


**BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
BUILDING THE INTER-ISLAND PASSENGER/VEHICULAR FERRY BOAT
IN
WESTERN SAMOA**

APRIL 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

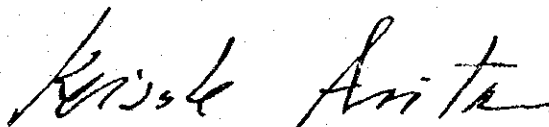
In response to the request of the Government of Western Samoa, the Government of Japan has decided to conduct a basic design study on the Project for Building the Inter-Island Passenger/Vehicular Ferry Boat and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Western Samoa a study team headed by Mr. Takao Shinohara, Deputy Director, Safety Standards Division, Maritime Technology and Safety Bureau, Ministry of Transport from December 9 to 27, 1986.

The team had discussions on the Project with the officials concerned of the Government of Western Samoa and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

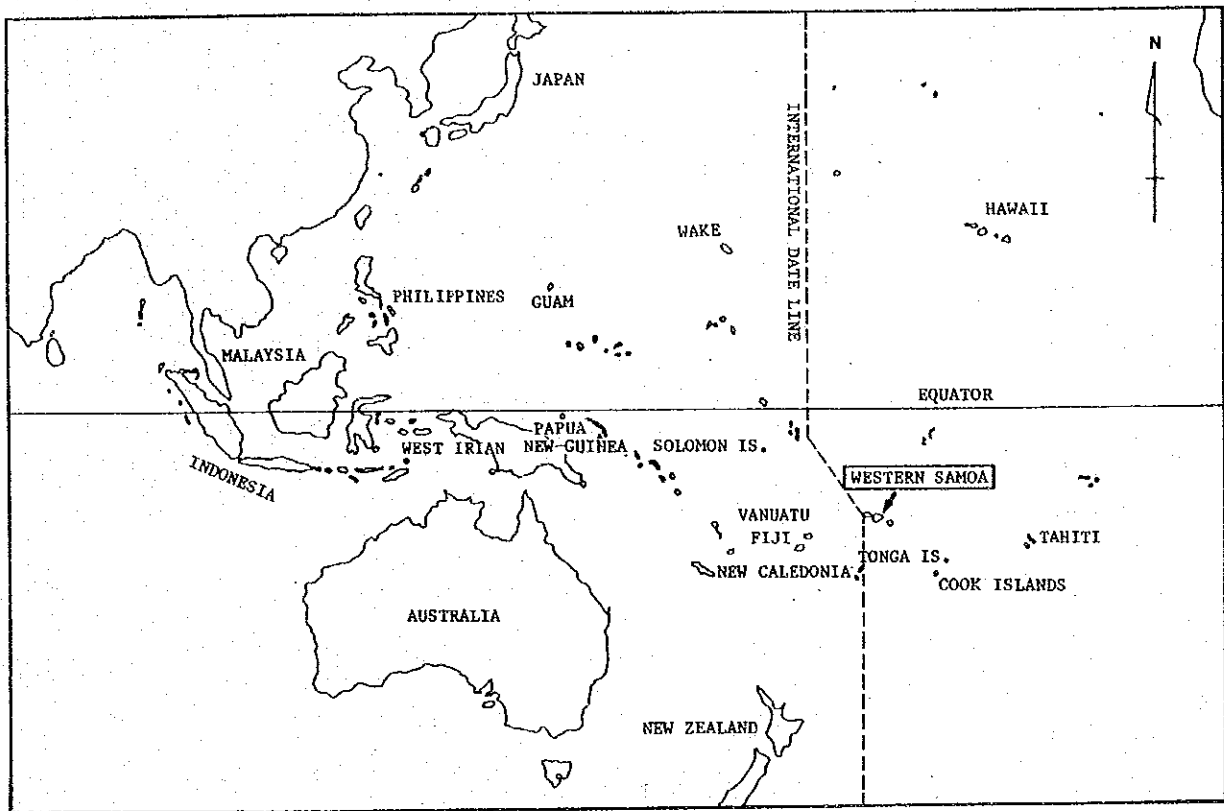
I wish to express my deep appreciation to the officials concerned of the Government of Western Samoa for their close cooperation extended to the team.

