the balance for the evaluation process, a set of evaluation criteria was defined which was relatable to the basic goals and objectives described in Chapter II. The criteria developed and used specifically for this route evaluation process are shown in Table V-1.

The evaluation of factors were separated into tangible and intangible groups which were weighted equally in terms of importance, i.e. 50% for tangible adn 50% for intangible. The tangible factors were primarily related to costs including capital cost, right-of-way and relocation cost, and property tax loss.

The intangible factors are listed in Table V-2, along with the relative weights for each factor. The weights reflect the composite opinion of a panel of professional planners and representatives of various community groups who assisted the planning staff on the evaluation of alternatives. The results of course reflected a wide range of opinions. However, to overcome this wide divergence of opinion a computer program was utilized to measure the sensitivity of each factor to changes in their relative weights or values. In addition to this analytical process, due consideration was given to desires and requests of various governmental agencies, private organizations, and citizens of the Honolulu area through several hundred meetings held with interested community residents and their leaders all along the corridor.

Upon selection of the most desirable route, station sites were further evaluated to determine optimum station placement along the selected route. The basic parameters used in evaluating station locations were similar to criteria used for route evaluation but with special emphasis on the following factors:

- Maximum service to area
- Beneficial impact on adjacent properties
- Convenient access to arterial and local streets
- Maximum interface with feeder bus routes
- Availability of proper vehicle parking site, where needed

AR00053314

- Least physical constraints to users
- Compliance with civil engineering design criteria (not on excessive curves, grades, etc.)
- Proper spacing between stations (average about one mile; less in urban core, more in outlying areas)

AR00053315

TABLE V-1

ROUTE EVALUATION FACTORS

TRANSIT DEVELOPMENT OBJECTIVE	ROUTE PLANNING EVALUATION FACTORS
OBJECTIVE 1	
a. Availability & coverage	- NA* (same as 2.a.)
b. Travel time	- Length of line
c. Service reliability	- NA
d. Rider convenience	- Station site & accessibility
e. Rider comfort	- Curvature & grade - Passenger acceptability
OBJECTIVE 2	
a. System patronage	- Service to origins - Service to destinations
b. System Capacity	- System line extendability - System carrying capacity
OBJECTIVE 3	
a. Consumption of land	- NA (same as 3.a. and b.)
b. Displacement of residents	- Displacement of residents
c. Displacement of businesses	- Displacement of businesses
d. Reduction of comm. amenities	- Physical identify of community
e. Disruption to future dvlpmt	- Character of adjacent property
f. Disruption to local circulation	- Local traffic impact - Constraints to freeway - Constraints to arterial streets
g. Disruption from const. activities	- NA (same as 3.f.)
h. Consumption of energy	- NA (same as 1.a.)
i. Technical risks	- NA
OBJECTIVE 4	
a. Support regional dvlpmt	- Enhance dvlpmt potential - Reinforce present plan
b. Support comm. dvlpmt	- Relation to comm. planning goals - Urban design potential

*NA - Not Applied

AR00053316

TRANSIT DEVELOPMENT OBJECTIVE	ROUTE PLANNING EVALUATION FACTORS
OBJECTIVE 5	
a. Air pollution	- Air pollution
b. Noise level	- Noise
c. Visual intrusion	- Natural beauty
d. Vistas	- Natural beauty
e. Historic sites	- Urban environmental quality
OBJECTIVE 6	
a. Reduction in accident exposure	- NA
b. Security	- NA
OBJECTIVE 7	
a. Total cost	- Construction cost - ROW acquisition cost - Tax losses
b. Cost per ride	- NA
c. Benefit-cost ratio	- NA

AR00053317

TABLE V-2

WEIGHTING OF INTANGIBLE FACTORS IN PEEP I ROUTE PLANNING

Factors	Total Weight
I. Service	
4. Service to Origins	40
a. Population Centers	
b. Concentrations of Labor Force	
c. Low-Income Areas	
5. Service to Destinations	
a. Employment	
b. Business/Shopping	
c. Institutional/Cultural	
d. Recreation	
II. Impact	
6. Local Impact	48
a. Relation to Community Planning Goals	
b. Urban Design Potential	
c. Relocation of Resident	
d. Relocation of Businesses	
e. Effect upon Physical Identity of Community	
f. Effect upon Character of Adjacent Property	
g. Local Traffic Impact	
7. Corridor Impact	
a. Enhances Development Potential	
b. Reinforces Present Planning Goals	
8. Environmental Aspects	
a. Noise Levels	
b. Air Pollution	
c. Retention of Natural Beauty	
d. Retention of Urban Environment Quality	
III. Design	
9. Physical Design	8
a. Curvature and Grades	
b. Station Sites and Accessibility	
c. Length of Line	
d. Passenger Acceptability	
10. Transit System Expansion Capability	
a. Extensions	
b. Carrying Capacity	
IV. Constraints	
11. Constraints to Transportation	4
a. Freeways	
b. Arterial Streets	
Total for Intangible Factors	100

AR00053318

C. ROUTE PLANNING ANALYSIS

For purposes of evaluation, the 23-mile corridor was divided into nine segments, each containing several alternative route locations. These transit corridor segments are shown in Figure V-1. PEEP I considered a segment through Waikiki which was subsequently eliminated because the high cost of constructing a spur or branch line was not justified. The analysis considered both horizontal and vertical alignments in the development of alternative routes. The vertical alignments or configurations included aerial, at-grade, and subway. Also considered, but not shown in the alternatives, are the alternative locations considered for the transit yard and shop site. Several locations were examined and it was concluded that the proposed site at Keehi Lagoon was far superior to any alternative site. Using the factors described in Table V-2 and their relative weights, each alternative was developed to the point where comparative evaluations could be made. The evaluation process was accomplished with the assistance of both public and private citizen groups.

One of the purposes of the PEEP II program was to refine the selection of routes and station locations made in PEEP I. For some segments, new alternatives were defined and evaluated.[27] These included the following:

- Segments 1-3 (Pearl City to Middle Street): evaluation of the feasibility of using the H-1 Freeway median
- Segment 4 (Kalihi-Palama): evaluation of using the middle of Dillingham Boulevard
- Segment 7 (McCully-Moiliili): evaluation of a whole new set of alternative routes between Waikiki and University stations
- Segment 8 (Kaimuki-Kahala): re-evaluation of the feasibility of using Lunalilo Freeway median

A key factor in the PEEP II evaluation was the elimination of the requirement that any street or highway facility used for rapid transit facilities must be replaced to its original capacity and condition. Otherwise, the criteria applied in PEEP II were similar to those applied in PEEP I with special attention given to relocation requirements.

Numerous alternative route locations and alignments were considered both in PEEP I and II. An initial screening process was conducted to reduce the number of alternatives to only those which were most viable and to a manageable number for detailed evaluation. In some cases a wide range of route locations were examined and deemed necessary to carry forward with the detailed evaluation stage, such as in the Kalihi-

AR00053319

Transit Corridor Segments

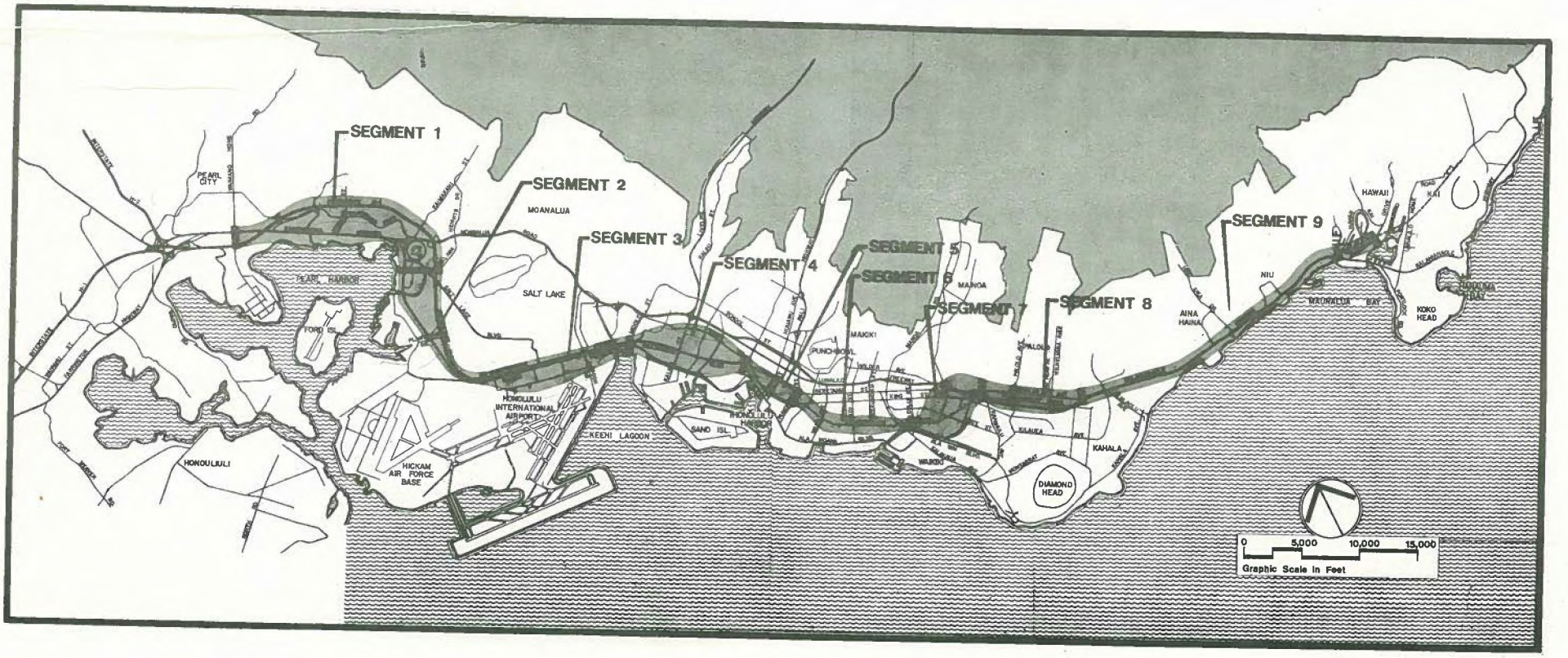


FIGURE V-1

Palama area which consisted of six alternative routes ranging in location from Nimitz Highway to King Street. In other cases, an equally wide range of locations were examined but it was possible to narrow the alternative route locations to a single general location with several different alignments. An example of this was in the Kakaako-Ala Moana area where the locations ranged from Ala Moana Boulevard to Lunalilo Freeway but the general Kapiolani Boulevard was determined to best serve the area with three alternative alignments selected for detailed evaluation.

After the initial screening process, the remaining routes or alignments were subjected to a thorough comparative evaluation as discussed earlier. These alternatives are described in Table V-3.

AR00053321

TABLE V-3: RAPID TRANSIT ALTERNATIVE ROUTE ALIGNMENTS AND STATION LOCATIONS

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuration
Segment 1 - Pearl City-Aiea (Pearl City to Aloha Stadium)	•H-1 Freeway	Median of H-1 Freeway	Transit at grade with roadway	Pearl City - H-1 Freeway west of Lehua Avenue	Aerial
				Pearl Ridge - H-1 Freeway east of Kaonohi Street	Aerial
	Kamehameha Highway*	Median of Kamehameha Highway	Aerial	Pearl City - Kamehameha Highway west of Lehua Avenue	Aerial
				Pearl Ridge - Kamehameha Highway east of Kaonohi Street	Aerial
	OR&L R.O.W.	Oahu Railway & Land Co. RR R.O.W. (portion)	Aerial and Subway	Pearl City - West of Lehua Avenue at Third Street	Aerial
				Pearl Ridge - On OR&L Co. R.O.W. west of Aica Kai Place	Aerial
Segment 2 - Halawa/Pearl Harbor (Aloha Stadium to Elliot Street)	•H-1 Freeway	Median of H-1 Freeway	Transit at grade with roadway	Halawa - H-1 Freeway at Halawa Heights Road	Aerial
				Pearl Harbor - H-1 Freeway north of new Plantation Drive	Aerial
	Kamehameha Highway	Along Kamehameha Highway on west side and then along south side of Nimitz Highway	Aerial	Halawa - Relocated Salt Lake Boulevard and Kamehameha Highway	Aerial
				Pearl Harbor - Nimitz Highway at Valkenburg Street	Aerial
	H-1 Freeway*	Cross stadium parking area and along H-1 on west side and then along south side of Nimitz Highway	Aerial at stadium, at grade along H-1, then aerial	Halawa - Stadium site at relocated Salt Lake Boulevard	Aerial
				Pearl Harbor - Nimitz Highway at Valkenburgh Street	Aerial

• Proposed location
* Alternative recommended in PEEP I

AR00053322

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuration
Segment 3 - International Airport (Elliot Street to Keehi Lagoon)	•Aolele Street	From H-1 Freeway median to airport terminal, then following Aolele Street through northern edge of Keehi Lagoon Park	Aerial	International Airport - North of proposed parking garage	Aerial
				Keehi Lagoon - Lagoon Drive and Aolele Street	Aerial
	H-1 Freeway	Median of H-1 Freeway	At grade with H-1	International Airport - Proposed H-1 Freeway near Rodgers Boulevard	Aerial
				Keehi Lagoon - Proposed H-1 Freeway at Lagoon Drive	Aerial
	Aolele Street*	From Nimitz Highway and Elliot Street to Airport terminal, follows existing drainage ditch along Aolele Street through Keehi Lagoon and cross Nimitz Highway	Aerial, except at grade just west of Keehi Lagoon Park	International Airport - North of existing parking garage	Aerial
				Keehi Lagoon - Lagoon Drive and Aolele Street	Aerial
	Aolele/Koapaka Streets	From Nimitz Highway and Elliot Street to airport terminal; Aolele Street then Koapaka Street at Lagoon Drive and through northern edge of Keehi Lagoon Park	Aerial	International Airport - North of existing parking garage	Aerial
				Keehi Lagoon - Lagoon Drive and Koapaka Street	Aerial

AR00053323

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuration
Segment 4 - Kalihi/Palama (Middle Street to River Street)	•Dillingham Blvd. (median)	Median of Dillingham Boulevard	Aerial then Subway before Iwilei Station	Kalihi - Dillingham Blvd., east of McNeill Street Iwilei - Between King Street and Dillingham Blvd. and Kaamahu Place	Aerial Subway
	King Street	Along North King Street	Aerial to Kalihi Stream, Subway along King Street	Kalihi - King Street between Kalihi Street & Mokauea St. Liliha - West of Liliha Street on King Street	Subway Subway
	Alokele Street	Along Alokele Street south of King Street	Aerial to Kalihi Stream, Subway through residential, Aerial across Kapalama Canal, Subway through Iwilei	Kalihi - East of Mokauea Street at Alokele Street Liliha - West of Dillingham Boulevard at Akepo Lane	Subway Aerial
	Dillingham Boulevard (South)*	Along south side of Dillingham Boulevard on private R.O.W.	Aerial to Dole Cannery, Subway through Iwilei	Kalihi - Dillingham Boulevard between Kalihi St. & McNeill St. Iwilei - Between King St. & Dillingham Blvd. and Kaamahu Place	Aerial Subway
	Nimitz Highway	Follow Nimitz Highway to Kapalama Canal, then OR&L RR R.O.W.	Aerial, then Subway through Iwilei	Kalihi - Kalihi Street & Nimitz Highway Iwilei - Just west of King Street and Iwilei Road intersection	Aerial Subway
	OR&L R.O.W.	Follow Oahu Railway & Land Co. RR R.O.W.	Aerial, then Subway through Iwilei	Kalihi - East of Kalihi Street at Hart Street Iwilei - Just west of King Street and Iwilei Road intersection	Aerial Subway

AR00053324

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuration
Segment 5 - Chinatown, Downtown, Civic Center (River Street to Alapai Street)	•Hotel Street*	Follow Hotel Street through Chinatown, downtown, and Civic Center	Subway	Fort Street - Fort Street/Nuuanu Avenue at Hotel Street	Subway
				Civic Center - Just west of Kapiolani Boulevard Extension & King Street	Subway
	King Street	Follow King Street to Punchbowl Street, then onto Kapiolani Boulevard	Subway	Fort Street - Fort Street/Nuuanu Avenue at King Street	Subway
				Civic Center - Punchbowl Street and King Street	Subway
Segment 6 - Kakaako/Ala Moana (Alapai Street to Atkinson Drive)	•Waimanu/Kona Street	South of Kapiolani Boulevard along Waimanu Street and Kona Street	Subway to Dreier Street, then Aerial	Ward Avenue - Ward Avenue and Waimanu Street	Aerial
				Ala Moana - Keeaumoku and Kona Street	Aerial
	Kapiolani	Follow Kapiolani Boulevard	Subway	Ward Avenue - Ward Avenue & Kapiolani Boulevard	Subway
				Ala Moana - Keeaumoku Street and Kapiolani Boulevard	Subway
	Makaloa Street	Follow Kapiolani to McKinley High School then along Makaloa, then cross to Kona Street	Subway to McKinley High School, then Aerial	Ward Avenue - Ward Avenue and Kapiolani Boulevard	Subway
				Ala Moana - Keeaumoku Street at Makaloa Street	Aerial

AR00053325

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuration
Segment 7 - Moiliili/ University (Atkinson Drive to Kapahulu Ave)	oMB - Kapiolani/ University with Date and UH Quarry Stations	Middle of Kapiolani, middle of University Avenue past Freeway, easterly through UH & then along Waialae Road	Aerial	Waikiki - Between Kalakaua Avenue & McCully Street, north of Ala Wai Canal	Aerial
				Date Street - University Avenue and Date Street	Aerial
				University - UH Quarry	Aerial
	A - Kapiolani Boulevard	Middle of Kapiolani Boulevard to H-1 Freeway at Kapahulu Avenue	Aerial	Waikiki - Between Kalakaua Ave. and McCully Street, north of Ala Wai Canal	Aerial
				Kapiolani - On Kapiolani Blvd. between University & Date	Aerial
	B_1 - Kapiolani/ University/Old Waialae Road	Middle of Kapiolani, middle of University Avenue past Freeway, easterly through UH and then along Waialae Road	Aerial	Waikiki - Between Kalakaua Ave. and McCully Street north of Ala Wai Canal	Aerial
				University - University Avenue between King Street & H-1 Freeway	Aerial
	B_2 - Kapiolani/ University/South of H-1	Same as B_1 but turns east at King Street then over and into the median of H-1	Aerial	Waikiki - Between Kalakaua Ave. and McCully Street north of Ala Wai Canal	Aerial
				University - Between King Street and H-1 east of University Ave.	Aerial
	C - Isenberg/ UH/Old Waialae Road	Kapiolani to Isenberg, north to King Street, northeast to UH then east along Waialae Road	Aerial	Waikiki - Between Kalakaua Ave. and McCully Street north of Ala Wai Canal	Aerial
				Isenberg Street - South of King St. on Isenberg Street	Aerial
				University - On UH property east of Varsity Circle	Aerial

NOTE: Five other routes were evaluated in PEEP I and rejected prior to the evaluation of the above five in PEEP II. These were Manoa-Palolo Drainage Canal, Ala Wai Canal/University Avenue (subway), Kapiolani/University (subway), Kapiolani/University (aerial), and a private right-of-way across Coolidge and Hausten Streets.

AR00053326

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuration
Segment 8 - Kaimuki/Kahala (Kapahulu Avenue to Kahala Mall)	•Middle of Lunalilo Freeway (Grade)	Middle of Freeway	At-grade	6th Avenue - On Freeway west of 6th Avenue	At-grade
				Koko Head - On Freeway west of Koko Head Avenue	At-grade
				Kahala - Kahala Mall on Freeway near Hunakai Street	At-grade
	Waialae Avenue	Along Waialae Avenue	Subway in Waialae Avenue and then Aerial over the Freeway to Kahala Mall	6th Avenue - 6th Avenue & Waialae Avenue	Subway
				Koko Head - Koko Head Avenue and Waialae Avenue	Subway
				Kahala - Kahala Mall at Kilauea Avenue	Aerial
	North of Lunalilo Freeway*	Private R.O.W. along northern edge of Freeway and crosses Freeway near Waialae Avenue to Kahala Mall	Aerial with a small portion in Subway under Koko Head Avenue	6th Avenue - 6th Avenue & Lunalilo Freeway (north)	Aerial
				Koko Head - Koko Head Avenue & Lunalilo Freeway (north)	Subway
				Kahala - Kahala Mall at Kilauea Avenue (south)	Aerial
	Median of Lunalilo Freeway (Aerial)	Median of Freeway	Aerial	6th Avenue - Above Lunalilo Freeway east of 6th Avenue	Aerial
				Koko Head - Koko Head Avenue at Lunalilo Freeway	Aerial
				Kahala - Kilauea Avenue at Freeway	Aerial
	South of Lunalilo Freeway	Private R.O.W. south of Freeway	Aerial	6th Avenue - 6th Avenue and Lunalilo Freeway (south)	Aerial
				Koko Head - Koko Head Avenue & Freeway (south)	Aerial
				Kahala - Kahala Mall at Kilauea Avenue (south)	Aerial

AR00053327

Corridor	Alternative	Route Alignment	Route Configuration	Station Location	Station Configuratio
Segment 9 - Kahala/Hawaii Kai (Kahala Mall to Hawaii Kai)	•Kalanianaole Highway (median)*	Median of widened Kalanianaole Highway	Aerial	Aina Haina - Kalanianaole Highway just east of West Hind Drive	Aerial
				Niu - Kalanianaole Highway near Halemaumau Street	Aerial
				Hawaii Kai - Between Ainahou St. and Keahole Street south of Hawaii Kai Drive	Aerial
	Kalanianaole Highway (South)	Along south side of Kalanianaole Highway	Aerial	Same locations as Kalanianaole Highway (median) above	

NOTE: Three alternatives were not considered for full evaluation: north of Kalanianaole Highway; along the slopes of the Koolaus; and off-shore reef.