April, 1987

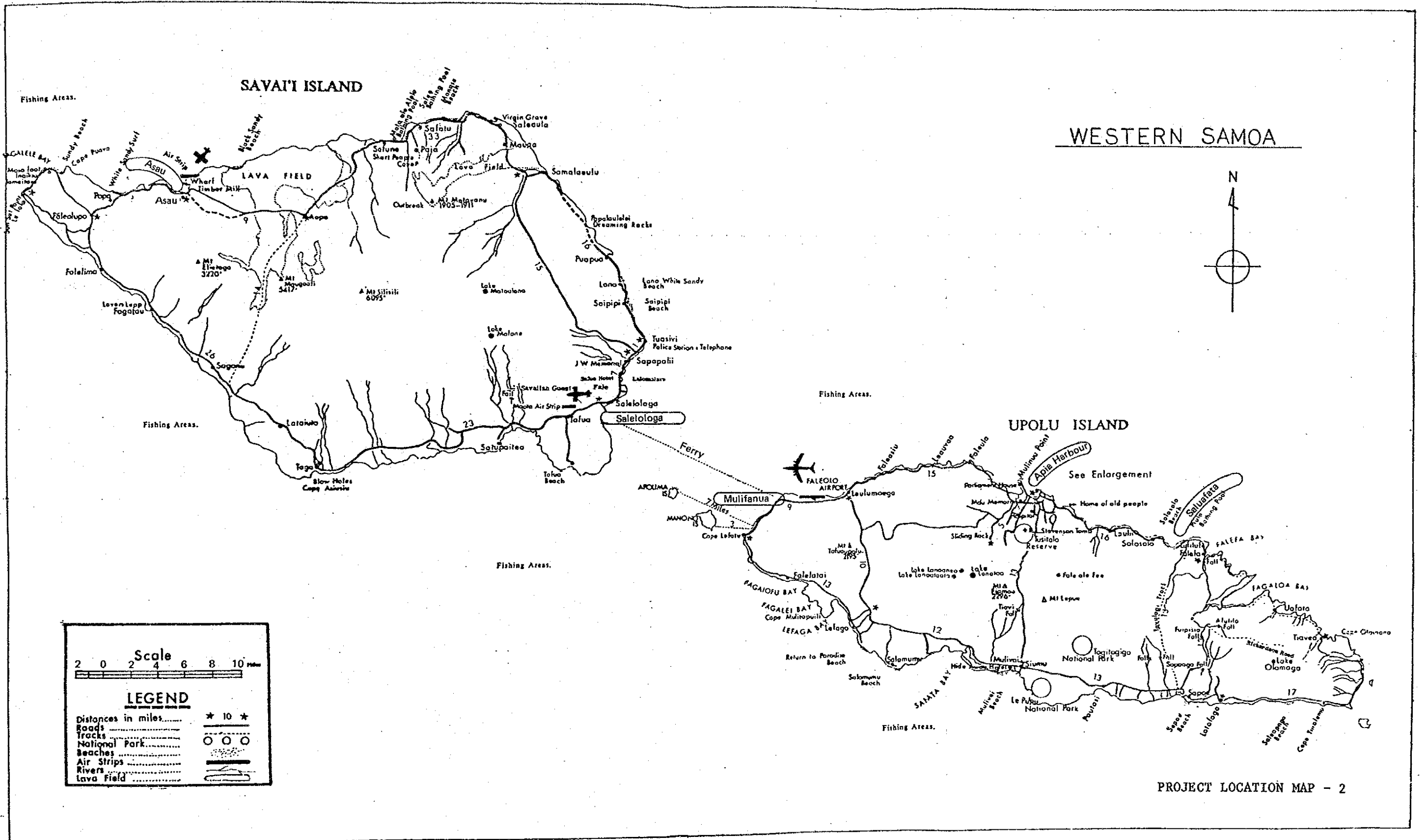


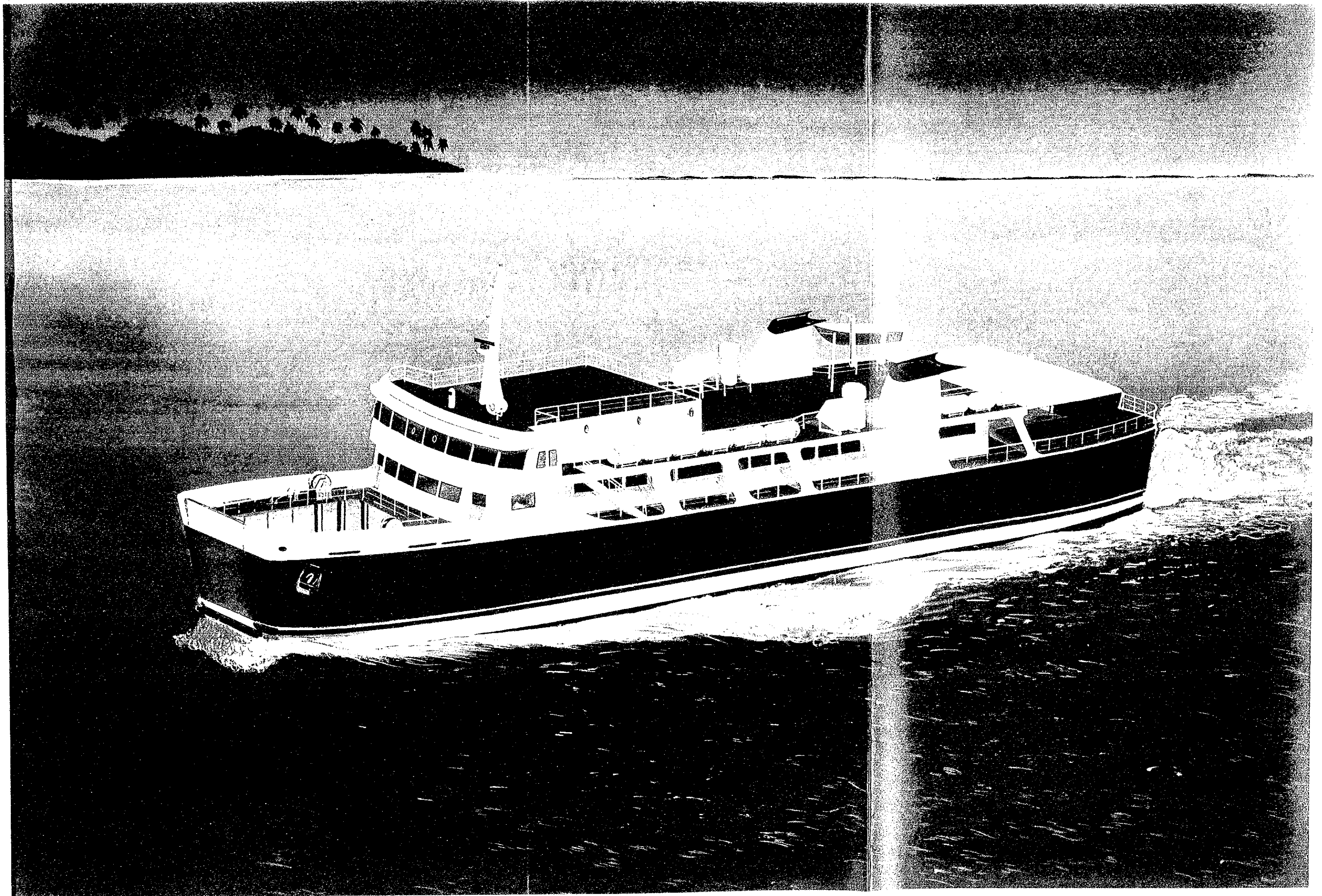
Keisuke Arita

President
Japan International Cooperation Agency



PROJECT LOCATION MAP - 1





SUMMARY

SUMMARY

Western Samoa consists of two (2) main islands (Upolu Island and Savaii Island) and seven (7) small islands. Due to its geographical characteristics, sea transportation is of vital importance.

In its Fifth Development Plan (1985-1987) the Government of Western Samoa has set fifth goals for increasing the nation's productivity and for securing economic independence. In order to accomplish these goals, it is essential to improve the sea transportation system in order to handle the increasing volume of raw materials and items of daily necessity moving to and from rural areas. Further, through the development of a more efficient transportation system, significant cultural and economic growth can be achieved.

During 1984 and 1985 the Government of Western Samoa, with grant aid from the Japanese Government, improved the channels, berth facilities, and ferryboat terminals at the Mulifanua Port and Salelologa Port. This port facilities project has contributed greatly to the improvement of ferryboat service. However, except for one ferryboat, other two ferryboats that sail between the Mulifanua and Salelologa ports are not usable, either too old or beyond economical use.

Due to the lack of repair parts, machinery, and repair skills, the ferryboats are not being properly maintained. This inadequacy is the cause of frequent suspensions of service and poses a threat to safe and reliable transportation.

In order to establish a safe and reliable sea transportation, a new ferryboat which will cope with increasing transportation needs is an urgent requirement, and the ability to provide "in-country" maintenance and repair is definitely essential.

In view of the aforementioned, the Government of Western Samoa requested grant aid from the Government of Japan to fund the costs of one (1) passenger/vehicle ferryboat and the necessary spare parts, and sought the cooperation of the United Nations Development Programme (UNDP) in the shipping maintenance programme.