AR00053328

D. CONCLUSION AND RECOMMENDATIONS

The route selection recommendations are summarized below. A more detailed discussion of the results is provided in various technical reports published during both PEEP I[26] and PEEP II.[27]

Segments 1-2 (Pearl City to Pearl Harbor): PEEP I recommended a route generally following the median of Kamehameha Highway from Pearl City to Aloha Stadium and then along the side of the proposed H-1 Freeway and Nimitz Highway, with stations located at Pearl City, Pearl Ridge, Aloha Stadium, and Pearl Harbor. PEEP II recommended the use of the median of the H-1 Freeway throughout these segments with stations located in the same four general areas but within the freeway. The primary reason for the revised recommendation was the lower cost and lesser environmental impact.

Segment 3 (Airport): The route and station locations through the airport area are substantially the same in the PEEP I and PEEP II recommendations except that the revised route would enter the airport area from the median of the proposed H-1 Freeway. The airport station, mauka of the parking garage, and Keehi Lagoon station will be connected by an alignment running along Aolele Street. While a route remaining in the H-1 Freeway would have a lower capital cost, the proposed route would provide direct service to the airport without the need for a supplementary system.

Segment 4 (Kalihi-Palama): PEEP I recommended a route on a private right-of-way along the makai side of Dillingham Boulevard, with stations at Kalihi Street and Iwilei. The proposed route selected in PEEP II by the consultants and community representatives would locate the fixed guideway above the center of Dillingham Boulevard in order to reduce the amount of relocation and total cost. The Kalihi station would also be placed one block farther east in order to separate it from Kalihi-Kai Elementary School.

Segment 5 (Chinatown-Downtown-Civic Center): The proposed route, placing the guideway in a subway under Hotel Street with stations at Fort Street and the Civic Center, was recommended in PEEP I and reaffirmed in PEEP II. The route was chosen primarily on the basis of cost and the location of future growth.

Segment 6 (Kakaako-Ala Moana): The proposed route running generally makai of Kapiolani Boulevard along Waimanu Street and Kona Street was recommended in PEEP I and confirmed in PEEP II. The key factors were

AR00053329

lower cost, slightly better service characteristics, and greater development potential compared to the other alternatives.

Segment 7 (Moiliili-University): The recommended route was selected in PEEP II after an extensive evaluation of five routes, with considerable community input. The recommended route would contain two stations and thus provide direct service to the University and Moiliili residential areas (Date Street). This route is similar to a route initially evaluated in PEEP I except for the two station locations and the use of the middle of Kapiolani Boulevard rather than private right-of-way along the south and north side. The PEEP I recommendation for a route which would have traversed residential areas of Moiliili along Coolidge and Hausten Streets rather than up the middle of University Avenue was rejected primarily because of the amount of relocation and other negative community impacts.

Segment 8 (Kaimuki-Kahala): PEEP I recommended a route following mauka of the Lunalilo Freeway on a private right-of-way, with stations located at 6th Avenue, Koko Head Avenue, and Kahala Mall. The proposed route using the middle of the freeway (requiring the use of the two center lanes) has similar station locations and was recommended in PEEP II to reduce relocation, costs, negative visual effects, and noise impacts.

Segment 9 (Kahala-Hawaii Kai): The PEEP I studies initially projected insufficient patronage to justify placement of a fixed guideway facility in the Kalanianaole corridor. Subsequently, based on a City-State agreement for an integrated transportation strategy which would generate more transit ridership, it was recommended that the fixed guideway facility be extended from Kahala to Hawaii Kai. Based on an evaluation of alternative routes which was similar to that conducted in other segments, the route recommended in PEEP I would follow the median of a widened Kalanianaole Highway, with stations at Aina Haina, Niu, and Hawaii Kai. PEEP II reaffirmed this selection on the basis of lower cost, relocation, and environmental impact, compared to the alternative route makai of the highway.

Auxiliary Facilities: The yard and shop site at Keehi Lagoon was selected in PEEP I on the basis of its large area, central location, accessibility to the route, and minimal relocation or development impact. No other available large area could be found to meet these requirements.

AR00053330

The recommended route location provides a good balance between maximizing transit service and attainment of community objectives and minimizing relocation and cost. It will provide a high level of service, and hence attractiveness, by serving various population centers and all major activity and employment centers on Oahu. In these centers are concentrated most of Central Honolulu's existing and future employment opportunities which represent 80% of the total island-wide employment. On the origin end of the trip in addition to direct service to various population centers, a full coverage feeder bus service is provided to make transit service available to all urbanized areas on the island. At the same time, through judicious alignment studies and excellent use of existing transportation rights-of-way, approximately 170 residential units and 180 business units are displaced based on the use of a guided rapid transit system. This is accomplished with only a short section of tunnel in the heart of downtown Honolulu, helping to reduce costs.

Although a great deal of deliberate analysis has gone into the selection of the recommended route location, from a great number of alternatives and with public involvement, the Environmental Impact Statement and public hearings have yet to be completed. Through this final step of the planning process, a full review of the technical conclusions reached will be made.

AR00053331

CHAPTER VI

ALTERNATIVE SYSTEMS EVALUATION

A. BACKGROUND OF TRANSIT PLANNING STUDIES

As discussed in Chapter I, various transit planning studies for Honolulu have been conducted which dealt with basic transportation alternatives beginning with the 1967 Oahu Transportation Study extending through PEEP II. The results of these studies are all in accord relative to the need for an exclusive, grade separated rapid transit system to meet the near term and long term travel needs of the island as was described in Chapters III and IV. In Chapter V, the route evaluation process described led to the selection of a recommended route for an exclusive, grade separated transit system. With the need and location established, a deliberate process of selecting a transit system which would best satisfy the transportation goals and objectives of the island is the subject of this chapter.

Various alternative vehicle systems were examined over the past 8-10 years in Honolulu with many of the systems discarded as non-appropriate for Honolulu. Those systems which seemed appropriate were reviewed and then subjected to further detailed analysis as described in this chapter.

AR00053333

B. PEEP I ALTERNATIVES STUDIED

In order to determine the type of rapid transit system most suitable for Honolulu, various alternative systems were examined and comparisons made as part of the PEEP I program completed in late 1972.[28] Although the initial emphasis in the PEEP I program was directed at re-evaluating the recommendations of the prior OTS program for a grade separated rapid transit system, it was also necessary to examine a broader range of alternative concepts. In that context, the study analyzed busway, fixed guideway, and waterborne alternatives which took into consideration various technical, economic, social, and environmental factors.[29]

For the bus concept, a low capital intensive system that basically extended the current service level to 1995 was defined and used as the baseline system. The baseline bus system assumed use of the existing streets and highways. Its operating characteristics were comparable with current bus operations. The 1972 patronage volume was extrapolated to 1995 to reflect growth in population and total trips projected for the island. This resulted in a patronage volume of 188,000 passengers per day. Use of this system as a baseline provided the basis for measuring certain performance characteristics of the alternative systems selected for evaluation.

A bus concept system, developed and evaluated in detail, was a busway system. The busway facilities utilized exclusive, grade separated roadway for providing high speed line-haul service. Two exclusive busway lengths of 22 and 19 miles were analyzed.

The waterborne concept which was evaluated utilized 250 passenger ocean-going hydrofoils to provide high speed line-haul service. It was assumed that local and feeder services would be provided by either buses or by a combination of canal boats and buses. The analysis was made on two patronage basis: patronage volume equivalent to the fixed guideway system and patronage volume based on modal split analysis.

The fixed guideway concept which was analyzed was based on a 22-mile system with 20 stations. An island-wide network of local and express buses was provided to complement the fixed guideway, trunk line system. The result of the comparative cost analysis of these systems is summarized in Table VI-1.

Of the three basic alternative concepts studied - busway, waterborne, and fixed guideway, the waterborne concept was found to be the least cost-

AR00053334

TABLE VI-1: SUMMARY OF ALTERNATIVES ANALYSIS - PEEP I

	FIXED GUIDEWAY	BUSWAY		WATERBORNE		
		A	B	1-A	1-B	1-C
LINE HAUL LENGTH (MI.)	22	22	19	22	22	22
NO. STATIONS	20	20	18	13	7	7
DAILY PASSENGER VOLUME	484,000*	484,000**	471,000***	484,000**	226,000*	185,000*
ANNUAL PASS. VOL. (MILLION)	146.2	146.2	142.3	146.2	68.3	55.9
FAST LINK VEHICLES	405	458	416	224	75	43
CAPITAL COST ($ MILLION)	577.8	537.7	483.2	935.7	377.0	244.9
ANNUALIZED CAP. COST ($ MILLION) (30 YRS. @ 4%)	33.4	31.1	27.9	54.1	21.8	13.2
ANNUAL O&M ($ MILLION)						
FAST LINK	17.0	23.6	20.4	76.6	25.4	14.6
FEEDER	19.0	19.0	20.0	16.9	8.5	7.4
TOTAL	36.0	42.6	40.4	93.5	33.9	22.0
TOTAL ANNUAL COST ($ MILLION)	69.4	73.7	68.3	147.6	55.7	36.2
COST/PASS. TRIP (¢)	47.5	50.4	48.0	101.0	81.6	64.8

* BASED ON MODAL-SPLIT ANALYSIS (PEEP I)

** ASSUMED PATRONAGE SAME AS FIXED GUIDEWAY

***PATRONAGE ESTIMATE BASED ON MANUAL DERIVATION

AR00053335

effective. Because the waterborne system cannot penetrate the main acitivity centers as well as the land based concepts, it provides a lower level of service. This is reflected by the comparative patronage volumes. The high operating and maintenance costs of the hydrofoil system result in a cost per trip that is much higher than the land based systems. Accordingly, this waterborne concept was determined to be inferior to the other concepts and dropped from further analysis.

The 19- and 22-mile busway systems were analyzed using both standard 40 foot buses and a combination of standard buses and large articulated buses operating as captive vehicles on the busway. A special travel demand forecast for the system was not made for this analysis since the level of service was assumed to be nearly comparable to the fixed guideway system. Later studies in PEEP II indicated this was not precisely correct in that the fixed guideway patronage is slightly higher than busway patronage. The location of the route and stations for the busway were essentially the same as the fixed guideway system. The operating characteristics of the busway system were found to be nearly comparable with the fixed guideway system. The busway had a slightly lower average trip speed but had the advantage of eliminating transfers for certain bus routes. However the no-transfer advantage was assumed to be offset by the greater schedule reliability and greater attractiveness of the fixed guideway system. It was therefore concluded that, although the cost and service characteristics between the busway and fixed guideway were nearly comparable, the fixed guideway had the overall advantage in terms of environmental and community factors. These factors were air pollution, noise level, visual impact, and dislocation of residents and businesses, all as fully described in the Draft Environmental Impact Statement, Honolulu Rapid Transit Preliminary Engineering Evaluation Program, September 1972, Volume 2.[29]

Also during PEEP I, a review of the dual-mode and PRT transit systems was conducted to determine their feasibility for application in Honolulu.[30] Two of the overriding factors against the dual-mode and PRT concepts were the unavailability of demonstrated hardware and the lack of proven operational experience; therefore they were rejected.

After completion of the PEEP I study, the City and County of Honolulu and the State of Hawaii jointly sponsored a study of an automatic rapid transit (ART) system and a review of the busway alternative study which was completed under PEEP I. The study defined and analyzed the ART operating characteristics, the network and travel characteristics, and economic and environmental factors.[31] A comprehensive review of the previously described busway alternative analysis including review of the physical design, operating concept, and costs was conducted to determine the validity of the analysis and if any improvements could be made to the system.

AR00053336

The separate study conducted for the automated rapid transit (ART) system found that it had about equal attractiveness as the fixed guideway based on the best current predictions of the system operating characteristics. The ART system analyzed consisted of over 33 miles of two-way guideway with 77 stations as compared to the 22-mile, 20 station fixed guideway system. The cost of the ART system was about 15% higher than the fixed guideway system in both capital cost and annual operation cost.

This operating cost did not include train and station attendants for the ART while the fixed guideway system did. The fixed guideway system could, if so desired, be operated without train attendants and also without station attendants as on the Lindenwold Line System in Philadelphia. If the estimates were made on the same basis relative to the attendants, the O&M cost for the fixed guideway system would be significantly lower than for the ART system.

Relative to the attractiveness of the ART system, it was concluded that under the most favorable assumptions regarding operating speed, with greater attendant risks and particularly high speed, the ART would have a slightly greater patronage potential than the fixed guideway only during peak periods. Based on this study, the City and State agreed to reject the ART system from further consideration.

Relative to the busway review, this joint study concluded that the cost of busway alternative could possibly be reduced with greater use of highway facilities. Accordingly, the City and State agreed to proceed with transit planning in Honolulu based on further studies of the fixed guideway and busway.

AR00053337

C. ALTERNATIVES SELECTED FOR DETAILED STUDY

The extensive study and re-study of transit system requirements described briefly in earlier chapters and sections of this report had produced several significant conclusions. Very briefly they may be summarized as follows:

- An all bus system, without exclusive, grade separated facilities in the urban core area, is not a viable alternative in Honolulu because it cannot attract enough patronage to alleviate the transportation deficiencies over the short run or the long run. Its use, even on the short run, is limited due to the physical constraints of surface streets to accommodate any increase in the number of buses in the downtown area.

- The waterborne alternative was found to provide a lower level of service with attendant line patronage volume and have a higher cost per passenger trip than the land-based alternatives and therefore rejected from further consideration as the primary transit mode for Honolulu.

- The dual-mode and PRT system were found to be lacking in available demonstrated hardware and proven operational experience to meet Honolulu's program schedule.

- The ART system was found to have only comparable patronage potential with the fixed guideway system but with higher costs which led to the rejection of this system.

With these conclusions and with more recent developments in transit vehicle systems, particularly the resurgent interest in Light Rail Transit, three basic approaches were selected for further detailed analysis in PEEP II:

- A Minimum Length (7-Mile) Busway

- A Light Rail Transit (LRT) System

- A Fixed Guideway System

These alternatives were then developed for analysis and subsequent evaluation and for each alternative, an appropriate feeder and express bus system to produce comprehensive transit coverage and service was provided.

AR00053338

Each system network and operating plan were carefully structured and designed to reflect the particular attributes of the system characteristics. For example, the busway system utilizing conventional bus equipment was planned to operate both on and off the busway to minimize passenger transfers. It was also provided with passenger stations located similarly to the other systems to make it as nearly comparable as the other systems in terms of passenger convenience and accessibility. The LRT system was designed to take advantage of its capability to operate in both exclusive and non-exclusive right-of-way and with and without grade separation.

Therefore, the three systems were structured to provide maximum advantage of the unique characteristics of each and yet to be directly comparable. These systems are described briefly in this section and summary results of the systems analysis presented. Alternative systems are shown on Figures VI-1, VI-2, and VI-3 and described very briefly below. More detailed discussion of these alternatives and their analyses may be found in Appendix A to this report as well as in the report titled "Alternative Transit Concepts Analysis."[32]

1. Basic Assumptions and Design Features

   a. Transit Corridor: A single corridor served by a single route alignment and set of station locations will produce the best balance between operational, service, minimal disruption and cost factors as established in the "Long Range Transit Plan" developed during PEEP I.[25]

   b. Route and Station Locations: Various alternative rapid transit routes and station locations have been thoroughly studied as described in Chapter V. A recommended route with the most desirable station spacing and location has been identified which considered service quality, minimum community disruption, and cost. This recommended route will therefore be followed by all alternative systems specifically between Halawa and Hawaii Kai. Between Pearl City and Halawa, either the H-1 Freeway route or the Kamehameha Highway route could be considered as appropriate to a given system. Any deviations from the recommended route would penalize any particular system in terms of patronage volume, community disruption and cost.

   c. Service Levels: Comparable level of local and express bus network and service was provided for each system. The supporting feeder bus system relative to level of service and coverage are therefore basically the same for the alternative systems with the only difference occurring in the interfacing of the bus routes

AR00053339

Busway Transit System

RAPID TRANSIT STATIONS

1. Keehi Lagoon
2. Kalihi
3. Iwilei
4. C.B.D.
5. Civic Center
6. Ward Avenue
7. Ala Moana
8. Waikiki
9. Date Street
10. University

1 Stations
Busway
Express Bus Route

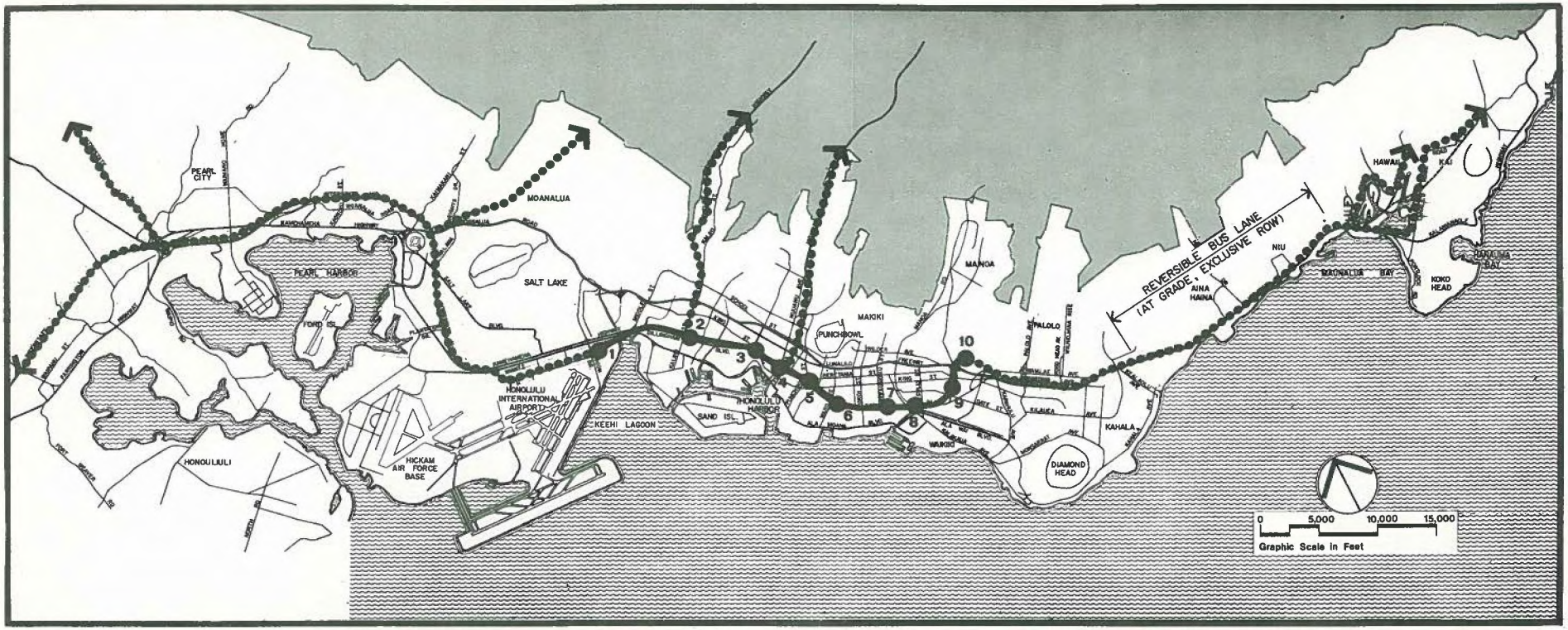


FIGURE VI-1

Light Rail Transit System

RAPID TRANSIT STATIONS

1. Pearl City
2. Waimalu
3. Pearl Ridge
4. Halawa
5. Pearl Harbor
6. Airport
7. Keehi Lagoon
8. Kalihi
9. Iwilei
10. C.B.D.
11. Civic Center
12. Ward Avenue
13. Ala Moana
14. Waikiki
15. Date Street
16. University
17. Sixth Avenue
18. Koko Head Avenue
19. Kahala
20. Waialae Iki
21. Aina Haina
22. Niu
23. Kuliouou
24. Hawaii Kai

1 Stations
Grade separated, Exclusive R.O.W.
At-Grade, Exclusive R.O.W.
At-Grade in Mixed Traffic
Express Bus Route

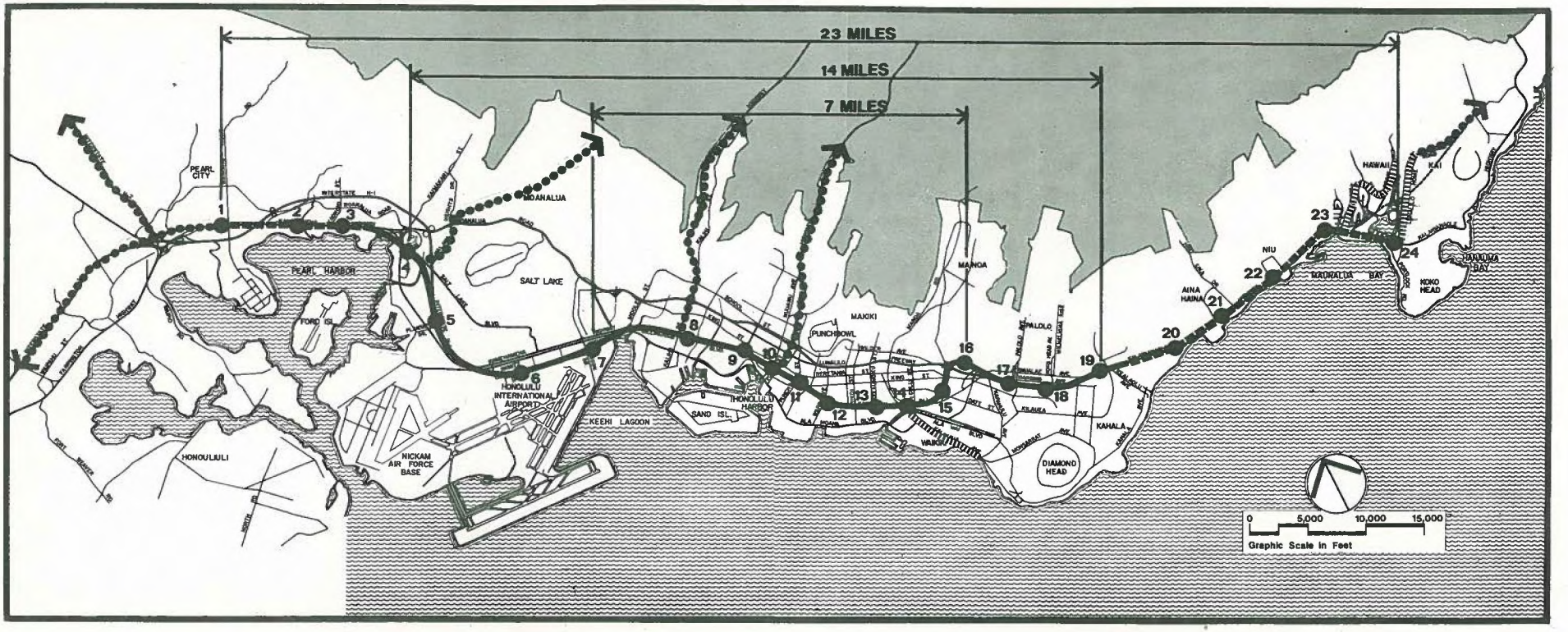


FIGURE VI-2

AR00053341

Fixed Guideway Transit System

RAPID TRANSIT STATIONS

1. Pearl City
2. Pearl Ridge
3. Halawa
4. Pearl Harbor
5. Airport
6. Keehi Lagoon
7. Kalihi
8. Iwilei
9. C.B.D.
10. Civic Center
11. Ward Avenue
12. Ala Moana
13. Waikiki
14. Date Street
15. University
16. Sixth Avenue
17. Koko Head Avenue
18. Kahala
19. Aina Haina
20. Niu
21. Hawaii Kai

1 Stations
Fixed Guideway
Express Bus Route

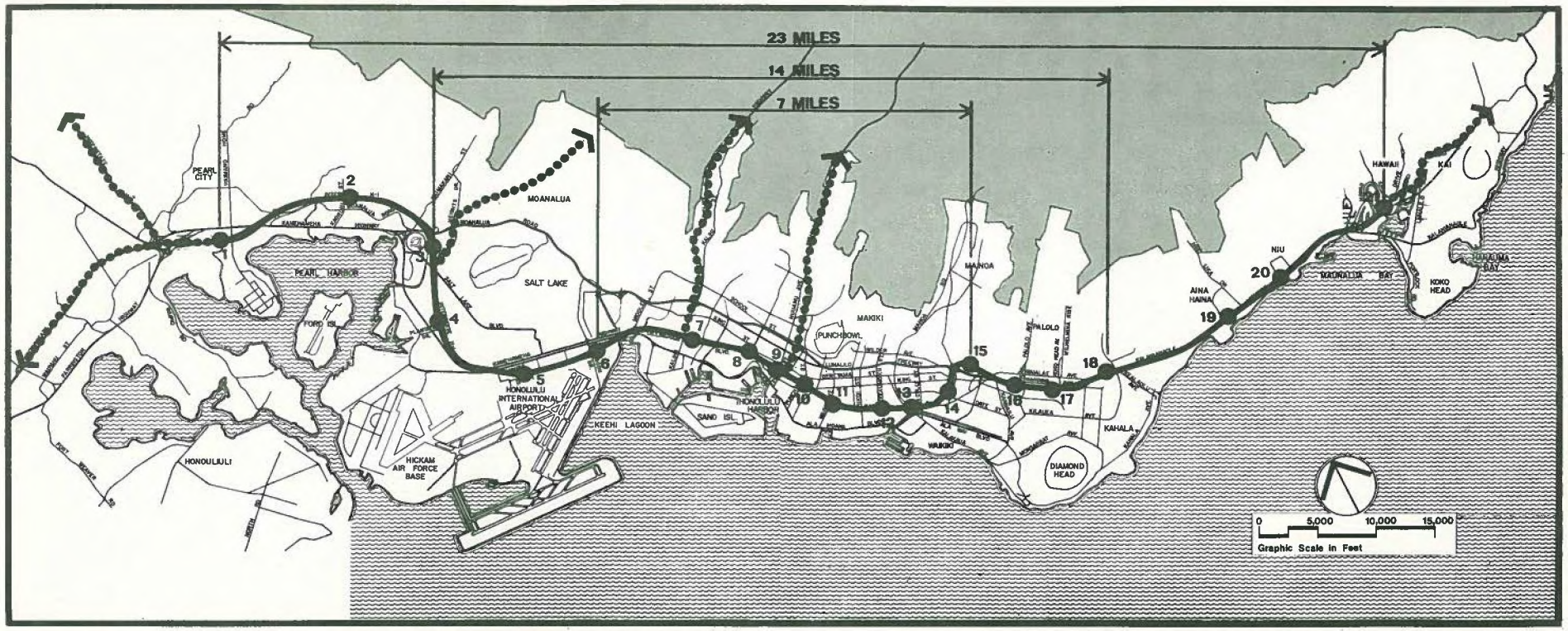


FIGURE VI-3

AR00053342

with the respective routes and station locations of each alternative system or system length. Similarly, all system alternatives incorporated comparable frequencies on the fixed segments.

d. Summary of Assumptions and Parameters: Basic assumptions and design features of the alternative systems and their attendant vehicles are summarized in Table VI-2.

2. Systems Descriptions

a. Busway: For the busway system, only a 7-mile length of exclusive, grade-separated right-of-way was analyzed. This is based on the fact that this system could utilize existing freeways beyond the 7-mile segment which would essentially be exclusive right-of-way without incurring the additional cost of building a separate busway facility. From the results of the busway system evaluation conducted in PEEP I, it was concluded that providing a longer separate busway facility is less cost effective than a shorter busway system which maximizes the use of existing freeway facilities.

b. LRT: A full 28-mile LRT system network was developed and analyzed which consisted of 14 miles of exclusive grade separated right-of-way, 9 miles of exclusive but non-grade separated right-of-way, and 5 miles of double track route in streets operating in mixed traffic. To assure comparability, shortened alternatives were analyzed. These included a 23-mile system which eliminated the 5 miles of street operation; and the 7- and 14-mile lengths of all exclusive, grade separated right-of-way operation.

c. Fixed Guideway: The fixed guideway system, which is entirely on exclusive, grade separated right-of-way, was evaluated for 3 different lengths of 7, 14, and 23 miles. For each alternative system, the feeder bus system network was completely developed for the longest length and then those bus routes affected by the shortening of the guideway facility were appropriately modified.

3. Summary Analysis of Alternative Systems

After definition of the alternative systems, each was subjected to a rigorous analysis which included estimates of patronage through application of mode split models; estimates of capital cost reflecting all construction, rights-of-way, relocation, and transit vehicles and equipment; operating costs reflecting total maintenance and operating

AR00053343

TABLE VI-2

SUMMARY OF DESIGN ASSUMPTIONS

Design Item	Busway	LRT	Fixed Guideway
• Route Location			
- Halawa & Hawaii Kai	Same	Same	Same
- Pearl City & Halawa	-	Kam Hwy	H-1 Fwy
• Bus Feeder System			
- Local bus coverage	Same	Same	Same
- Line haul route	Same	Same	Same
• Vehicle Operating Characteristics			
- Maximum speed	50 mph	50 mph	50 mph
- Acceleration rate	2.0 mphps	3.0 mphps	3.0 mphps
- Deceleration rate	1.5 mphps	2.6 mphps	2.6 mphps
• Frequency on Line-Haul Segment			
- Peak Hour	12 sec.*	2 min.	2 min.
- Base	40 sec.*	4 min.	4 min.
- Night	2 min.*	4 min.	4 min.

*Frequency at max. point on busway-includes local and express buses entering busway which do not stop at all stations

• Average Station Dwell Time	30 sec.	20 sec.	20 sec.
• Vehicle Capacity/ Area Per Passenger			
- Seated load	53	68	36
- Design Load	61/4.57 ft^2	100/4.57 ft^2	72/4.57 ft^2
- Crush Load	92/2.99 ft^2	154/2.99 ft^2	110/2.99 ft^2
• Train Length			
- Minimum	1	1	2
- Maximum	1	8*	10

*Assumes modest redesign of limiting factors will allow training more than present 4 car limit

• Special Features			
- On-line coupling & decoupling trained vehicles	-	Yes	No
- Vehicle operating on non-exclusive & non-grade separated Right-of-Way	Yes	Yes	No
- Short turn radius for street operation	Yes	Yes	No

AR00053344

requirements of the vehicles and fixed facilities; and various operating statistics that would be useful in later evaluation of the systems. In estimating all costs, unit prices for material and labor prevalent in Honolulu during late 1974 were used. A 10% contingency allowance was included for all costs and 13% applied to capital costs to cover administration and engineering. Table VI-3 presents a concise summary of selected analytical results. These and other statistics determined in the analysis are used in the evaluation of alternatives described in the next section.

AR00053345

TABLE VI-3: SUMMARY OF ANALYTICAL RESULTS

SYSTEM	TRAVEL CHARACTERISTICS						OPERATING CHARACTERISTICS				COST	
	Total Daily Transit Trips	Mode Split (Total) %	Daily Trips on Gwy.	% Pk. Hr. Work Trips By Transit	Avg. Trip Length (Mi.)	Avg. Trip Time (Min.)	Vehicles Required (With Spares)		Vehicle Miles Operated Daily		Total Capital Cost ($1,000)	Annual Operating Cost ($1,000)
							Gwy.	Feeder	Gwy.	Feeder		
7-Mi. Busway	456,250	13.8	288,200	42.4	7.31	36.3	179	752	30,308	121,408	414,411	42,713
LRT												
28 Mile	474,520	14.4	358,750	44.6	7.22	32.4	410	443	79,515	71,645	712,289	41,480
23 Mile	474,520	14.4	353,700	44.6	7.21	32.3	325	477	75,530	75,910	646,537	40,313
14 Mile	473,300	14.3	306,900	44.2	7.26	33.7	198	580	45,840	94,260	529,321	38,428
7 Mile	459,300	13.9	277,300	42.8	7.19	35.2	109	774	23,580	124,605	406,808	43,355
Fixed Guideway												
23 Mile	490,000	14.8	332,600	46.0	7.50	31.6	421	493	111,495	78,390	647,900	40,861
14 Mile	473,300	14.3	306,900	44.2	7.26	33.7	264	580	64,225	94,260	517,318	38,055
7 Mile	459,300	13.9	277,300	42.8	7.19	35.2	161	774	34,335	124,605	398,676	43,294

AR00053346

D. COMPARATIVE EVALUATION OF ALTERNATIVES

After the alternative systems were defined and analyzed, they were evaluated to determine the degree to which they met the transit development objectives described in Chapter II which were formulated to serve as the criteria for system selection. Since three alternative systems were selected and analyzed with two of the systems having optional lengths, the evaluation process included the following series of comparisons:

- Comparative evaluation of the short (7-mile) length of all three alternative systems.

- Comparative evaluation of the medium (14-mile) length of the LRT and fixed guideway systems.

- Comparative evaluation of the long lengths (23- and 28-mile LRT system and 23-mile fixed guideway system).

This series permits direct comparison of comparable lengths of alternative systems which provides a uniform basis for comparing alternatives as related to the qualitative objectives. However, for the cost objective, different lengths within each alternative and between alternatives can be appropriately compared.

In using the results of this comparative evaluation, one critical fact must be constantly kept in mind. That fact is simply that the detailed examination of alternatives has been made on systems which survived an iterative and recursive process of elimination using the same set of criteria and evaluation parameters throughout. The result is that systems producing wide variation or differences have already been weeded out and only subtle differences remain between systems. If this were not so, they would not have survived to the final detailed examination step.

For example, criteria related to Objective 2 - Balanced Transportation - has two measures which can be expressed in absolute terms: system patronage adequate to minimize the need for additional new highways and system capacity to accommodate that patronage level. Each system analyzed in detail was determined through prior iterations to be capable of reasonably meeting these criteria. Any others failing this test had already been dropped. Similar conditions resulted from application of the other criteria so that only the "best" alternatives remained.

That process combined with the fact that all systems evaluated represent "complete" transit systems wherein service levels and coverage are highly

AR00053347

comparable, produces, as should be expected, highly comparable results. For example, as mileage of fixed guideway and LRT systems was cut back, it was replaced with express bus service and only subtle differences resulted.

In essence, any of the three remaining systems would each produce a reasonable level of transit service on Oahu. The ensuing discussion of system evaluation, therefore, is directed at identifying the best of the best and ultimate selection will hinge on a full range of considerations rather than some marked performance differences.

1. Evaluation Measures and Methodology

The basic transportation goals and objectives adopted by the area for development of transportation plans formed the basis for defining specific transit development objectives as shown in Table II-1. Complementing each specific objective is a set of standards or criteria established to use as a measure in testing and evaluating alternative systems. These criteria may be either tangible (monetary terms) or intangible. The intangible criteria may be either quantitative (absolute) or qualitative (comparative).

Patronage in Objective 2 or Travel Time in Objective 1 are absolute measures in that specific values can be determined. Rider comfort in Objective 1, on the other hand, is an example of a comparative measure since it can only be related on a better-equal-worse basis when compared to competing alternatives.

Similarly, certain absolute measures are more appropriately treated as comparatives. An example of such a measure is minimizing the displacement of residents. No desirable value can be realistically assigned and its application, therefore, must be a comparative one in which the alternative system resulting in the lowest number of displacement is deemed to best meet the criteria.

Therefore Objectives 1 through 6 containing both absolute and comparative measures are all treated as comparatives. Objective 7 related to cost is the only one that is totally tangible and will therefore be treated separately from the others.

Objectives 1 through 6 are classified as qualitative objectives with no standardized techniques available to combine all measures into a single overall measure. They also relate to a wide variety of service, community, environmental, and social factors which further complicates the synthesizing process. In order to overcome this problem, a simplified approach was used by ranking the alternatives in the order

AR00053348

of how well they were able to meet the objective. The further ranking of objectives based on their relative importance was not done due to the highly subjective nature of this process. However, as part of the total evaluation process, a sensitivity test was made to determine if the application of varying values would have any effect on the final composite ranking of the systems.

Objective 7 which specifically relates to cost is stated as "a transportation system which will provide the greatest efficiency and service by meeting all other objectives at the lowest cost possible." Accordingly, this objective contains 3 tangible cost measures: total cost, cost per passenger trip, and benefit-cost ratio. The total cost including capital and operating costs provides a measure for total public investment required of each system. The cost per passenger trip provides a means of combining total cost with system attractiveness and usage into a single measure. The third measure involves the benefit-cost analysis which quantifies benefits and relates it to cost as a method of evaluating returns on public investment.

It is pointed out that many of the qualitative objectives and their measures are directly or indirectly reflected in the benefits computed for the benefit-cost analysis. Benefits are based on transit ridership volumes for which in turn, reflects the quality of service provided by the various alternative systems. On the cost side of the ledger, various community related measures such as consumption of land and displacements are included as part of the total cost. However, since there are various secondary benefits or costs associated with certain measures which are explicitly accounted for in the benefit-cost analysis, the separate evaluation of those qualitative objectives would not be considered as double counting.

2. Comparative Analysis of Alternative Systems

Table VI-4 shows the results of the series of comparative analysis of all alternatives as listed in the beginning portion of this section. While most of the entires in the tables are self-explanatory, the following additional explanation and comments are provided to insure uniform interpretation of each objective and criteria measure.

AR00053349

TABLE VI-4: COMPARISON MATRIX FOR ALTERNATIVE SYSTEMS

	Short 7-Mile Length			Medium 14-Mile Length		Long 23 & 28 Mile Length		
	Busway	LRT	Fixed Guideway	LRT	Fixed Guide.	23-Mile LRT	28-Mile LRT	23-Mile F.G.
OBJECTIVE 1								
a. Availability & coverage	Same	Same	Same	Same	Same	Same	Same	Same
b. Avg. trip time (min.)	36.3	35.2	35.2	33.7	33.7	32.3	32.4	31.6
c. Service reliability	(2)	(1)	(1)	Same	Same	(2)	(2)	(1)
d. Rider convenience	(1)	(2)	(2)	Same	Same	(2)	(1)	(2)
e. Rider comfort	(2)	(1)	(1)	Same	Same	Same	Same	Same
OBJECTIVE 2								
a. System patronage	137.8	138.7	138.7	142.9	142.9	143.3	143.3	148.0
b. System capacity	*	Same	Same	Same	Same	Same	Same	Same
OBJECTIVE 3								
a. Consumption of land (acres)	42	21	20	23	22	36	36	32
b. Displacement of residents (units)	233	152	148	166	162	179	179	167
c. Displacement of businesses (units)	257	168	164	187	183	194	194	184
d. Reduction of community amenities	Same	Same	Same	Same	Same	Same	Same	Same
e. Disruption to future dvlpmt.	Same	Same	Same	Same	Same	Same	Same	Same
f. Disruption to local circulation	Same	Same	Same	Same	Same	(2)	(3)	(1)
g. Disruption from constr. activities	Same	Same	Same	Same	Same	(1)	(2)	(1)
h. Savings in energy (million gal/yr.)	10.0	8.5	8.9	8.5	9.4	5.0	4.8	8.5
i. Technical risk	(3)	(1)	(2)	(1)	(2)	(1)	(1)	(2)
OBJECTIVE 4								
a. Support regional dvlpmt.	Same	Same	Same	Same	Same	Same	Same	Same
b. Support comm. dvlpmt.	Same	Same	Same	Same	Same	Same	Same	Same
OBJECTIVE 5								
a. Reduction Air pollution (tons/yr.)	2,970	3,240	3,260	4,110	4,150	4,120	4,140	4,930
b. Noise level (dBA)	75-80	72-79	64-71	72-79	64-71	72-79	72-79	64-71
c. Visual intrusion	(3)	(2)	(1)	(2)	(1)	(2)	(2)	(1)
d. Vistas	(2)	(3)	(1)	(2)	(1)	(1)	(1)	(2)
e. Historic sites	Same	Same	Same	Same	Same	Same	Same	Same
OBJECTIVE 6								
a. Reduce accident exposure	Same	Same	Same	Same	Same	(2)	(2)	(1)
b. Security	Same	Same	Same	Same	Same	Same	Same	Same

OBJECTIVE 7 Interest Rates	4%	10%	4%	10%	4%	10%	4%	10%	4%	10%	4%	10%	4%	10%	4%	10%
a. Total annual cost	70.63	90.10	70.16	89.35	69.63	88.43	71.50	96.72	70.43	95.06	79.72	110.65	84.55	118.66	80.42	111.40
b. Cost per trip	51.3¢	65.4¢	50.6¢	64.4¢	50.2¢	63.8¢	50.0¢	67.7¢	49.3¢	66.6¢	55.6¢	77.1¢	59.0¢	82.8¢	54.3¢	75.3¢
c. Benefit-cost ratio	1.15	0.90	1.19	0.93	1.20	0.94	1.26	0.93	1.28	0.95	1.18	0.85	1.11	0.79	1.25	0.90

Note: Numbers in parenthesis (1) show ranking of alternatives based on how well they met the objective
*Practical capacity for busways are unknown and assumed to be less than for guided systems

AR00053350

Objective 1 - Improve Accessibility by serving and interconnecting existing and future urbanized areas of Oahu. This objective relates to improved transit service to all areas of the island and to all segments of its population. Criteria measures are:

- Availability and coverage relates to reasonable accessibility to transit at both ends of the trip for all residents (coverage) and to the frequency of service (availability).

- Trip time reflects the door-to-door trip time and is expressed as a system average in minutes.

- Service reliability relates to the assurance of completing a trip within a scheduled time. As such it includes vehicle reliability against in-service failure, schedule reliability against missed connections at transfer points and schedule adherence in terms of arrival and departure times.

- Rider convenience measures the perceived ease of using the vehicle and transit system. As such it includes minimum number of transfers, ease of fare collection through automatic collection rather than on-board exact fare systems, boarding and alighting ease (curb-side vs. raised platform), sheltered waiting areas, etc.

- Rider comfort recognizes the overall ride quality of the vehicle system including climate control, noise levels, vibrations, jerk rate, etc.

Objective 2 - Provide a balanced transportation system of transit and highways. This objective is directed toward offering a high quality transit service which will attract sufficient ridership to minimize the need for added highways in the urban area of Honolulu. Criteria measures are:

- System patronage expressed as the total annual patronage estimated for each system.

- System capacity reflects the ability of the transit vehicle system(s) to accommodate maximum projected patronage within prescribed loading standards at the maximum load points on the system.

AR00053351

Objective 3 - Minimize expenditure of resources and disruption to the community. This objective relates to the area of secondary social and economic cost as a result of consumption of or disruption to the community or its resources and amenities as differentiated from direct financial costs. Measures are:

- Consumption of land expressed as the total number of acres required for rights-of-way (excluding existing street and freeway rights-of-way) to implement the system and its ancillary facilities including stations and vehicle storage areas.

- Displacement of residents expressed as the total number of residential dwelling units taken.

- Displacement of businesses reflects total business establishments taken.

- Reduction of community amenities relates to the use of existing public facilities such as parks, etc. for other purposes supportive of the transit system.

- Disruption of future development reflects the usability of adjacent land for its intended purpose after development of the transit system.

- Disruption of local circulation reflects street closures or loss of street capacity as a result of transit system development.

- Disruption from construction activities is a measure of local impact resulting from construction activities. It includes such factors as traffic disruption, dust and noise, reduced access to street frontage, etc. These impacts are short-term impacts applicable only during construction periods.

- Savings in Energy Consumption reflects the net savings in energy used resulting from savings by diverted motorists less that consumed by the transit system itself expressed in millions of gallons of fuel.

- Technical risk is a function of the degree to which any combination of vehicle system and operating concept may assure workability.

Objective 4 - Support land use and development policy. This objective relates to the development of a transit system which can aid in directing growth and development as desired and expressed through stated policies. Its measures are:

AR00053352

- Support regional development is a reflection of the extent to which deployment of a particular transit system supports overall regional planning.

- Support community development is a measure of the same factors at the neighborhood or community level such as around a station or within an identifiable community such as Moiliili.

Objective 5 - Preserve environment. This objective relates to the preservation or enhancement of Oahu's unique environment. Its measures are:

- Reduction in Air Pollution reflects the net reduction which results from diverted motorists who use transit less the air pollution contributed by the transit system itself expressed in tons of total pollutants.

- Noise level indicates the amount of noise produced by the transit vehicle system(s) expressed in decibels (dbA) produced at operating speeds 50 feet from the vehicle.

- Visual intrusion reflects the size or mass of the transit structures or the visual "clutter" that results from their introduction into the existing vistas. It assumes that all structures would be carefully and sensitively designed for harmony with surrounding developments to minimize intrusion.

- Preservation of vistas is a function of the vertical alignment and the mass of the transit structures with respect to blocking existing views.

- Preservation of historic and scenic sites is a function of route location with respect to identified historic or scenic places.

Objective 6 - Safety. This objective relates to the safety of the transit user with respect to on-board accidents, boarding and alighting accidents, etc. and to non-users in terms of conflict with the transit vehicle either as a pedestrian or motorist. Its measures are:

- Reduce accident exposure reflects primarily the exclusivity of the transit rights-of-way but also includes operational characteristics such as jerk rate which could produce falls on-board by standing passengers.

- Security reflects the personal well-being of the transit patron while riding on or waiting for the transit vehicle.

AR00053353

Objective 7 - Provide the most economical system which best meets all other objectives. This objective deals with the overall cost effectiveness and financial demands of the system. Its measures are:

- Total annual cost which includes total capital, operating and maintenance costs associated with building and operating the system expressed in total annual costs. Operating costs were based on the 1995 system operating and reflected full operating and maintenance for vehicles and transit facilities. Capital costs were annualized over a 30 year period at interest rates of 4% and 10% to determine if different rates would influence the relative ranking of the alternatives.*

- Cost per trip is a measure of cost effectiveness relating total annual cost to patronage.

- Benefit-cost ratio is a measure of economic effectiveness of the alternatives in terms of public benefits accruing from expenditure of public funds. Benefits used in this analysis reflected only user and non-user travel benefits to present a conservative measure and to avoid inclusion of simple transfer benefits.

3. Comparative Evaluation and Selection Process

The final selection of a recommended system from among the alternatives is predicated on the overall ability of each system to meet the specific transit development objectives. As the first step in the system selection process, a comparative evaluation was made according to the extent each system met each criteria. Where numerical terms were developed, the ranking was readily determined based on a simple comparison of the numerical values. Where only qualitative terms were applicable, the alternative systems were ranked based on a relative comparison of how well the criteria was met as was fully described in the previous section.

Examination of the comparative analysis table bears out the earlier statement that few if any compelling differences are evident between

---

*It should be noted that the various interest rates did not alter the relative ranking between system alternatives. However, within the LRT and fixed guideway systems the lowest cost per passenger value shifted from the 14-mile system to the 7-mile at the 10% interest level reflecting the impact of higher construction cost.

AR00053354

alternatives for any individual criterion or objective. However, taken as a whole, the set of objectives and criteria demonstrate a clear and consistent pattern of superiority of the fixed guideway alternatives. Table VI-5 presents a summary of the rankings for each comparative analysis and illustrates this superiority.

By examination, it can be readily seen that the fixed guideway alternative received by a wide margin more top rankings than the other alternatives. Accordingly, any assignment of reasonable values to the objectives based on the relative importance would not change the ranked order of the alternatives.

AR00053355

TABLE VI-5: SUMMARY OF RANKINGS

	7-Mile Bus.	7-Mile LRT	7-Mile FG	14-Mile LRT	14-Mile FG	23 Mi. LRT	28 Mi. LRT	23 Mi. FG
OBJECTIVE 1								
a. Availability & coverage	-	-	-	-	-	-	-	-
b. Avg. trip time (min.)	2	1	1	-	-	2	3	1
c. Service reliability	2	1	1	-	-	2	2	1
d. Rider convenience (transfers per trip)	1	2	2	-	-	2	1	2
e. Rider comfort	2	1	1	-	-	-	-	-
OBJECTIVE 2								
a. System patronage	2	1	1	-	-	2	2	1
b. System capacity	2	1	1	-	-	-	-	-
OBJECTIVE 3								
a. Consumption of land (acres)	3	2	1	2	1	2	2	1
b. Displacement of residents (units)	3	2	1	2	1	2	2	1
c. Displacement of businesses (units)	3	2	1	2	1	2	2	1
d. Reduction of community amenities	-	-	-	-	-	-	-	-
e. Disruption to future dvlpmt.	-	-	-	-	-	-	-	-
f. Disruption to local circulation	-	-	-	-	-	2	3	1
g. Disruption from constr. activities	-	-	-	-	-	1	2	1
h. Savings in energy (million gal/yr.)	1	3	2	2	1	2	3	1
i. Technical risk	3	1	2	1	2	1	1	2
OBJECTIVE 4								
a. Support regional dvlpmt.	-	-	-	-	-	-	-	-
b. Support comm. dvlpmt.	-	-	-	-	-	-	-	-
OBJECTIVE 5								
a. Reduction Air pollution (tons/yr.)	3	2	1	2	1	3	2	1
b. Noise level (dBA)	3	2	1	2	1	2	2	1
c. Visual intrusion	3	2	1	2	1	2	2	1
d. Vistas	2	3	1	2	1	1	1	2
e. Historic sites	-	-	-	-	-	-	-	-
OBJECTIVE 6								
a. Reduce accident exposure	-	-	-	-	-	2	2	1
b. Security	-	-	-	-	-	-	-	-
OBJECTIVE 7								
a. Total annual cost	3	2	1	2	1	1	3	2
b. Cost per trip	3	2	1	2	1	2	3	1
c. Benefit-cost ratio	3	2	1	2	1	2	3	1
No. of Firsts	2	6	15	1	11	4	3	15
No. of Seconds	6	10	3	11	1	14	10	4
No. of Thirds	10	2	0	0	0	1	6	0

AR00053356

E. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The results of the comparative evaluation of the alternative systems presented herein formed the basis for selecting and recommending a system for implementation. Although the evaluation and selection procedure was previously discussed in detail, it is worth summarizing some of the key factors which led to the selection of the recommended system.

1. Busway Conclusions

The busway system, although reasonably meeting all objectives, provided the least relative compliance with the various objectives of all alternative systems evaluated. The busway system utilizing individually driven vehicles powered by internal combustion engines has inherent disadvantages in providing quality service, minimizing community disruptions, and reducing environmental impacts comparable to the electrically propelled and trainable vehicles of the guided systems.

In addition, the busway system provides no cost advantage over the guided systems at the patronage levels projected for Honolulu. In fact the 7-mile busway system has a higher operating and maintenance cost per passenger carried than the guided systems reflecting the labor intense feature of bus operation which will also be more susceptible to labor rate escalation than the guided systems. In summary, the busway system is found to be generally inferior to the guided systems in terms of service, community disruption, preservation of the environment, cost effectiveness, and possible limitations in capacity and therefore should be dropped from consideration.

2. LRT vs. Fixed Guideway Conclusions

Based on the results of the comparative evaluation, the LRT and fixed guideway systems were both judged to adequately meet the basic requirements of overall system attractiveness and desired system capacity together with various other qualitative objectives. A review of the comparative values, given in numerical and qualitative terms, applied to the measures identified with various objectives, indicates only a slight difference between the two systems. However, the fixed guideway system shows a definite superiority, however slight for each measure, in terms of the number of measures in which it ranked higher than the LRT system. This superiority is reflected in nearly all objectives related to service, community disruption, and preservation of the environment.

AR00053357

Relative to the cost objective, for comparable lengths with all grade separated routes, the total capital and operating costs are essentially the same. In comparing the 23-mile length system, the LRT with partial grade separated routes has a slightly lower total capital and operating cost than the fixed guideway system. However, because of its slightly lower system operating speed resulting from the at-grade service in Kalanianaole and Kamehameha Highway medians, the LRT attracts less passengers which then results in a slightly higher cost per passenger carried. The longer 28-mile LRT system was found to have both higher total cost and higher unit cost per passenger carried than the 23-mile fixed guideway system.

From the results of this comparative evaluation, the 2 guided systems were found not to differ significantly relative to the various measures used. Since the two systems have similar performance characteristics, they are rated as having equal service quality capabilities. The primary difference is in the physical characteristics of the vehicles. The LRT vehicles being larger and heavier, requires larger aerial guideway structures. Where partial grade separated routes are considered for the LRT system, the requirement for overhead trolley wires increases the visual intrusion. With the guideway structure proposed to be preponderantly in aerial configuration through the urban Honolulu core, the above features are considered to be a critical factor in this environmentally sensitive area.

One additional factor of importance which was not included as one of the comparative measures is the grade climbing capability of the systems. Sustained grades of 5% to 6% are encountered in the Kaimuki area and any future crossing of the Koolau Range would also require a grade of approximately 6%. Although the steel wheeled LRT system can negotiate these grades, they would require the systems to be operated at slower rates of acceleration and deceleration and lower operating speeds than the fixed guideway system thus resulting in reduced quality of service and higher capital and operating costs.

In summary, the fixed guideway system is concluded to possess those essential qualities to best meet the overall objectives defined for transit development. Although the advantage shown for any single measure may be slight, they collectively indicate the overall superiority of the fixed guideway as the long-range transit system for the area and combine to produce a recommendation for adoption of a 23-mile fixed guideway system.

AR00053358

3. System Staging Potential

As part of the development of the alternative systems, the potential of each system for staged development was analyzed by considering several different lengths for implementation. A further examination was made of staged development by initially beginning with a lower level of service which could be upgraded at a later date to a higher level system. An example of this would be to provide an at-grade LRT system located in existing streets or other available rights-of-way which would require a lower capital investment as compared to a fully grade separated LRT system.

A review of this potential for staged development using the LRT system was found to be difficult due to the lack of suitable streets or other available ROW for locating the tracks of the LRT system. This is especially true in the downtown area where the travel demand is the greatest but where transportation facilities are most lacking. In Honolulu, the critical need is in the urban core area where it has been determined that a full grade separated, high level system is critically needed to meet the forecasted demand. Due to the unavailability of suitable rights-of-way and the immediate need for a high level service, the provision of an at-grade LRT system as the initial staged development would be economically unsound.

In those instances where initial construction of a grade separated transit system cannot be justified by demand volume in the near-term or even prior to 1995, it will be extremely difficult to justify the construction cost associated with at-grade trackage compared to bus service. While the capital cost is substantially less than for a grade separated facility, it is also substantially above that necessary to operate conventional buses on a preferential treatment basis. At the same time, the capacity of the LRT in this mode of operation is limited by train length (probably 2-car maximum) due to an at-grade crossing of intersecting streets. It is also restricted in speed by safety considerations at these same at-grade crossings.

Under these conditions, the continued use of buses on corridors or routes, other than the primary east-west corridor in the urban core would be the most cost effective form of transit service until a higher level system can be justified. With buses utilizing existing streets and highways and with plans underway to provide more reserved bus lanes, the bus system cannot be surpassed by any form of an at-grade system as the interim or short-range transit solution for Honolulu.

AR00053359

As a result, it is concluded that no advantage can be assigned to either LRT or fixed guideway systems from a staging viewpoint. Either system can reasonably be staged to meet Honolulu requirements. Therefore, staging is not a factor in ultimate system selection and the previously discussed conclusion to select the fixed guideway holds.

4. Vehicle Conclusions

In the evaluation of alternative systems, the vehicle system assumed for the fixed guideway alternative was a medium capacity, rubber-tired vehicle. In concluding upon a recommendation for fixed guideway, the issue that requires discussion pertains to the type of wheels - rubber tire versus steel. Based on studies conducted during the course of the program, it was found that the conventional heavy rail, steel wheel system and the medium capacity, rubber-tired system were quite similar in many respects.

Basically, a fully grade separated LRT system has essentially the same physical and operating characteristic as the heavy rail system. Other than for the difference in the car design and the location of the propulsion power system, i.e. third rail versus overhead trolley wire, these two systems can be designed to provide similar operating characteristics as well as fixed facilities including guideway and station structures. The comparative evaluation presented in this chapter between the LRT and the fixed guideway systems would be applicable as well to a comparison between heavy rail and fixed guideway.

As mentioned repeatedly in this chapter, the real difference between the LRT and fixed guideway is quite small when each individual measure is examined separately. Even in the cost measures, the difference is relatively small with the final conclusion and recommendation based on that fact that the fixed guideway can better meet more of the measures, however slight the difference may be for each measure, as specifically applied to the Honolulu condition and environment.

Although all U.S. systems have eventually decided upon steel wheel systems, the completion of new rubber-tired systems in Montreal, Mexico City and Sapporo (Japan), and in airports in Tampa, Seattle-Tacoma, and Dallas-Fort Worth, has provided the industry with sufficient design and operating experience in recent years to lead us to the conclusion that a rubber-tired system can be designed and built for Honolulu.[33] While not entirely without risk with any new system, the knowledge and experience gained from these rubber-tired vehicle systems and those proven automatic train control systems used by

AR00053360

both rubber-tired and steel wheel vehicle systems, the overall risk is minimized.

The selection of a medium capacity, rubber-tired vehicle system is supported by a number of considerations unique to Honolulu.

a. The need for quiet operation: Housing in Honolulu commonly involves "open window" construction with natural air conditioning provided by the trade winds. Additionally, high land costs have resulted in very high densities in the corridor which the system will traverse. Because the system will, for the most part, be built within existing major streets and highways, the noise produced by rubber-tired vehicles will be very similar to the ambient noise within the corridor. The alignment of the system, selected to minimize relocations in a "land short" island includes curve radii which would result in flange noise from steel-on-steel operation, a sound unknown on Oahu today and distinctly different from the ambient noise in the corridor.

b. The need for grade climbing capability: The terrain in the corridor involves negotiating sustained grades of five per cent which could only be avoided by tunneling, heavy grading, or high trestling. With almost daily rainfall, the suitability of steel-on-steel for such operations would entail operations at lower acceleration and deceleration rates and operating speeds whereby schedule reliability and minimum headway would not be at the same level as the rubber-tired vehicle system. Grades of 8% for short distances to achieve vertical alignment transition from subway to aerial guideway are required to minimize dislocation and community disruption. Moreover, if the system is ultimately extended across the Koolau Mountains to Kailua and Kaneohe, sustained grades of six per cent under wet track conditions will be required. Thus the rubber-tired vehicle was prefered for this reason as well.

c. The need for light weight vehicles: The size of the vehicle was based on the patronage estimates which indicated that peak demand of approximately 20,000 persons per hour in one direction by 1995 would require a medium-capacity system. With vehicles of this size, lighter weight aerial structures to minimize visual intrusion, can be used for the guideway. Additionally, existing highway structures can accommodate this vehicle weight without major modification and attendant cost as would be required with steel wheel systems.

AR00053361

d. Compatibility of systems not a factor: There are no existing or planned steel rail systems on Oahu so that there is little or no likelihood that compatibility of systems will become an issue as it has in some Mainland cities and in many foreign countries where commuter rail systems could become parts of an expanded system.

e. Community acceptance: Public sentiment repeatedly expressed is overwhelmingly in favor of a rubber-tired system, principally because of the nature of the sound such a system would create as contrasted with a steel-on-steel system.

5. Overall Recommendation

Based on the conclusions reached in this analytical and evaluation comparison, it is recommended that a 23-mile fixed guideway system employing a light weight, medium capacity, rubber tired vehicle system be adopted as the long-range rapid transit system for Honolulu. This system must be supported by a high quality feeder and express bus system extending transit service to those areas where travel volume is and will remain inadequate to warrant extensions of the grade separated fixed guideway system.

AR00053362

CHAPTER VII

ALTERNATIVE LENGTHS EVALUATION

A. GENERAL

With previous chapters presenting the conclusions reached for the need of a high level rapid transit system, its route location, and the type of system best suited for Honolulu, it remains to decide how much of the system to build initially. The recommended fixed guideway system was analyzed and planned for staged development by identifying various segment lengths of the full 23-mile system that are operationally viable. In identifying potential segment lengths for detailed evaluation, the primary consideration was location of terminal stations relative to accessibility by all modes of travel and availability of appropriate sites. The absolute minimum segment length considered to be operationally viable was from Keehi Lagoon Park to the University of Hawaii campus which comprises approximately 7.3 route miles. An extension of some 1 mile to this minimum segment to serve the Honolulu International Airport was selected as the second alternative segment length which results in approximately 8.4 route miles. A further extension to the 8.4 mile segment on its western end of some 3 miles to Halawa (Aloha Stadium) provides an excellent terminus for this segment length of 11.5 route miles. An extension of 2.5 miles on the eastern end to Kahala would provide a 14 route mile segment with an excellent terminus at both ends.

The four alternative segment lengths selected for detailed evaluation are shown in Figure VII-1 and described below:

Segment Lengths	West Terminus	East Terminus
7 miles (7.3 mi.)	Keehi Lagoon Drive	University
8 miles (8.4 mi.)	Airport	University
12 miles (11.5 mi.)	Halawa	University
14 miles (14.0 mi.)	Halawa	Kahala

Any extensions beyond the 14-mile segment, based on patronage forecasts and costs for the early years, would not be economically justified. The maximum peak hour link volume, one way, for either of the outer segments in 1985 is estimated to be approximately 5,000 passengers. At this volume, a high level, grade separated guideway facility is not warranted especially where exclusive or reserve bus lanes can be provided in existing highway rights-of-way.

AR00053364

Alternative Segment Lengths

RAPID TRANSIT STATIONS

1. Pearl City
2. Pearl Ridge
3. Halawa
4. Pearl Harbor
5. Airport
6. Keehi Lagoon
7. Kalihi
8. Iwilei
9 Fort Street
10. Civic Center
11. Ward Avenue
12. Ala Moana
13. Waikiki
14. Date Street
15. University
16. Sixth Avenue
17. Koko Head Avenue
18. Kahala
19. Aina Haina
20. Niu
21. Hawaii Kai

1 Stations
Aerial
At Grade
Underground
Express Bus

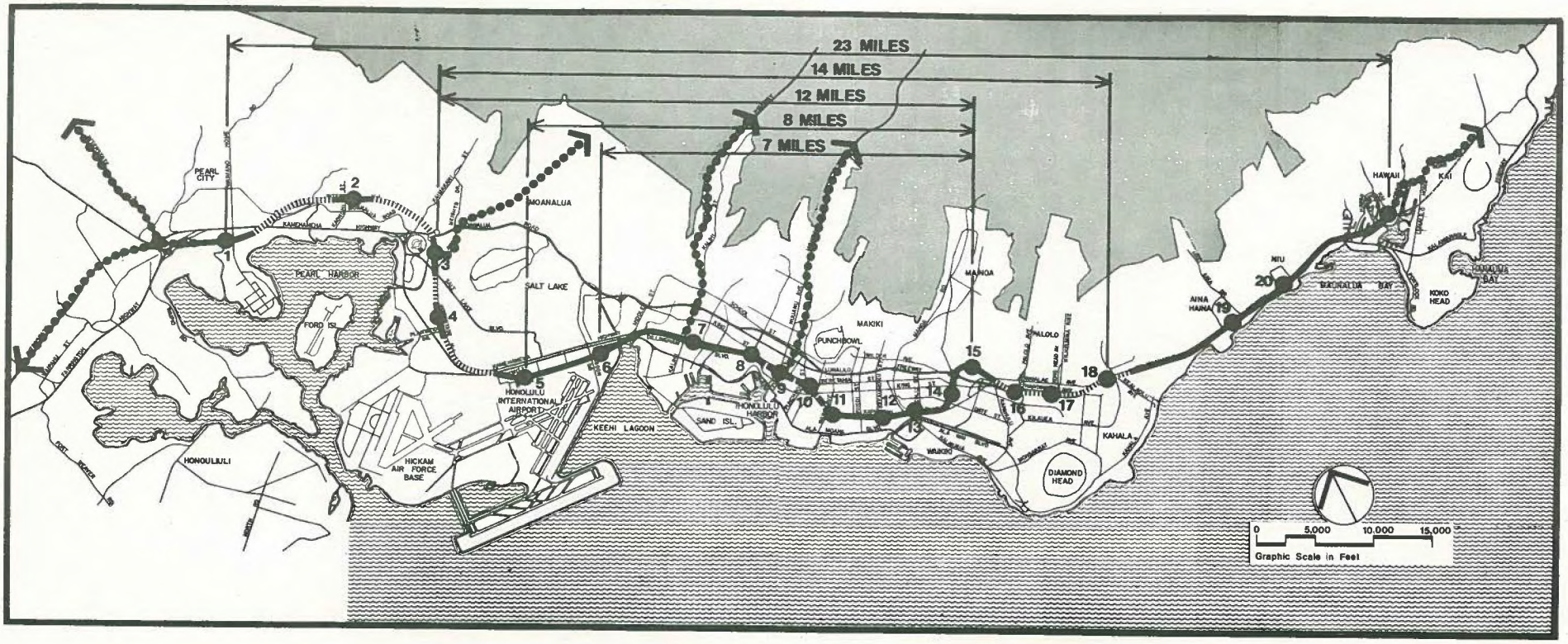


FIGURE VII-1

AR00053365

B. ASSUMPTIONS AND METHODOLOGY

The purpose of this study is to develop an orderly process for the evaluation of alternative system lengths as the basis for selecting the initial segment for implementation. For the analysis, it was assumed that up to 5 to 6 years would be required to design and construct the initial segment thus placing the system in revenue service in the early 1980's. In order to provide several years of operation before the first system extension can be made, 1985 was selected as the study year.

For purposes of this analysis, a 15 year study period from 1980 to 1995 was selected with relevant data developed for 5 year increments. The patronage and cost estimates were developed for the years 1980 and 1995 from which estimates for 1985 and 1990 were derived by interpolation.

Patronage estimates were developed for the 7, 12, and 14 mile segment lengths by computer processing of the modal split and trip assignment models. For the 8 mile segment length, the patronage forecasts were developed by manually adjusting trip assignment values for those portions of the system network modified from the 7 and 12 mile lengths. The resulting trip assignments for each alternative length system were used to evaluate its performance and to determine the vehicle requirements, operating costs, etc. for the fixed guideway and feeder bus system.

The alternative length systems were carefully analyzed in terms of terminal station location and its development to ensure efficient access for various modes of arrival. Each terminal station location was carefully studied and planned for accommodating access and transfer facilities for all modes. The location and facilities planned for each terminal station was used as the basis for developing the feeder bus network which served as input to the modal split and trip assignment model.

For comparative evaluation of alternative lengths, both quantitative and qualitative measures were applied as in prior alternative system evaluation. However, certain measures, such as system capacity, technical risk, and others, while meaningful when comparing one system vs. another, have little or no influence when applied to varying lengths of the same system. Therefore, only those measures which could be related to variation in system length and service have been used in this analysis.

AR00053366

C. ANALYSIS OF SYSTEM NETWORKS

The full 23-mile fixed guideway system would have terminal stations located in Pearl City and Hawaii Kai. Six express bus routes serving northern, central and leeward areas of Oahu utilizing the H-1 and H-2 Freeways, would interface at the western end of the system at the Pearl City Station. At the eastern end of the system, two express bus routes from the Waiamanalo and Kalama Valley areas would interface with the fixed guideway at the Hawaii Kai Station. All other bus routes serving these terminal stations would be local service. As the full 23-mile system is cut back into shorter segments, the express bus routes from outlying areas must travel farther to interface with the terminal stations that get progressively closer to the downtown area. Also those local buses serving stations that are eliminated by shortening the fixed guideway would be re-routed to the new terminal station which increases both their travel distance and the concentration of buses at the terminal station. The basic change in the overall system network to reflect alternative lengths is modifying the bus network to conform with each fixed guideway length. Essentially, total coverage and transit availability remain constant although mode and travel time may change.

As the system length was reduced on the western end, the express buses from the outlying areas were routed on the H-1 Freeway to Halawa (Aloha Stadium) Station to interface at this location for the 12- and 14-mile alternatives. For the 7 and 8 mile alternatives, these express buses were extended on the H-1 Freeway, leaving the freeway at the Pearl Harbor Interchange, with stops at Valkenburgh Road and at the airport, proceeding along Aolele Street to terminate at the Keehi Lagoon Station. Termination at the Keehi Lagoon Station was planned for both shorter length alternatives in order to minimize potential congestion occurring at the airport with the 8-mile length.

Local feeder buses operating in conjunction with the 12- and 14-mile segments serving the Pearl City-Pearl Ridge areas and westerly, were routed along the Kamehameha Highway and Moanalua Road to terminate at the Halawa Station. For the 7- and 8-mile alternatives, these feeder buses were routed to terminate at the Keehi Lagoon Station. The feeder bus routes serving the Halawa Heights-Foster Village and interfacing at the Halawa Station in the longer systems were modified to interface at the Keehi Lagoon Station for the 7- and 8-mile alternatives.

As system length was reduced on the eastern end, the two express bus routes from Waimanalo and Kalama Valley were routed on an exclusive bus lane in the middle of Kalanianaole Highway to terminate at the Kahala Station for

AR00053367

the 14-mile segment. For the 12-, 8-, and 7-mile segments, these express buses were routed to continue on the Lunalilo Freeway in mixed traffic or reserved bus lane and terminated at the University Station.

For the 14-mile segment, 4 local bus routes originating from the Hawaii Kai, Niu and Aina Haina areas were routed in mixed traffic on Kalanianaole Highway to interface at the Kahala Station. For the 12-, 8-, and 7-mile segments, these 4 local bus routes were extended on local streets to interface at the Date Street Station. In addition, 5 other bus routes originating in areas between the University and Kahala and operating on the various local streets were re-routed to the Date Street Station with the 12-, 8-, and 7-mile alternatives.

Modifications and extensions to the feeder bus system for operation in conjunction with shortened guideway system lengths involve increases in bus-miles and bus-hours of operation and in the number of vehicles required to replace the guideway system. Conversely, with shortened guideway lengths, appropriate reductions in guideway vehicle miles and hours would occur.

AR00053368

D. ANALYSIS OF QUALITATIVE MEASURES

As indicated earlier, the measures applicable to the evaluation of alternative lengths are necessarily different from measures applicable to alternative routes and alternative systems evaluation. Measures which are specifically applicable to alternative lengths evaluation have been identified and are analyzed and discussed in this section. Table VII-1 shows the results of the evaluation in matrix form. The table is supplemented by the following narrative evaluation relative to each objective.

1. Objective 1. Improve Service

The basic availability and coverage of the transit system would essentially be the same for all lengths. Travel time, service reliability, rider convenience, and rider comfort would all improve with increased length due to faster average speed, higher equipment and schedule reliability, fewer transfers, and greater comfort on the fixed guideway system over the bus system. Consequently, the longer the system, the better this objective is met.

2. Objective 2. Balanced Transportation

System patronage volume becomes progressively higher with increased length due to the superior service characteristics of the fixed guideway system over the bus line haul system. The indicated volumes do not include tourist trips which represent a high percentage of transit trips originating from Waikiki. Today the transit population represents about 5% of the total resident population. The increasing demand for transit service by this segment of potential riders can be better served with the longer guideway lengths.

3. Objective 3. Minimize Expenditure of Resources

The consumption of land and displacements of residents and businesses are naturally greater with longer length systems. However, when a short system is extended at a later date, the impact caused by the extension could possibly be much greater at a later date due to additional development having taken place. Whatever difference that may exist between alternatives is relatively small and of short duration and therefore the alternatives are rated as being the same for these measures.

For measure d. - since there are no community facilities affected for alternative lengths longer than the 7-mile length, all alternatives are rated as being the same for this measure.

AR00053369

TABLE VII-1: COMPARATIVE EVALUATION MATRIX

	7-Mile	8-Mile	12-Mile	14-Mile
OBJECTIVE 1				
a. Availability & coverage	Same	Same	Same	Same
b. Avg. trip time (min.)	35.2	35.2	34.5	33.7
c. Service reliability *	4	3	2	1
d. Rider convenience*	4	3	2	1
e. Rider comfort *	4	3	2	1
OBJECTIVE 2				
a. System patronage - 1985 (million/yr.)	94.37	94.46	95.64	97.37
b. System capacity	Same	Same	Same	Same
OBJECTIVE 3				
a. Consumption of land (acres)	Same	Same	Same	Same
b. Displacement of residents (units)	Same	Same	Same	Same
c. Displacement of businesses (units)	Same	Same	Same	Same
d. Reduction of community amenities	Same	Same	Same	Same
e. Disruption to future dvlpmt.*	3	3	2	1
f. Disruption to local circulation*	3	3	2	1
g. Disruption from constr. activities	Same	Same	Same	Same
h. Savings in energy (million gal/yr.)	4.1	4.3	4.3	4.5
i. Technical risk	Same	Same	Same	Same
OBJECTIVE 4				
a. Support regional dvlpmt.	Same	Same	Same	Same
b. Support comm. dvlpmt. *	4	3	2	1
OBJECTIVE 5				
a. Reduction Air pollution (tons/yr.)	1,830	1,880	2,160	2,260
b. Noise level*	4	3	2	1
c. Visual intrusion	Same	Same	Same	Same
d. Vistas	Same	Same	Same	Same
e. Historic sites	Same	Same	Same	Same
OBJECTIVE 6				
a. Reduce accident exposure*	4	3	2	1
b. Security	Same	Same	Same	Same
OBJECTIVE 7				
a. Total annual cost** ($ million)	95.4	96.6	98.3	102.3
b. Cost per trip *** ($)	1.453	1.452	1.425	1.425
c. Benefit-cost ratio	DNA	DNA	DNA	DNA

*For comparative measures, alternatives are ranked in the order of how well they met the objective.
**Based on 7% interest rate.
***Based on escalation rate of 7% and interest rate of 7%.

AR00053370

Measure e. - disruption to future development and use of adjacent properties, would be affected by the alternatives relative to the location of the terminal stations. On the western end, the terminus for the 7-mile segment at Keehi Lagoon requires the acquisition of additional industrial properties to provide adequate facility to accommodate buses interfacing at this location. The 8-mile segment would also use this same station at Keehi Lagoon for interfacing buses in order to reduce the number of buses at the Airport terminus. The acquisition of additional industrial properties for terminal facilities does not significantly inhibit future development of the area but with the terminal at Halawa, these private properties would not be required. The most significant impact would occur at the eastern terminus at the University for the 7-, 8-, and 12-mile segments. The station is located near the southern boundary of the University of Hawaii campus property. The entire area is currently used for automobile parking but is master planned for an athletic field which is currently being implemented. The station structure and the guideway structure can be reasonably accommodated without seriously constraining the planned development. However, any expansion of the station site for bus facilities would seriously impact the development potential of the site. Consequently, only express buses would interface at this terminal station with local buses routed to the next station at Date Street. This requires a longer transit time for certain bus routes and also significantly impacts this particular station area.

Measure f. - disruption to local circulation is affected only by the location of the terminal station since the guideway is all grade-separated. The shorter length alternatives require the various local and express bus routes to interface in areas of greater congestion. Therefore, the longer systems are better able to meet this criteria than the shorter systems.

Measure g. - disruption by construction activities is less with the shorter system but again, when the system is extended, the disruption could be greater at a later date than if done all at one time. Therefore, the alternatives are rated as being equal for this measure.

Measure h. - savings in energy is best met by the 14-mile length, second best by the 8- and 12-mile length and lastly by the 7-mile length.

Measure i. - technical risk would naturally be the same for all alternatives.

AR00053371

4. Objective 4. Land Use Policies

In terms of the regional development policy, it is difficult to differentiate between alternative lengths since it is the basic system type and area served that influences this measure over a long-run basis. However, the support of local community development policies is more sensitive to short term influence. The area most affected is the Kaimuki area which will be directly served by the 14-mile fixed guideway length but not by the shorter lengths.

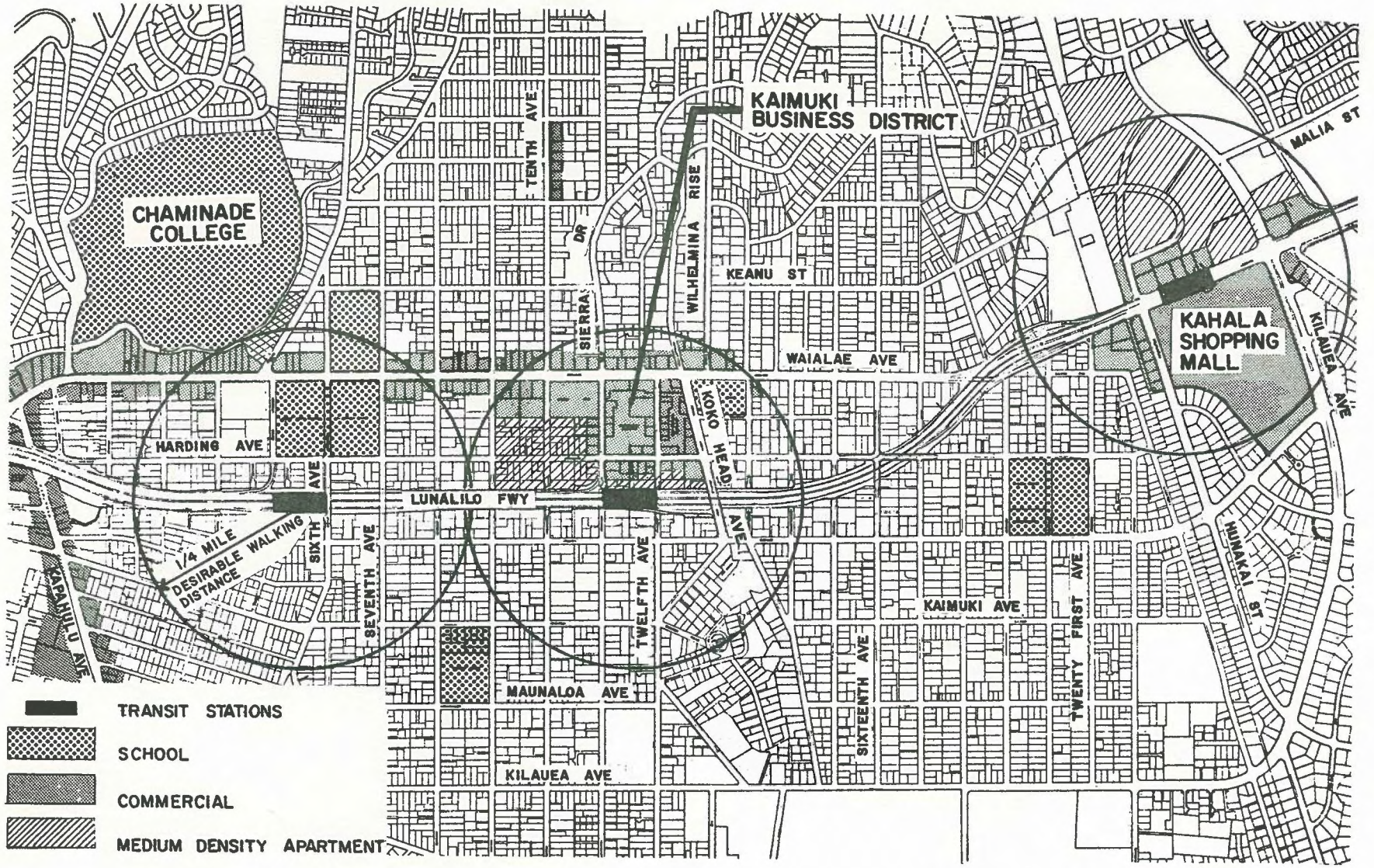
The land use and various activity centers affected are shown in Figure VII-2. The activities most influenced by transportation facilities are high density residential, commercial, and institutional centers. At both the Koko Head and Kahala Stations zoning permits medium density apartment development. This type of use would be reinforced by the transit stations. The 6th Avenue Station provides direct service within walking distance to a private college and high school. Relative to commercial centers, Kahala Mall is a regional shopping center which will be favorably impacted by the station. Perhaps of greater importance is the smaller Kaimuki business district which would be served by the Koko Head Station. This business district has been adversely affected by the Kahala Mall Shopping Center but it serves a vital role in providing community and neighborhood shopping opportunities to the local residents. A station located at Koko Head could aid in re-vitalizing this district which may not be realized by a shorter system.

Located on the western end of the alternative system lengths are two of the major activity centers on Oahu, namely the Honolulu International Airport and the Aloha Stadium. Providing direct service to these activity centers with the fixed guideway would be a definite support to these developments. With the short 7-mile system length neither the airport nor the stadium will be provided with direct service by the fixed guideway. The airport would be served directly with the 8-, 12-, and 14-mile system lengths and both the airport and the stadium will be directly served with the longer 12- and 14-mile systems.

5. Objective 5. Preserve Environment

Reduction in air pollution and noise level would be improved with the longer length system by replacing the more polluting and noiser buses and automobiles with the fixed guideway system. However, visual intrusion and disruption of vistas would hardly be affected by the longer length systems due to the type of areas traversed and the route location in existing freeway rights-of-way. Historic sites are not affected by the length of the system.

AR00053372



LAND USE AND ACTIVITY CENTERS IN THE KAIMUKI COMMUNITY

FIGURE VII-2

AR00053373

6. Objective 6. Safety and Security

Greater reduction in accident exposure would be realized with a longer system since exclusive grade separated routes provide safer transportation service than those in mixed traffic. Security with the system should not be affected by the length of the system.

7. Objective 7. Provide the Most Economical System

This objective has three separate measures with a. total annual cost and b. cost per trip discussed in detail in the following section. The last measure, c. cost benefit ratio, is not applicable to this analysis because of the relatively short time duration that exists between alternative lengths.

AR00053374

E. ANALYSIS OF QUANTITATIVE MEASURES

In addition to various service, community, and environmental measures, economic and financial considerations are equally important in the decision-making process. Since economic and financial considerations involve more than the mere cost of constructing the project, various cost measures relevant to transportation facilities are included. In conducting the comparative cost analysis, 1985 was selected as the near-term study year which reflects a reasonable time period to design and construct the system and provide at least a few years of system operation. The study also assumes that there are no financial constraints in implementing up to a 14-mile system.

The various cost measures to be considered include total annual project cost, total annual operating and maintenance cost, cost per trip, and cost per passenger mile. The various annual cost measures provide a means of comparing the financial implications of the proposed project in terms of capital repayment and the on-going operating and maintenance cost. The cost per trip combines the annual cost and system attractiveness, expressed in terms of patronage volume, into a single measure. The cost per passenger mile measure compares the annual cost to system efficiency, in terms of both passenger volume and trip distance. For all of the above cost measures, capital costs are annualized and then combined with annual operating and maintenance cost to obtain total annual cost.

1. Annual Cost Analysis

a. Capital Cost: Capital cost for each alternative length was estimated including the transit car and feeder bus requirements to meet the projected patronage volumes on a five year basis. The capital cost was annualized over a 30 year repayment period which represents a reasonable average life of the fixed facilities and transit cars without major replacement costs. Bus costs were annualized at 10 years to reflect the shorter life of bus equipment. All construction costs were escalated at 8% per year, compounded, through the scheduled construction periods. Although the cost of money to federal and local governments range between 5.5% to 7% rate of interest, capital costs were annualized using interest rates of 4%, 7%, and 10% to test the sensitive of the analysis.

b. Operating and Maintenance Cost: The operating plan for each guideway system length and its supporting feeder bus system was developed and the O&M cost estimated based on 1980 and 1995 patronage volumes. The costs for intermediate 5-year points

AR00053375

of 1985 and 1990 were obtained by interpolation.

Since cost estimates were developed using the late 1974 price levels, the O&M costs were updated to reflect the latest wage rate settlement which resulted in $1.00 and $0.75 per hour per year increase for 1975 and 1976 for operating and maintenance personnel and clerical personnel, respectively. The O&M costs developed also reflect the rapid increase in fuel costs (including generation of electric power) experienced over recent years and thus produced a more realistic base for subsequent escalation.

The updated O&M costs were then escalated at 8% per year, compounded, for the years 1977 through 1980. The rate of 8% was used to be consistent with the escalation rate used for the construction cost estimate.

Since virtually all construction on even the longer systems was scheduled for completion by 1980-81, the costs escalated for this period are referred to as "constant 1980 dollars" in this report. Therefore all maintenance costs for ensuing years were based on 1980 price levels as were equipment costs for buses and transit cars purchased between 1980 and 1995. This permitted an evaluation based on a constant dollar value.

c. Summary of Annual Costs: A summary of annual costs is presented in Table VII-2. This table presents the results of system comparisons based on a "constant 1980 dollar" approach for the three interest rates.

As shown in the table, the short 7-mile system produces the lowest total annual costs under the three interest rates until 1990 when the 12-mile system becomes more economical at the lowest 4% interest rate. In 1995, the 12-mile system remains the most economical at the lowest rate while the 8 mile becomes lowest in cost at the 7% rate. At the highest 10% rate, the lowest capital cost 7-mile system still remains the least costly. However, for the annual O&M cost only, the 14-mile system is the lowest at any interest rate from 1980 through 1995. This analysis shows that the shortest system with its lowest capital cost would provide the lowest total annual cost even with its higher O&M cost based on constant 1980 dollars.

AR00053376

TABLE VII-2: ANNUAL COSTS*
($ Million)

	1980			1985			1990			1995		
	4%	7%	10%	4%	7%	10%	4%	7%	10%	4%	7%	10%
7-MILE												
Capital Cost	28.90	38.98	50.24	31.27	41.90	53.76	33.64	44.82	57.28	34.67	46.05	58.72
O&M Cost	41.59	41.59	41.59	53.50	53.50	53.50	65.41	65.41	65.41	77.32	77.32	77.32
Total	70.49	80.57	91.83	84.77	95.40	107.26	99.05	110.23	122.69	111.99	123.37	136.04
8-MILE												
Capital Cost	30.54	41.32	53.36	32.68	43.94	56.51	35.06	46.89	60.09	36.09	48.12	61.55
O&M Cost	41.36	41.36	41.36	52.65	52.65	52.65	63.94	63.94	63.94	75.22	75.22	75.22
Total	71.90	82.68	94.72	85.33	96.59	109.16	99.00	110.83	124.03	111.31	123.34	136.77
12-MILE												
Capital Cost	33.75	45.97	59.63	36.05	48.85	63.16	38.24	51.58	66.50	39.44	53.08	68.34
O&M Cost	38.95	38.95	38.95	49.43	49.43	49.43	59.91	59.91	59.91	70.38	70.38	70.38
Total	72.70	84.92	98.58	85.48	98.28	112.59	98.15	11.49	126.41	109.82	123.46	138.72
14-MILE												
Capital Cost	37.72	51.60	67.12	39.97	54.45	70.63	42.32	57.45	74.33	43.51	58.95	76.17
O&M Cost	(37.98)	(37.98)	(37.98)	(47.87)	(47.87)	(47.87)	(57.76)	(57.76)	(57.76)	(67.64)	(67.64)	(67.64)
Total	75.70	89.58	105.10	87.84	102.32	118.50	100.08	115.21	132.09	111.15	126.59	143.81

*All costs based on constant 1980 dollars

Note: 70.49 indicates lowest total annual cost
(37.98) indicates lowest annual O&M cost

AR00053377

This analysis does not reflect the fact that escalation of capital cost stops when construction is completed while O&M costs continue to rise due to inflation. Neither does this analysis reflect the system attractiveness and the difference in number of passengers accommodated within those total annual cost amounts. In order to determine the effects of these two factors on cost relationship, the cost per trip measure is used.

2. Cost Per Trip and Cost Per Passenger Mile Analyses

a. The comparison of cost per trip between various system lengths combines the system cost and attractiveness factors into a single measure. The cost per trip for each system length is derived by dividing the total annual cost by annual patronage volume. To reflect anticipated increases in O&M costs over time, annual O&M costs based on varying escalation rates were used to the alternative lengths.

Table VII-3 presents the cost per trip for a range of interest and escalation rates for each system length. For the analysis, a common rate for both interest and escalation was used since there is a relationship of high interest rate with high escalation or inflation rate and vice versa. A combination interest and escalation rate of 10% was selected for the upper range and a rate of 4% for the lower range with a 7% rate to represent the median point. These rates should provide the extremes for probable interest and escalation rates for the foreseeable future.

For the year 1980, when patronage volumes and the operating costs are relatively low, the shortest 7-mile system has the lowest cost per trip at any interest and escalation rates. However, by 1985, which is the near-term year selected for the analysis, the 12- and 14-mile lengths have the lowest costs with the 12-mile length slightly lower at the low rate and the 14 mile slightly lower at the high interest and escalation rate. This analysis shows that the two longer lengths, i.e. 12- and 14-mile, would provide lower cost per trip than the shorter 7- and 8-mile length by 1985.

The total passenger miles traveled for each of the system lengths were examined and found that the average trip length did not vary significantly between different system lengths. Accordingly, it was determined that the relationship of the cost per passenger mile between different system lengths would be similar to the relationship of cost per trip. Therefore, the results of the cost per trip analysis would also apply to the cost per passenger mile comparison.

AR00053378

TABLE VII-3

COST PER TRIP

	1980	1985	1990	1995
10% RATE*				
7-Mile	$1.310	$2.113	$2.615	$2.942
8-Mile	1.349	2.106	2.582	2.892
12-Mile	1.386	2.055	2.468	2.740
14-Mile	1.448	2.046	2.419	2.660
7% RATE*				
7-Mile	$1.090	$1.453	$1.680	$1.822
8-Mile	1.118	1.452	1.663	1.795
12-Mile	1.140	1.425	1.600	1.710
14-Mile	1.182	1.425	1.578	1.671
4% RATE*				
7-Mile	$0.892	$1.007	$1.079	$1.118
8-Mile	0.911	1.008	1.071	1.104
12-Mile	0.918	0.990	1.034	1.057
14-Mile	0.944	0.993	1.024	1.037

*Common to both interest and escalation rates

AR00053379

Based on this cost per trip analysis and conclusions reached after examining escalated O&M costs, it is apparent that selection of the near term system should be between the 12- and 14-mile systems. However, because of the closeness of their results, a further analysis was made by testing, for the year 1985, the impact on cost effectiveness with the use of different escalation rates and different interest rates which is discussed in the following section.

b. The previous section established the fact that by 1985, the longer 12- and 14-mile lengths would be the most cost effective based on common escalation and interest rates of 4%, 7% and 10%. A further analysis to test the most cost effective length in 1985 was conducted by applying four different escalation rates of 0%, 4%, 7%, and 10%, using constant 1980 dollar cost estimates as the base, to the O&M cost and applying the three different interest rates of 4%, 7%, and 10% to annualize the capital costs.

The results of this analysis is shown in Table VII-4. For the 0% and 4% escalation rates applied to the O&M costs, the 12-mile length had the lowest cost per trip for the 4% interest rate applied to the capital cost and the 7-mile length was the lowest for interest rates of 7% and 10%.

For the escalation rate of 7%, the 14-mile length was the lowest at 4% interest rate, the 12- and 14-mile lengths were the lowest at 7% interest rate and the 12-mile length was the lowest at the 10% interest rate.

TABLE VII-4: COST PER TRIP AT VARYING ESCALATION AND INTEREST RATES - 1985 VOL.

	1980 $			e = 4%			e = 7%			e = 10%		
	i=4%	i=7%	i=10%	i=4%	i=7%	i=10%	i=4%	i=7%	i=10%	i=4%	i=7%	i=10%
7-Mile Cost/Trip($)	0.898	1.011	1.137	1.007	1.112	1.245	1.341	1.453	1.579	1.875	1.988	2.113
8-Mile Cost/Trip($)	0.903	1.022	1.155	1.008	1.113	1.260	1.333	1.452	1.585	1.853	1.972	2.106
12-Mile Cost/Trip($)	0.894	1.028	1.177	0.990	1.125	1.274	1.291	1.425	1.574	1.772	1.906	2.055
14-Mile Cost/Trip($)	0.902	1.051	1.217	0.993	1.143	1.308	1.277	1.425	1.592	1.731	1.870	2.046

AR00053380

At the highest escalation rate of 10%, the 14-mile length had the lowest cost per trip for all three interest rates.

Based on the assumption that the most probable escalation rate as well as the interest rate would be in the neighborhood of 7%, the 12- and 14-mile lengths would be the most cost effective of the four alternative lengths. As stated previously, there is a relationship between inflation and interest rate which decreases the probability of low escalation rate and high interest rate occurring simultaneously. Under this context, the implementation of a longer length would provide the most cost-effective system.

AR00053381

F. COMPARATIVE EVALUATION

In a major rapid transit program, several levels of government are involved in the funding of the program and therefore, various economic and financial analyses are required to determine the implications of the program as they affect each party. The recommendation for the long-term investment, as presented in the previous chapter, was for a 23-mile fixed guideway system. A near-term investment decision on how much of the recommended system should be built as the initial segment requires a careful comparison of economic and financial aspects of the program.

Since the recommended system is proposed to serve a single transit corridor with a common route, the various alternative segment lengths are incremental extensions of the shortest 7-mile length to the ultimate 23-mile length. The areas served and the travel characteristics are such that variations in the fixed guideway length do not significantly alter the service quality and attractiveness of the system. Any differences in impact on the community and the environment would also be indistinguishable since the alternatives would traverse the area in the same location and configuration.

As should be expected, given this degree of similarity in service and impacts, the differences between alternative lengths are quite small. However, a careful examination of the alternatives as to how well they met the objectives would indicate a definite superiority of the longer 12 and 14 mile lengths over the shorter 7 and 8 mile lengths. In comparing the alternatives for the various qualitative measures, there is a consistent pattern of the longer lengths being better able to meet the selected measures. Similarly, with the cost measures, the longer systems again show their superiority in providing higher overall cost effectiveness in terms of the cost per trip measure. Therefore, it can be concluded that the longer 12- and 14-mile lengths would provide greater overall benefits than the shorter 7 and 8 mile lengths.

In the choice between the 12 and 14 mile lengths, the critical issue is whether the immediate investment for the 14-mile system would be economically justified or if deferring the additional 2 mile segment until after 1985 by initially building only the 12-mile segment is the better economic solution. An economic comparison of these investment alternatives was made based on the following assumptions:

- The 14-mile segment is necessary and would be implemented by 1985 in either case.

- The deferring of the additional 2 mile segment would not cost more to construct at a later date.

AR00053382

- Present worth calculations are based on a 4% discount rate and constant 1974 dollars which does not reflect future increases in costs and benefits due to inflation.

- Either alternative could be completed prior to 1982 to permit the analysis based on 3 full years of operation (1983, 1984, and 1985).

The result of this analysis is shown below in Table VII-5.

TABLE VII-5

COMPARISON OF IMMEDIATE AND DEFERRED INVESTMENT FOR 14-MILE SYSTEM

($ Million)

	12-Mile Initial Construction	14-Mile Initial Construction
CAPITAL INVESTMENT		
Fixed Guideway	382.21	432.05
Feeder Buses	25.73	23.23
Total Initial Capital Investment	407.94	455.28
DEFERRED INVESTMENT		
Present Worth of $47.34 Difference (3 yrs. @ 4%)	41.32	-
O&M COST		
Present Worth of O&M Cost (3 yrs. @ 4%)	73.43	71.62
Total Present Worth	522.69	526.90
Difference		+ 4.21
TRAVEL BENEFITS		
Present Worth (3 yrs @ 4%)	163.49	168.61
Difference		+ 5.12

A net capital and operating cost savings of $4.21 million in present worth is realized by the immediate construction of the 12-mile system and deferring the 2 mile segment until 1985 when compared to the immediate construction of the 14 mile system. However, during the 3 year period of operation, present worth benefits in the amount of $168.61 million would have accrued with the 14 mile system as compared to $163.49 million for the 12-mile system, or a difference of $5.12 million. Thus the benefits derived from building the 14 mile system immediately would be greater than the higher cost by nearly $1 million based on very conservative assumptions.

AR00053383

Another comparison can be made without the consideration of benefits in the analysis by eliminating the assumption that the deferred segment would not cost more to construct at a future date. Delaying construction of the 2-mile segment would inherently increase costs due to the loss of economies of scale, real appreciation of property value, new developments occurring in future right-of-way lands, new governmental regulation, etc. It is difficult to predict what the combined results of these factors may be but even for a moderate increase of some 3% per year for 3 years, or say 10%, would amount to nearly $5 million. This potential increase would be approximately equal to or greater than the savings realized by deferring the 2 mile segment. If any consideration is given to probable increases in cost due to inflation, there would potentially be even greater savings by the immediate construction of the 14-mile system.

The decision for immediate construction of the 14-mile system would also receive various benefits other than the purely economic one. As previously stated, the longer the fixed guideway system, the higher the quality of service including the superior terminal points. Also, community disruptions are minimized and preservation of the environment enhanced. Perhaps of greatest importance is the relationship of the system to land use and development policies. The additional 2 mile length serving the Kaimuki and Kahala areas would provide positive impact in preserving existing land use activities and supporting future development policies in these areas.

At the local level, the on-going operation and maintenance costs are of prime importance. With the ever increasing labor costs, the greater operating efficiency of the fixed guideway system produces lower overall O&M costs with the longer system. This would be reflected in lower fares and lower subsidy requirements vital to all transit operating properties.

AR00053384

G. CONCLUSION AND RECOMMENDATION

Based on the comparative evaluation presented in the previous section, Table VII-6 summarizes the key points supporting the selection of the initial fixed guideway segment for implementation. The conclusions drawn from the evaluation are as follows:

1. The longer 12- and 14-mile length alternatives, and more specifically the 14-mile length, are superior to the shorter 7- and 8-mile length alternatives based on the following key points of the qualitative measures:

   - The longer length alternatives are generally better able to meet all applicable measures.

   - The longer the length, the more patronage it can attract.

   - The longer length alternatives, especially the 14-mile length, can provide superior terminal station locations.

   - The longer length alternatives can provide direct service to all major activity centers.

   - The 14-mile length alternative can aid in preserving and reinforcing existing and future land use and development policies in the Kaimuki area.

2. The longer length alternatives are more cost effective than the shorter length alternatives based on the cost per trip which combines total annual cost and patronage volume into a single measure. For total annual cost only, the 7-mile system is the lowest, which is as expected, since the capital cost is the least and the O&M cost reflects the lowest volume of patronage of all the alternatives. The 12- and 14-mile lengths have comparable cost per trip which is lower than those for the 7- and 8-mile lengths. Another measure of great local importance is the lower O&M costs of the longer systems since this would have a direct bearing in the fare structure and/or the operating subsidy required.

3. Based on the foregoing, the 14-mile length is concluded to be superior to all other lengths in terms of qualitative measures and about equal to or slightly better than the 12-mile length in terms of cost measures. Finally, the economic comparison between an initial investment for a full 14-mile length and an initial investment for a 12-mile length with the additional 2-mile length deferred until after 1985 indicated that the initial construction of the full 14-mile length was a better public investment.

AR00053385

From the foregoing conclusions, it is recommended that the 14-mile length fixed guideway be implemented as the initial segment of the system. The guideway route and station locations and the type of line haul bus routes to complement the guideway system are shown in Figure VII-3.

On the eastern end of Central Honolulu, the Kalanianaole Highway corridor will be served by an exclusive bus lane in the median of the highway. This project is currently underway as part of a highway improvement program of the State. On the western end, from Halawa to the various outlying areas of Central and Leeward Oahu, the existing H-1 and H-2 Freeways will be used as bus routes with the buses operating in mixed traffic initially and on reserved bus lanes later. To the Windward region, the three routes of the trans-Koolau corridor are the Pali Highway, Likelike Highway and the H-3 Freeway. Each of these routes would be used for express bus service either in mixed traffic or in reserved bus lanes.

The physical and operating characteristics of the recommended system including patronage estimates, capital and operation cost estimates, program schedule, and other implementation data are all described in detail in the final report of the PEEP II study. In addition, preliminary designs, plans and drawings, and design criteria and general specification documents have been developed as the final step preparatory to program implementation.

AR00053386

TABLE VII-6: SUMMARIZED COMPARISON MATRIX

	ALTERNATIVE LENGTHS				REMARKS
	7-Mile	8-Mile	12-Mile	14-Mile	
A. QUALITATIVE MEASURES					
1. Ranking based on all measures	4	3	2	1	• Longer systems are better able to meet objectives
2. Patronage (million/yr)*	94.5	94.6	95.5	97.4	• Longer systems can attract more transit riders
3. Terminal station location					
- Western terminus	Poor	Poor	Good	Good	• The 12- and 14-mile lengths have good terminal location at Halawa
- Eastern terminus	Poor	Poor	Poor	Good	• Only the 14-mile length has a good terminal location at Kahala
4. Support major-activity centers					
- Airport	No	Yes	Yes	Yes	Only the 12- and 14-mile lengths serve all major activity centers
- Pearl Harbor-Hickam	No	No	Yes	Yes	
- Aloha Stadium	No	No	Yes	Yes	
5. Support existing & future developments in Kaimuki area					
- High school and college	No	No	No	Yes	Only the 14-mile system would serve all of these varied land use activities
- Shopping centers	No	No	No	Yes	
- Medium & High density residential	No	No	No	Yes	
B. QUANTITATIVE MEASURES					
1. Total annual cost ($ million)	95.4	96.6	98.3	102.3	• The 7-mile system has the lowest capital cost & patronage volume, hence the lowest total annual cost
2. Cost per trip ($)	1.453	1.452	1.425	1.425	• The 12- & 14-mile lengths have the lowest cost per trip which is the key measure of cost effectiveness
3. Annual O&M cost ($ million)	53.5	52.7	49.4	47.9	• The 14-mile length has the lowest annual operating cost
4. O&M cost per trip ($)	0.567	0.557	0.517	0.492	• The 14-mile length has the lowest operating cost per trip
C. INVESTMENT ANALYSIS					
1. Present worth cost ($ Million)	-	-	522.7	526.9	The 14-mile length would have a better economic return on investment by costing $4.2 million more in present worth but returning $5.1 million more in benefits than the 12-mile length with the additional 2-mile segment deferred until after 1985
2. Present worth benefits ($ Million)	-	-	163.5	168.6	

*Does not include special tourist trips.

AR00053387

14-Mile Fixed Guideway System

RAPID TRANSIT STATIONS

1. Halawa
2. Pearl Harbor
3. Airport
4. Keehi Lagoon
5. Kalihi
6. Iwilei
7. C.B.D.
8. Civic Center
9. Ward Avenue
10. Ala Moana
11. Waikiki
12. Date Street
13. University
14. 6th. Avenue
15. Koko Head Avenue
16. Kahala

1 Stations
Aerial
At-Grade
Underground
Express Buses in Exclusive Bus Lane
Express Buses in Reserved Bus Lanes or Mixed Traffic

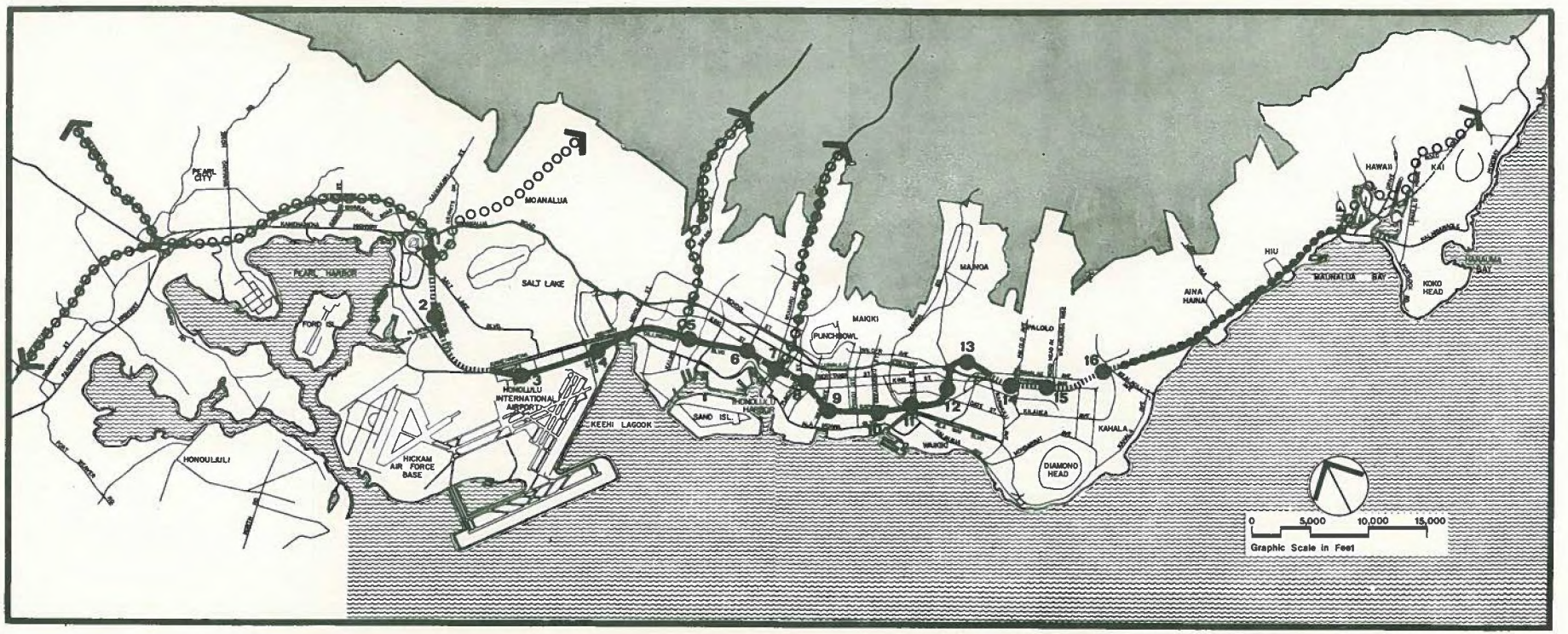


FIGURE VII-3

AR00053388

REFERENCES

REFERENCES

1. "Goals and Objectives," Honolulu Rapid Transit Project, October 1971, Daniel, Mann, Johnson, & Mendenhall

2. "Oahu General Plan," 1964, City & County of Honolulu

3. "Oahu Transportation Study," Volumes,I, II, and II, 1967, State of Hawaii and City & County of Honolulu

4. "Issues, Goals & Objectives for the Seventies and Beyond," City & County of Honolulu

5. "Proposed Objectives and Policies for the Revised General Plan," March 1974, Department of General Planning, City & County of Honolulu

6. "Population Summary for Hawaii, 1972," Statistical Report 87, January 7, 1972, Department of Planning & Economic Development, State of Hawaii

7. "State of Hawaii Growth Policies Plan: 1974-1984," General Plan Revision Program, 1974, Department of Planning & Economic Development, State of Hawaii

8. Report CTC-28, Hawaii Census Tract Committee, February 28, 1975, State of Hawaii

9. State Department of Planning & Economic Development Memo, Subject: State Economic Model Inputs, November 22, 1971

10. "Data Book, 1974" The State of Hawaii, Department of Planning & Economic Development

11. From Tables Obtained From the State Land Use Commission and Dated April 11, 1974

12. "Land Use Alternatives, Technical Report: No. 3," March 1974, Department of General Planning, City & County of Honolulu

13. OTS Land Use Model Printout dated January 7, 1972

14. "Patronage and Revenue Estimates," Honolulu Rapid Transit Project, PEEP II, November 1974, Alan M. Voorhees and Associates, Inc.

AR00053390

15. "TOPICS STUDY: Defining the Federal-Aid Primary Type II System and the Areawide TOPICS Plan for Honolulu," February 1971, Traffic Department, City & County of Honolulu

16. "Highway Functional Classification and Needs Study, State of Hawaii, 1970-1990," December 1971, Department of Transportation, State of Hawaii, Belt, Collings/Wilbur Smith & Associates

17. "Bus Rapid Transit Options for Densely Developed Areas," U. S. Department of Transportation, February 1975, Wilbur Smith & Associates, et al.

18. "Transportation Analysis, Technical Report No. 4," March 1974, Department of General Planning, City & County of Honolulu

19. "Highway Capacity Manual," 1965 Special Report 87, Highway Research Board

20. "Benefit-Cost Analysis" Technical Memorandum, Honolulu Rapid Transit Project, PEEP II, March 1975, Environment Capital Managers, Inc.

21. "Lunalilo Freeway (Interstate Route H-1) Traffic Surveillance and Control Study, Phase II," Draft Interim Report, September 1975, State Department of Transportation, Austin, Smith/Howard, Needles Consultants

22. "Leeward Oahu Bicycle Transportation Plan, Principle Routes," 1973 Oahu Transportation Planning Program

23. "Central Honolulu Bicycle Plan," 1974 Department of Transportation Services, City & County of Honolulu

24. "Short-Range Bus Plan for Oahu (1975-1980 Inclusive)" Interim Technical Report, February 1975, City & County of Honolulu

25. "Long Range Regional Transit Plan," Interim Report, Honolulu Rapid Transit Project, March 1972, Daniel, Mann, Johnson, & Mendenhall

26. "Route Planning Study," Honolulu Rapid Transit Project, Volumes 1, 2, & 3, March 1972, Daniel, Mann, Johnson, & Mendenhall

27. Alternative Route Evaluations conducted in PEEP II are contained in the following reports:

    a. "Feasibility Study of the H-1 Freeway Route for Fixed Guideway System," Honolulu Rapid Transit Project, PEEP II, March 1974, Daniel, Mann, Johnson, & Mendenhall

AR00053391

b. "Study of Alternative Alignments in the Dillingham Boulevard Corridor," Honolulu Rapid Transit Project, PEEP II, April 1974, Daniel, Mann, Johnson, & Mendenhall

c. "Study of Alternative Routes in the Moiliili/University Area," Honolulu Rapid Transit Project, PEEP II, May 1974, Daniel, Mann, Johnson, & Mendenhall

28. "Honolulu Rapid Transit System," Preliminary Engineering Evaluation Program, Final Report, December 1972, Daniel, Mann, Johnson, & Mendenhall

29. "Draft Environmental Impact Statement," Volumes I, II & III, September 1972, Daniel, Mann, Johnson, & Mendenhall

30. "Evaluation of Transit Concepts and Vehicles," Honolulu Rapid Transit Project, Interim Report, December 1971, Applied Technology Laboratory

31. "Evaluation of Alternative Transportation Systems for the Pearl City - Hawaii Kai Corridor," March 1973, Alan M. Voorhees & Associates, Inc.

32. "Alternative Transit Concepts Analysis," Draft Technical Report, Honolulu Rapid Transit Project, PEEP II, July 1975, Daniel, Mann, Johnson, & Mendenhall

33. "A Study of Rubber-Tired Transit Technology," Technical Report, Honolulu Rapid Transit Project, PEEP II, December 1974, Applied Technology Laboratory

AR00053392

APPENDIX A

DESCRIPTION AND ANALYSIS OF ALTERNATIVE SYSTEMS

TABLE OF CONTENTS

		PAGE
A.	ALTERNATIVES SELECTED FOR DETAILED STUDY	A-1
B.	THE BUSWAY TRANSIT CONCEPT	A-2
C.	THE LIGHT RAIL TRANSIT CONCEPT	A-9
D.	THE FIXED GUIDEWAY TRANSIT CONCEPT	A-18

TABLES

A-1	COMPARISON OF BUSWAY OPERATING CONCEPTS	A-3
A-2	OPERATIONAL PARAMETERS - BUSWAY	A-4
A-3	1995 PATRONAGE PROJECTIONS - BUSWAY SYSTEM	A-6
A-4	SELECTED TRIP CHARACTERISTICS - 1995 BUSWAY SYSTEM	A-6
A-5	SELECTED OPERATING STATISTICS - 1995 BUSWAY SYSTEM	A-7
A-6	ESTIMATED COSTS - 1995 BUSWAY SYSTEM	A-8
A-7	VEHICLE AND SYSTEM CHARACTERISTICS, LRT ALTERNATIVES	A-11
A-8	1995 PATRONAGE PROJECTIONS - LRT ALTERNATIVES	A-14
A-9	SELECTED TRIP CHARACTERISTICS - 1995, LRT ALTERNATIVES	A-15
A-10	SELECTED OPERATING STATISTICS - 1995 LRT ALTERNATIVES	A-16
A-11	ESTIMATED COSTS - 1995 LRT ALTERNATIVES	A-17
A-12	VEHICLE AND SYSTEM CHARACTERISTICS - FIXED GUIDEWAY ALTERNATIVES	A-20
A-13	1995 PATRONAGE PROJECTIONS - FIXED GUIDEWAY ALTERNATIVES	A-22
A-14	SELECTED TRIP CHARACTERISTICS - 1995 FIXED GUIDEWAY ALTERNATIVES	A-23
A-15	SELECTED OPERATING STATISTICS - 1995 FIXED GUIDEWAY ALTERNATIVES	A-23
A-16	ESTIMATED COSTS - 1995 FIXED GUIDEWAY ALTERNATIVES	A-25

REFERENCES A-26

A. ALTERNATIVES SELECTED FOR DETAILED STUDY

The main body of this report has described the range of alternative transit modes and concepts considered for detailed study. After the initial screening, three basic concepts were selected for detailed analysis:

- A Minimum Length (7-Mile) Busway
- A Light Rail Transit (LRT) System
- A Fixed Guideway System

These alternatives were then developed for analysis and subsequent evaluation including consideration of optimum system length. Each alternative included an appropriate feeder and express bus system to produce complete comprehensive transit coverage and service. These systems are briefly described in this appendix and summary results of the system analysis presented.

AR00053395

B. THE BUSWAY TRANSIT CONCEPT

In PEEP I evaluations[1/], it had been determined that a long busway comparable to the 23 mile fixed guideway concept produced both operational problems and high cost. However, the service flexibility of the basic concept and the potential for high speed and reasonable schedule reliability through the densest urban area indicated that a reduced length system may provide competitive service and cost factors. Therefore, a 7-mile busway extending from Middle Street through Central Honolulu to the University of Hawaii was selected.

At the eastern and western ends of the Busway, express service extension has been projected on existing highways using combinations of mixed traffic and reserved bus lanes. Similarly, service to Windward has been included on existing and committed highways. To provide intermediate access to the busway segment, 10 busway stations were selected where transfer to local and feeder buses could be made. In addition, direct bus access was programmed at intermediate points at Kalihi and Waikiki stations. (See Figure VI-1 in Chapter VI of this report.)

1. Busway Configuration and Operating Concept

Because of the high-volume patronage through the busway segment and resulting high volume vehicle requirements, any decision on busway configuration is directly related to and impacts operating concepts and vice versa. Therefore, it was necessary to carefully examine these features together.

Essentially, this examination considered platooned and random vehicle sequencing on a single-file busway (2-lane) and flexible operations on a busway with by-pass capabilities. Each concept was examined for headway requirement (capacity determinant), time factors, schedule reliability, system reliability, express and local operational ability, and miscellaneous through-operation capability. On the basis of this evaluation, it was concluded that the operational constraints, problems, and potential delays of the single-file concept were such that the added capital cost of the flexible concept was warranted. Table A-1 presents a summary of the evaluations.

2. System Operating Characteristics

In order to provide an acceptable balance between service flexibility and no-transfer travel, an operating plan was developed which offered both local (all station) and express (limited stop) operations on the

AR00053396

TABLE A-1: COMPARISON OF BUSWAY OPERATING CONCEPTS

	Single File Concept		Flexible Concept
	Platoon	Random	
Theoretical Line Capacity (50 passengers per bus)	13,300 passengers/hour	25,000 passengers/hour Constrained at station	25,000 passengers/hour Unconstrained at station
Time Required to Start Busway Operations	Poor - buses arriving at busway must wait for its designated platoon - buses entering platoon must maneuver into designated place or slot	Good - buses arriving at busway can enter freely	Good - buses arriving at busway ca enter freely
Time Required to Operate Through Stations	Fair - free to dock at designated space - must wait for front buses to leave	Poor - must wait if designated space is ahead of docked bus - must wait for front buses to leave	Good - free to dock at designated space - free to leave station unconstrained
Overall Schedule Reliability	Poor - must wait for right platoon, must maneuver into proper slot, must wait for entire platoon to move through station	Fair - unconstrained at guideway entrance but constrained at station	Good - unconstrained at guideway entrance and at station
System Reliability	Fair - buses required to by-pass disabled buses on opposite lane when clear - easier and safer with platoons	Poor - buses required to by-pass disabled buses on opposite lane when clear - difficult with random method	Good - all buses free to by-pass disabled bus at any time but at reduced speed
Express Operation	Fair - possible use of reverse lane for by-passing outlying stations by use of radio communication to control passing operation - must operate two types of platoons, local and express	Poor - possible use of reverse lane for by-passing outlying stations but difficult for safe operation due to large number of individual buses to control	Good - all stations provided with by-pass lanes
Miscellaneous Through Operations	Poor - dead-heading buses and removal of disabled buses constrained	Poor - dead-heading buses and removal of disabled buses constrained	Good - dead-heading buses and removal of disabled buses not constrained

AR00053397

busway.

Express operations were oriented to the longer trips with buses entering the busway at the ends (Keehi Lagoon and University Stations) and at the Kalihi Station. These buses would operate in a through-express mode with intermediate stops only at the Waikiki and CBD Stations, the largest destination stations on the busway. Local feeder buses would enter the busway at Keehi Lagoon and Waikiki Stations, stopping at all intermediate stations to provide local service. In addition, a number of "captive" buses would operate only on the busway, stopping at all stations.

This overall operational plan provided the maximum opportunity to capitalize on the higher speed capability and minimum transfer requirement of the busway concept and still offer a high level of access to non-CBD destinations. Operational features of the vehicles and busway are shown in Table A-2.

TABLE A-2

OPERATIONAL PARAMETERS - BUSWAY SYSTEM

Acceleration: 0-30 mph - 15 sec.; 30-50 mph-31 sec.
Operating Speed: 50 mph max.; 30 mph through stations (express)
Avg. Busway Speed: Express - 31 mph; local (all stations) - 23 mph
Vehicle Capacity*/: Seated - 53; Design Load - 61; Crush - 93
Avg. Dwell Time: 30 seconds

*/ Design load and crush load based on equal space per passenger for all vehicle systems to provide equivalent and uniform service standards for system comparison

3. Station Requirements

In the busway concept, station requirements are a function of the frequency (in terms of buses stopping at that station per hour) and dwell time which in turn is a function of docking time and boarding/alighting volume. These variables produce the minimum number of docking positions required for normal operations.

In addition provisions for abnormal conditions (vehicle breakdown, schedule delays, etc.) and future expansion must be included to maintain scheduling flexibility and preclude early obsolesence. To accommodate these factors, a "safety factor" of 2 was applied to the minimum number of bays required at each station and a 33%

AR00053398

expansion provision made to assure capacity beyond 1995. Sizing of all busway stations was based on the projected 1995 boarding and alighting forecast at each station from the mode split procedure.

4. Busway Requirements

To permit express operation, by-pass provisions must be incorporated at stations. In addition, acceleration-deceleration lanes at each end of the station will be necessary for safe operation and also to permit queuing of local buses if a delay occurs. For most of the busway lengths, the combination of acceleration-deceleration lane requirements, high busway volume and approximately 1/2 mile station spacing produce a requirement for a four-lane busway. This section extends between Waikiki and Kalihi Stations. For the balance of the busway, two-lane segments are provided between acceleration-deceleration lane merge points to reduce cost. However, sufficient shoulder width is provided to permit passing a stalled bus at reduced speed.

A radio communication system is also provided between stations, bus operator and central control to aid in traffic control on the busway. Added facility requirements for the Busway concept include provision of storage and maintenance facilities for an added 500 buses by 1995.

5. Concept Analysis

Analysis of the Busway alternative included system patronage and subsequent definition of vehicle requirements, vehicle miles, costs, benefits and other pertinent statistical data. These service and cost measures of the concept are combined with a qualitative analysis dealing with the comparative evaluation of alternatives.

a. Patronage Projections: A total of 456,250 daily passengers was forecasted for the busway system and its associated feeder systems during 1995. A summary of the patronage analysis is presented in Table A-3 showing distribution of trips between peak/daily, work/non-work, mode split, etc. Selected trip characteristics are presented in Table A-4.

b. Operational Analysis: After patronage demands were known, a detailed operating plan was prepared to match service and demand. This operational plan was the basis for estimating system requirements and performance. The various statistical measures such as bus miles, vehicle requirements etc. thus determined were

AR00053399

TABLE A-3
1995 PATRONAGE PROJECTIONS - BUSWAY SYSTEM

ANALYSIS CATEGORY	TOTAL DAILY	% TOTAL	P.M. PEAK HOUR	% TOTAL
1. TRANSIT PERSON TRIPS	456,250	100.0	78,790	100.0
WORK	206,640	45.3	46,050	58.4
NON-WORK	249,610	54.7	32,740	41.6
2. TRANSIT PERSON TRIPS AS:				
% TOTAL TRIPS	13.8	-	21.4	-
% TOTAL WORK TRIPS	30.7	-	42.4	-
% TOTAL NON-WORK TRIPS	9.5	-	12.6	-
3. TRANSIT TRIPS BY MODE*				
BUSWAY	288,200	-	56,270	-
BUS	554,898	-	97,780	-
4. TRANSIT USE BY AREA				
URBAN HONOLULU	329,540	72.2	56,910	72.2
WINDWARD	64,140	14.1	11,080	14.1
CENTRAL	15,410	3.4	2,660	3.4
LEEWARD	47,160	10.3	8,140	10.3

*INCLUDES INTRA-MODAL TRANSFERS

TABLE A-4
SELECTED TRIP CHARACTERISTICS - 1995
BUSWAY SYSTEM

	DAILY		PEAK HOUR	
CHARACTERISTIC	TOTAL SYSTEM	BUSWAY	TOTAL SYSTEM	BUSWAY
PASSENGER MILES	3,131,331	754,301	576,220	135,446
PASSENGER HOURS	142,361	31,467	25,785	5,911
AVERAGE TRIP TIME (MIN.)	-	-	36.3	-
AVERAGE TRIP LENGTH (MI.)	6.86	2.62	7.31	2.41
AVERAGE TRIP SPEED (MPH)	-	-	12.1	-

AR00053400

subsequently used to establish operating costs and appropriate capital costs. They are used in the main body of this report in comparative evaluation of alternatives. Selected operating characteristics are presented in Table A-5.

TABLE A-5: SELECTED OPERATING STATISTICS - 1995
BUSWAY SYSTEM

Statistic	Total System	Busway		Feeder Bus	
		Local	Express	Local	Express
Vehicle Hours (Daily)	7,838	729	616	3,594	2,899
Vehicle Miles (Daily)	151,716	14,651	15,657	43,126	78,282
Vehicles in Peak Hour					
Service	847	81	82	291	393
Spares	84	8	8	29	39
Passengers/Vehicle Mile	3.01	-	-	-	-

c. Capital and Operating Cost: Cost estimating for both capital and operating cost was based on Honolulu unit price levels prevalent in late 1974. Included in the capital cost are vehicle requirements for the total transit system including feeder and local service. In addition to all busway costs including right-of-way, the reversible, at-grade exclusive lane in Kalanianaole Highway from Kahala to Hawaii Kai is also reflected as part of the feeder-bus system. Operating costs include all labor and material necessary to maintain and operate the 1995 system including all facilities. Table A-6 presents a summary of capital and operating costs for the 1995 system.

AR00053401

TABLE A-6

ESTIMATED COSTS - 1995 BUSWAY SYSTEM
($ THOUSANDS)

Total Capital Costs

Item	Cost
1. Busway Facilities	
Way Structures	$ 95,850
Stations	88,862
Communications	1,000
Yards & Shops	5,000
Subtotal	$187,712
Contingency (10%)	18,771
Admin & Engrg (13%)	26,843
Total	$233,326
2. ROW & Relocation	$ 83,380
Contingency (10%)	8,338
Admin. (3%)	2,752
Total	$ 94,470
3. Feeder Bus System	
Kalanianaole Hwy	$ 26,100
Buses	60,515
Total	$ 86,615
4. Grand Total	$414,411

Annual Operating Costs

Item	Cost
1. Busway Facilities	
Way Structures	$ 986
Station Oper.	846
G&A	78
Station Power	490
Subtotal	$ 2,400
Contingency (10%)	240
Total	$ 2,640
2. Transportation	$40,073
3. Grand Total	$42,713

AR00053402

C. THE LIGHT RAIL TRANSIT CONCEPT

Light Rail Transit (LRT) is in reality a modern version of the PCC rail transit vehicle and is receiving serious consideration for application in several cities. Initial applications will be in San Francisco and Boston to replace existing PCC rail cars. Its development was the result of the combined efforts of those cities and UMTA to develop a standard vehicle system with expanded operational flexibility. Overhead power pick-up permits operation in non-exclusive rights-of-way as well as on aerial structure or in subway. Articulation permits short turning radius allowing operation on the surface of city streets. The vehicle may be operated as a single unit or coupled into trains (current designs permit 4-car maximum). Propulsion and control systems are relatively simple state-of-the-art versions of time proven concepts. These features offer extensive application potential and have sparked wide interest in the system.

1. Honolulu Application

In applying the LRT concept to Honolulu, a basic 28 mile system was developed to take full advantage of the inherent operational features. As with all alternatives, the same basic alignment was used for the grade separated segment through the heavily urbanized area of Central Honolulu. In addition, selected feeder bus routes were replaced with LRT. In order to complete comparative testing, variations on the basic system using 7, 14, and 23 mile alignments were also developed. This family of alternatives is briefly described below. (See Figure VI-2 in Chapter VI of this report.)

The basic 28-mile system is comprised of 14 miles of exclusive, grade separated right-of-way, 9 miles of exclusive, non-grade separated right-of-way, and 5 miles of route in city streets with mixed traffic operation. The shorter segment lengths tested are:

- a 23-mile length from Pearl City to Hawaii Kai which eliminates the 5 miles of city street operation of the 28-mile system.

- a 14-mile length from Halawa to Kahala which eliminates the 9 miles of exclusive, non-grade separated right-of-way of the 23-mile system.

- a 7-mile length from Keehi Lagoon to the University which is the minimum length system.

AR00053403

2. System Operating Characteristics

System operation was developed for each alternative LRT system which made maximum use of the inherent features of the concept. In the basic system, selected heavy bus routes were replaced with LRT to the extent operationally feasible within headway and capacity limitations in the primary corridor. As the system was scaled in length, the overall operating characteristics more and more closely paralleled the fixed guideway alternative. In essence, the 14-mile and 7-mile systems are identical in both concepts.

In all LRT alternatives, the compatibility to make in-service consist changes was used to balance system capacity to forecasted passenger demand by dropping or adding cars at appropriate points rather than turning back whole trains. This ability was also used to interject branch line service in the basic LRT alternative. This approach produces constant headways over the entire length of the system.

Table A-7 presents the basic vehicle and system operating parameters used in analyzing the LRT systems.[2/]

3. Guideway Requirements

Guideways for the LRT concept included (depending on sub-alternative): Aerial structure; Subway; At-grade exclusive R.O.W.; At-grade mixed traffic.

Aerial structure was based on the use of precast, prestressed concrete girders supported on single reinforced concrete columns with appropriate noise barriers at the outside edges. Trolley wire support uses a "T" support at the center of the 23' wide guideway. Subway structure was based on a double-box constructed by cut and cover methods. Piston effect of trains traveling through the subway sections was assumed to provide ventilation with emergency exhaust fans installed in vent shafts. Exclusive at-grade segments were based on conventional tie and ballast construction in a minimum 24' foot ROW with traffic barriers at the outer edge. Mixed traffic segments were based on tie and ballast construction with flush concrete paving to allow mixed traffic operations. Trolley wires were assumed supported from curbside poles.

4. Station Requirements

Four basic station types were projected, again depending on sub-alternative: aerial; subway; exclusive at-grade; street at-grade. All grade-

AR00053404

TABLE A-7

VEHICLE AND SYSTEM CHARACTERISTICS
LRT ALTERNATIVES

Vehicle

Dimensions:	71' long; 8'-10" wide; 11'-6" high; 69,000 pounds (empty)
Capacity* :	68 seated; 100 design load; 154 crush load
Training:	Min. train - 1 car; Max. train - 8 cars**
Performance:	Max. Speed - 55 MPH; Acceleration -2.8 MPHPS Braking - 3.5 MPHPS (Service), 6.0 MPHPS (Emergency

System

Avg. Speed:	Pearl City - Halawa:	28.2 mph
	Halawa - Kahala:	22.5 mph
	Kahala - Kuliouou:	26.6 mph
	Mixed Traffic on Street:	12.0 mph
	Avg. Dwell Time:	20 seconds
	Acceleration:	3.0 MPHPS***
	Deceleration:	2.6 MPHPS***
	Max. Train in Mixed Traffic:	2 cars
	Frequency:	Peak: 2 min; Base: 4 min; Night: 4 min.

*Design load and crush load capacities established to provide equal space per passenger on all vehicle concepts

**Assumes present limit of 4-cars/train can be increased to satisfy projected demand

***Acceleration/deceleration rates set equal to fixed guideway concept for equivalent passenger comfort

AR00053405

separated and exclusive right-of-way stations were projected to include fare collection equipment, ticket machines, money changers, etc. at the station concourse. All vertical in-station movements were provided by stairs, escalators and elevators. Platform length and location (center or side) was dictated at each station according to maximum train length to be accommodated and physical features of the station and ROW at specific locations. For in-street stops, curbed passenger islands were contemplated. Nominal illumination was assumed at each passenger island for night operations.

5. Train Control and Communication

The LRT system is based on manual operation with a conventional block signal system with wayside control and cab signals to provide train protection. In addition, radio communication between train, stations and central control was assumed.

6. Concept Analysis

Analysis of the overall LRT concept alternatives included patronage, operational requirements (vehicles, vehicle miles, etc.) costs, benefits and other quantitative statistical indicators. In addition, qualitative analyses were conducted as contained in the main body of this report.

a. Patronage: Mode split analysis was conducted on the basic 28-mile LRT alternative and manual adjustments were made in that output to produce 23-mile system forecasts based on system variations. The 14-mile and 7-mile systems used patronage forecasts from the fixed guideway analysis because the system performance of the two concepts (LRT and fixed guideway) were identical for these two common system lengths.

In the manual adjustment to the 28-mile system, it was concluded that removal of the two surface LRT routes in Hawaii Kai would produce a loss of approximately 2,000 daily riders. However, an offsetting gain was determined for the Waikiki area. The lower patronage with the LRT spur into Waikiki was a result of the replacement of the feeder buses in Waikiki with the LRT which eliminated the direct service between the University and Waikiki areas via the proposed University Avenue bridge across the Ala Wai Canal. Other trip interchanges were determined to be essentially equivalent under each alternative. Therefore from a system standpoint, overall patronage and travel characteristics were

AR00053406

judged generally equal between the 28 and 23 mile systems as tested. Table A-8 presents a summary of the patronage forecasts by LRT alternatives with selected trip characteristics shown in Table A-9.

b. Operational Analysis: Using the projected patronage and specific link and station volumes, other system parameters and operating statistics were determined for use in estimating capital and operating costs. Table A-10 presents selected operating statistics for the various LRT alternatives examined.

c. Capital and Operating Costs: Table A-11 shows the total estimated capital and 1995 operating costs based on late 1974 price levels. LRT and bus vehicle costs reflect the total vehicle requirements for each LRT alternative. Capital costs include all construction, rights-of-way and relocation costs associated with system development. Maintenance and operating costs reflect annual costs for operating the 1995 system expressed in 1974 dollars.

AR00053407

TABLE A-8
1995 PATRONAGE PROJECTIONS - LRT ALTERNATIVES

Analysis Category	28 Mile/23 Mile				14 Mile				7 Mile			
	Total Daily	% Total	PM Peak Hour	% Total	Total Daily	% Total	PM Peak Hour	% Total	Total Daily	% Total	PM Peak Hour	% Total
1. Transit Person Trips	474,520	100.0	82,210	100.0	473,300	100.0	81,860	100.0	459,300	100.0	79,380	100.0
Work	217,710	45.9	48,430	58.9	215,300	45.5	47,910	58.5	208,800	45.5	46,520	58.6
Non-Work	256,810	54.1	33,780	41.1	258,000	54.5	33,950	41.5	250,500	54.5	32,860	41.4
2. Transit Trips As:												
% Total Trips	14.4	-	22.3	-	14.3	-	22.2	-	13.9	-	21.6	-
% Work Trips	32.3	-	44.6	-	32.0	-	44.2	-	31.0	-	42.8	-
% Non-Work Trips	9.8	-	13.0	-	9.8	-	13.1	-	9.5	-	12.7	-
3. Transit Trips On:												
Guideway*	358,750	75.6	65,420	79.6	306,900	64.8	56,000	68.4	277,300	60.4	50,110	63.1
Bus	398,060	-	69,469	-	527,600	-	92,800	-	561,470	-	99,190	-
4. Transit Use by Area												
Urban Honolulu	342,730	72.2	59,380	72.2	341,850	72.2	59,120	72.2	331,740	72.2	57,330	72.2
Windward	66,710	14.1	11,560	14.1	66,530	14.1	11,510	14.1	64,560	14.1	11,160	14.1
Central	16,030	3.4	2,780	3.4	15,990	3.4	2,780	3.4	15,520	3.4	2,700	3.4
Leeward	49,050	10.3	8,490	10.3	48,930	10.3	8,450	10.3	47,480	10.3	8,190	10.3

*Trips using guideway system for all or part of total trip distance. In 23/28 Mile system, statistic is for 28 mile system and reflects trips using branch lines rather than feeder and local buses. Bus passengers include intra-mode transfers.

AR00053408

TABLE A-9
SELECTED TRIP CHARACTERISTICS - 1995
LRT ALTERNATIVES

Statistic	28 Mile/23 Mile				14 Mile				7 Mile			
	Daily		PM Peak Hour		Daily		PM Peak Hour		Daily		PM Peak Hour	
	System	Guideway*	System	Guideway*	System	Guideway	System	Guideway	System	Guideway	System	Guideway
Passenger Miles ($x10^6$)	3.22	1.76	.59	.33	3.23	1.18	.59	.21	3.10	.73	.57	.13
Passenger Hours ($x10^4$)	13.16	6.48	2.40	1.23	13.43	3.86	2.44	.69	13.60	2.53	2.47	.46
Avg. Trip Time (Min.)	-	10.8	32.4	11.2	-	7.5	33.7	7.4	-	5.5	35.2	5.5
Avg. Trip Length (Mi.)	6.79	4.90	7.22	5.09	6.82	3.84	7.26	3.76	6.74	2.63	7.19	2.64
Avg. Speed (MPH)	-	27.2	13.4	27.2	-	30.5	12.9	30.6	-	28.8	12.3	28.7

*Includes branch lines on street but excludes feeder bus portion of linked trips. (28 Mile system shown)

AR00053409

TABLE A-10

SELECTED OPERATING STATISTICS - 1995
LRT ALTERNATIVES

System Alternative	Daily Vehicle Miles	Vehicles In Peak Hour Service	Spares	Passengers Per Vehicle Mile
1. 28-Mile System				
Total System	151,160	776	77	3.14
Guideway	79,515	373	37	4.52
Local Buses	25,920	182	18	-
Express Buses	45,725	221	22	-
2. 23-Mile System				
Total System	151,440	729	73	3.13
Guideway	75,530	295	30	4.68
Local Buses	30,680	216	21	-
Express Buses	45,230	218	22	-
3. 14-Mile System				
Total System	140,100	707	71	3.38
Guideway	45,840	180	18	6.70
Local Buses	31,080	210	21	-
Express Buses	63,180	317	32	-
4. 7-Mile System				
Total System	148,185	803	80	3.10
Guideway	23,580	99	10	11.76
Local Buses	45,645	308	31	-
Express Buses	78,960	396	39	-

AR00053410

TABLE A-11

ESTIMATED COSTS - 1995 LRT ALTERNATIVES
($ THOUSANDS)

TOTAL CAPITAL COSTS	28-Mile	23-Mile	14-Mile	7-Mile
LRT Facilities and Equipment				
Way & Structure	146,457	138,267	109,492	83,243
Stations	85,429	85,429	74,443	53,804
Power & Control	49,618	46,080	35,687	21,454
Yards & Shops	13,194	13,194	11,716	10,925
Subtotal	295,198	282,970	231,338	169,426
10% Contingency	29,520	28,297	23,134	16,943
13% Admin & Engrg	42,212	40,465	33,081	24,228
TOTAL	366,950	351,732	287,553	210,597
ROW and Relocation	59,980	59,980	51,020	47,410
10% Contingency	5,998	5,998	5,102	4,741
3% Admin	1,967	1,967	1,684	1,575
	67,945	67,945	57,806	53,716
Transit Vehicles	215,250	169,575	103,950	57,225
10% Contingency	21,525	16,958	10,395	5,723
5% Admin & Engrg	11,839	9,327	5,717	3,147
	248,614	195,860	120,062	66,095
Buses	28,800	31,000	37,700	50,300
	712,289	646,537	503,121	380,708
Kalanianaole Highway Busway	-	-	26,100	26,100
GRAND TOTAL	712,289	646,537	529,321	406,808

ANNUAL OPERATING COSTS				
Way & Structure	2,863	2,493	1,788	1,362
Vehicle	3,005	2,416	1,547	967
Transportation	4,381	3,647	2,690	2,021
G&A	4,193	3,793	2,873	2,400
	14,442	12,349	8,898	6,750
Power	5,640	5,390	3,400	1,900
	20,082	17,739	12,298	8,650
10% Contingency	2,008	1,774	1,230	865
	22,090	19,513	13,528	9,515
Feeder Bus	19,390	20,800	24,900	33,840
GRAND TOTAL	41,480	40,313	38,428	43,355

AR00053411

D. THE FIXED GUIDEWAY TRANSIT CONCEPT

Fixed guideway transit is defined as a grade separated exclusive right-of-way system with trained vehicles operating in a normal transit mode; i.e. all trains stop at each station. The basic concept and requirements of this transit concept are well established with long histories of experience. Each application, however, incorporates current state-of-the-art improvements and is tailored to the specific demands of its service area.

1. Honolulu Application

Fixed guideway transit was analyzed as early as 1966 under OTS.[3/] Detailed planning of a similar system was completed in 1972. These studies provided extensive data and community factors on which to base system selection and location in Honolulu.

In essence, a potential for a basic 23-mile system was identified through a specific corridor and routes. Identified demand also indicated that a medium capacity system in the range of 25-30,000 passengers per hour was most appropriate. The particular vehicle system used in this study is a medium sized, rubber tired, light weight vehicle having these features.[4/] As in the busway and LRT alternatives, identical alignments have been used through Central Honolulu. As in the LRT alternative, various lengths of guideway have been considered to determine the most appropriate system length. Lengths of 23, 14, and 7 miles have been analyzed. The family of fixed guideway alternatives is briefly described below. (See Figure VI-3 in Chapter VI of this report.)

The basic 23-mile system is totally grade separated in exclusive rights-of-way and includes 6.3 miles at-grade in freeway rights-of-way between Pearl City and the Pearl Harbor Interchange and between the Kapiolani Interchange and Kahala, 1.7 miles of subway through the downtown area with the remaining 15.2 miles in aerial configuration. This system contains 21 stations. Shorter segment lengths are:

- a 14 mile system extending from Halawa to Kahala which eliminates the 5± mile aerial segment from Kahala to Hawaii Kai and the 4± mile at-grade segment from Halawa to Pearl City. This system contains 15 stations.

- a 7-mile system extending from Keehi Lagoon to the University which is a minimum length system containing 10 stations.

AR00053412

2. System Operating Characteristics

Various operational concepts were evaluated to identify the optimal service in terms of travel time, local and longer trip movements, and system efficiency.[5/] Station by-pass features to permit express or skip-stop operation were compared to conventional transit mode (all-station) operation.

From this evaluation, it was found that with system headways in the two-minute range, any time saving for express passengers was offset by time loss for shorter trip requirements. In addition, the relatively small express time saving could not justify the large increase in capital cost and community impact produced by the four-track system. Therefore, a conventional transit mode operating plan was adopted.

Similarly, branch lines were found to produce serious operating and capacity restraints and that the high cost could not be justified. Therefore, a single line route was adopted.

An operating plan was developed which provided through routing of all trains between terminals with no intermediate turnbacks. This will permit sizing trains to accommodate outlying passenger volume demands with seated loads and retain vehicle load factors in peak-load sections comparable to those provided in other concepts.

Table A-12 presents the basic vehicle and system operating parameters used in analyzing the fixed guideway system.

3. Guideway Requirements

Basic guideway configurations include aerial, at-grade and subway structures. Aerial structure was based on precast, pre-stressed concrete girders supported on single reinforced concrete columns with appropriate noise barriers at the outer edge of the 23' wide guideway. At-grade structure was designed as a double "T" section of precast concrete supported on conventional spread footings. Barrier walls at each side of the right-of-way topped with chain link fencing prevents auto-incursion and other access. Subway structure was based on a double box section constructed by cut and cover methods.

AR00053413

TABLE A-12

VEHICLE AND SYSTEM CHARACTERISTICS
FIXED GUIDEWAY ALTERNATIVES

VEHICLE

Dimensions: Length - 45'-0" (A-Car), 41'-8" (B-Car)

Width - 9'-2", Height - 11'-0", Empty Weight - 32,000 lbs. (A-Car), 29,000 lbs. (B-Car)

Capacity* : Seated - 36; Design - 72; Crush - 110

Training: Min. Train - 2 A-Cars; Max. Train - 2 A-Cars & 8 B-Cars

Performance: Max. Speed - 50 mph; Acceleration - 3 MPHPS; Braking - 2.6 MPHPS (Service)

SYSTEM

Avg. Speed (Terminal to Terminal): 23 mile - 32.7 MPH;
14 mile - 30.5 MPH;
7 mile - 28.7 MPH

Avg. Dwell Time - 20 seconds

Frequency - Peak: 2 min; Base: 4 min; Night: 4 min.

*Design load and crush load capacities established to provide equal space per passenger on all vehicle concepts.

AR00053414

4. Station Requirements

Each station was designed and sited in relation to traffic patterns, physical character of the area and to provide for bus and auto access for transfer of passengers. Auto parking was included at the Pearl City (750) and Hawaii Kai Stations (400) in the 23-mile system and stadium parking facilities were assumed available for transit users at the Halawa Station in the 23 and 14 mile systems. No parking was provided for the 7-mile system.

All stations were designed to accommodate the maximum 10-car trains. Stairs, escalators and elevators were included at each station to accommodate vertical movements in the stations and to permit use by handicapped persons.

5. Support Systems

Vehicles, stations, yard and shops area, and central control were interconnected with voice communication systems including telephone, radio and public address systems. Closed circuit television was assumed to monitor station activities outside the station agent's normal field of view. Automatic fare collection systems were included at all stations and control entry to the system. Train control systems provide for fully automatic train protection and train operation with provision for ultimate addition of train supervision to produce complete fully automated operation. Yards and shops to accommodate the 1995 system requirements would be located adjacent to Keehi Lagoon.

6. Concept Analysis

Analysis of the fixed guideway alternatives included patronage and operational analysis and projections of cost and operating statistics for use in subsequent system evaluations.

a. Patronage: Patronage projections were made through application of the computer models to each alternative length fixed guideway system and its accompanying feeder and express bus system. Projected 1995 patronage is shown for each sub-alternative in Table A-13 and selected travel characteristics presented in Table A-14.

b. Operational Analysis: Using the patronage estimates, a detailed operating plan was prepared for each sub-alternative and analyzed

AR00053415

TABLE A-13: 1995 PATRONAGE PROJECTIONS - FIXED GUIDEWAY ALTERNATIVES

ANALYSIS CATEGORY	7-MILE TOTAL DAILY	7-MILE % TOTAL	7-MILE P.M.PK. HOUR	7-MILE % TOTAL	14-MILE TOTAL DAILY	14-MILE % TOTAL	14-MILE P.M.PK. HOUR	14-MILE % TOTAL	23-MILE TOTAL DAILY	23-MILE % TOTAL	23-MILE P.M.PK. HOUR	23-MILE % TOTAL
1. TRANSIT PERSON TRIPS	459,300	100.0	79,380	100.0	473,300	100.0	81,860	100.0	490,000	100.0	84,920	100.0
WORK	208,800	45.5	46,520	58.6	215,300	45.5	47,910	58.5	224,500	45.8	49,890	58.7
NON-WORK	250,500	54.5	32,860	41.4	258,000	54.5	33,950	41.5	265,500	54.2	35,030	41.3
2. TRANSIT PERSON TRIPS AS:												
% TOTAL TRIPS	13.9	-	21.6	-	14.3	-	22.2	-	14.8	-	23.1	-
% TOTAL WORK TRIPS	31.0	-	42.8	-	32.0	-	44.2	-	33.3	-	46.0	-
% TOTAL NON-WORK TRIPS	9.5	-	12.7	-	9.8	-	13.1	-	10.1	-	13.5	-
3. TRANSIT TRIPS BY MODE												
GUIDEWAY	277,300	60.4	50,110	63.1	306,900	64.8	56,000	68.4	332,600	67.9	60,800	71.6
BUS *	561,470	-	99,190	-	527,600	-	92,800	-	568,800	-	103,700	-
4. TRANSIT USE BY AREA												
URBAN HONOLULU	331,740	72.2	57,330	72.2	341,850	72.2	59,120	72.2	353,920	72.2	61,340	72.2
WINDWARD	64,560	14.1	11,160	14.1	66,530	14.1	11,510	14.1	68,880	14.1	11,940	14.1
CENTRAL	15,520	3.4	2,700	3.4	15,990	3.4	2,780	3.4	16,550	3.4	2,870	3.4
LEEWARD	47,480	10.3	8,190	10.3	48,930	10.3	8,450	10.3	50,650	10.3	8,770	10.3

*INCLUDES INTRA-MODAL TRANSFERS

AR00053416

TABLE A-14: SELECTED TRIP CHARACTERISTICS - 1995 FIXED GUIDEWAY ALTERNATIVES

CHARACTERISTIC	7-MILE FIXED GUIDEWAY				14-MILE FIXED GUIDEWAY				23-MILE FIXED GUIDEWAY			
	DAILY		P.M. PK. HOUR		DAILY		P.M. PK. HOUR		DAILY		P.M. PK. HOUR	
	TOTAL SYSTEM	GUIDE-WAY	TOTAL SYSTEM	GUIDE-WAY	TOTAL SYSTEM	GUIDE-WAY	TOTAL SYSTEM	GUIDE-WAY	TOTAL SYSTEM	GUIDE-WAY	TOTAL SYSTEM	GUIDE-WAY
PASSENGER MILES	3,095,084	728,842	570,600	132,281	3,228,410	1,178,140	594,450	210,591	3,458,125	1,747,793	637,107	324,422
PASSENGER HOURS	136,043	25,310	24,670	4,610	134,326	38,570	24,400	6,871	137,510	53,390	25,044	9,815
AVERAGE TRIP TIME (MIN.)	-	5.5	35.2	5.5	-	7.5	33.7	7.4	-	9.6	31.6	9.7
AVERAGE TRIP LENGTH (MI.)	6.74	2.63	7.19	2.64	6.82	3.84	7.26	3.76	7.06	5.25	7.50	5.34
AVERAGE TRIP SPEED (MPH)	-	28.8	12.3	28.7	-	30.5	12.9	30.6	-	32.7	14.2	33.0

TABLE A-15: SELECTED OPERATING STATISTICS - 1995 FIXED GUIDEWAY ALTERNATIVES

STATISTIC	7-MILE FIXED GUIDEWAY				14-MILE FIXED GUIDEWAY				23-MILE FIXED GUIDEWAY			
	TOTAL SYSTEM	GUIDE-WAY	FEEDER BUS		TOTAL SYSTEM	GUIDE-WAY	FEEDER BUS		TOTAL SYSTEM	GUIDE-WAY	FEEDER BUS	
			LOCAL	EXPRESS			LOCAL	EXPRESS			LOCAL	EXPRESS
VEHICLE MILES (DAILY)	158,940	34,335	45,645	78,960	158,485	64,225	31,080	63,180	189,885	111,495	31,680	46,710
VEHICLES IN PEAK HOUR SERVICE	850	146	308	396	767	240	210	317	831	383	223	225
SPARES	85	15	31	39	77	24	21	32	83	38	22	23
PASSENGERS/VEHICLE MILE	2.89	8.08	-	-	2.99	4.78	-	-	2.58	2.98	-	-

AR00053417

for vehicle requirements, vehicle miles and other operating statistics necessary to determine costs and for subsequent system evaluation. Selected operating statistics are presented in Table A-15.

c. Capital and operating costs: Table A-16 presents the estimated capital and 1995 operating costs expressed in 1974 dollars. All unit costs used are late 1974 costs applicable in Honolulu. In the 7 and 14 mile systems, costs for the exclusive single lane reversible busway in Kalanianaole Highway between Hawaii Kai and Kahala is included as part of the feeder bus system. The 23 mile system does not require this busway and its costs are not included.

AR00053418

TABLE A-16
ESTIMATED COSTS - 1995 FIXED GUIDEWAY ALTERNATIVES
($ THOUSANDS)

	SYSTEM LENGTH		
	7-MILE	14-MILE	23-MILE
TOTAL CAPITAL COSTS			
F.G. FACILITIES & EQUIP.			
WAY STRUCT. & GUIDERAILS	$ 79,696	$112,235	$157,051
STATIONS	47,489	65,996	84,194
POWER & CONTROL	24,130	39,976	52,951
YARD & SHOPS	11,935	13,546	14,807
VEHICLES	52,800	86,600	137,800
SUBTOTAL	$216,050	$318,353	$446,803
CONTINGENCY (10%)	21,605	31,835	44,680
ADMIN & ENGRG. (13%)	30,895	45,524	63,892
TOTAL	$268,550	$395,712	$555,375
F.G. ROW & RELOCATION			
ROW & RELOCATION	$ 47,410	$ 51,020	$ 53,380
CONTINGENCY (10%)	4,741	5,102	5,338
ADMIN. (3%)	1,565	1,684	1,762
TOTAL	$ 53,716	$ 57,806	$ 60,480
FEEDER BUS SYSTEM			
KAL. HWY. IMPROVEMENTS	$ 26,100	$ 26,100	-
BUSES	50,310	37,700	$ 32,045
TOTAL	$ 76,410	$ 63,800	$ 32,045
GRAND TOTAL	$398,676	$517,318	$647,900

	F.G. SYSTEM LENGTH		
	7-MILE	14-MILE	23-MILE
ANNUAL OPERATING COSTS			
FIXED GUIDEWAY SYSTEM			
WAY & STRUCTURE	$ 1,458	$ 1,891	$ 2,643
VEHICLE	950	1,474	2,369
TRANSPORTATION	2,021	2,690	3,467
GENL. & ADMIN.	2,400	2,873	3,793
POWER	1,766	3,031	4,965
SUBTOTAL	$ 8,595	$11,959	$17,237
CONTINGENCY (10%)	859	1,196	1,724
TOTAL	$ 9,454	$13,155	$18,961
FEEDER BUS SYSTEM	$33,840	$24,900	$21,900
GRAND TOTAL	$43,294	$38,055	$40,861

AR00053419

REFERENCES

1. "Draft Environmental Impact Statement," Volume III, Honolulu Rapid Transit Project, September 1972, Daniel, Mann, Johnson, & Mendenhall

2. "Standard Light Rail Vehicle Specification," Technical Section, October 1972, Massachusetts Bay Transportation Authority and San Francisco Municipal Railway

3. "Oahu Transportation Study," Volumes I, II, and III 1967, State of Hawaii and City & County of Honolulu

4. "Study of Rubber-Tired Transit Technology," Honolulu Rapid Transit Project, PEEP II, December 1974, Daniel, Mann, Johnson, & Mendenhall

5. "Study of Fixed Guideway Operational Concepts," Technical Report, July 1974, Daniel, Mann, Johnson, & Mendenhall

AR00053420