The Government of Japan, in response to this request, decided to conduct a basic design study on the Project for Building the Inter-Island Passenger/Vehicular Ferry Boat and entrusted the study to the Japan International Cooperation Agency (JICA). JICA dispatched a study team, headed by Mr. Takao Shinohara, Deputy Director, Safety Standards Division, Maritime Technology and Safety Bureau, Ministry of Transport to Western Samoa. During the period 9 - 27 December, 1986, the team discussed the Project with concerned officials of the Government of Western Samoa, conducted a field survey, and collected and analyzed all necessary data.

The demand for passenger and vehicle transportation between the two main islands of Western Samoa has been increasing yearly. However, it is anticipated that two of the three available ferryboats will be taken out of service in the near future. The only remaining ferry, a small landing craft type, will not be able to handle the increasing demand alone. Therefore, there exists an urgent need to introduce a new ferryboat along with its necessary and appropriate spare parts.

The shipping maintenance programme of UNDP is directly related to the maintenance and repair for a new ferryboat.

In order to sustain the inter-island ferryboat service, it is important that an in country daily maintenance system for the boats be established by providing the necessary repair machinery and tools with grant aid from the Japanese Government in conjunction with the UNDP programme.

It is determined that one (1) passenger/vehicle ferryboat of the following general description, and the listed maintenance items are required:

PASSENGER/VEHICULAR FERRYBOAT

Tonnage:	Approximately 999 tons
Overall Dimensions:	Approximately 38.6 meters long x 11.5 meters wide x 2.25 meters draft
Transporting Capacity:	300 Passengers - Ten (10) Light Vehicles (average 3 tons each) - Seven (7) Trucks (10 ton) (Roll-on & Roll-off System)

Type:	Steel Construction
Speed:	Approximately 13 Knots
Crew:	Less than ten (10)
Spare Parts:	Two (2) year requirement Maintenance Items

MACHINERY FOR BOAT REPAIR

- 1 Lathe
- 1 Milling Machine
- 1 Drilling Machine
- 1 Gas Cutting Machine
- 1 Air Compressor
- 1 Steam Cleaning Facility
- 1 Chain Block

A total of twelve (12) months will be required to complete the Project - three and one half (3.5) months for the exchange of notes, detailed design, tender and contracting; seven (7) months for boatbuilding; one and one half (1.5) months for delivery of ferryboat.

For this project, no burden to the Government of Western Samoa is required.

The new ferryboat will be owned by the Ministry of Transport of the Government of Western Samoa and will be managed and operated by the government-financed Western Samoa Shipping Corporation.

Judging from revenues of the present ferryboat operation, the financial situation of the domestic ferryboat transportation's management and operation will be favorable after introducing the new ferryboat.

Accomplishment of the Project will provide reliable and safe domestic sea transportation. The improved transportation system will contribute to upgrading Western Samoa's standard of living and will stimulate its economic development. It is, therefore, very worthwhile that this Project be carried out with grant aid from the Government of Japan. Further, it is highly recommended that the Project's commencement be implemented as soon as possible.

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CHAPTER I INTRODUCTION

CHAPTER 1 INTRODUCTION

The Government of Western Samoa has listed the establishment of safe and reliable sea transportation as one of the Fifth Development Plan's (1985-87) major goals. Ferryboat transportation between the two (2) main islands (Upolu and Savaii) is especially vital to the country. However, the present system is not sufficient to handle the increasing passenger, vehicle and cargo loads. This is fundamentally due to an inadequate number of ferryboats, insufficient maintenance, and the lack of spare parts. With this in mind, the Government of Western Samoa requested grant aid from the Japanese Government to finance a ferryboat building. The request is to cover the following:

- The building of one (1) domestic inter-island passenger/vehicular ferryboat.
- The provision of the necessary spare parts needed for boat operation.

In response to the above request, the Japanese Government decided to conduct a basic design study on the Project for Building the Inter-Island Passenger/Vehicular Ferry Boat and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA dispatched a study team headed by Mr. Takao Shinohara, Deputy Director, Safety Standards Division, Maritime Technology and Safety Department, Ministry of Transport, to Western Samoa.

During the period 9 - 27 December 1986, the study team discussed the Project with concerned Government of Western Samoa officials, and conducted the following studies, surveys, and data collection:

- (1) Confirmation of the background of the request.
- (2) Confirmation of the detailed items and scale of the request.
- (3) Field investigation of the concerned area.
- (4) Investigation of present ferryboat management, maintenance, and operation.
- (5) Survey of nature, society, and economy.

- (6) Investigation of domestic ferryboat transportation and present ferryboats.
- (7) Investigation of present ferryboat repair facilities in Western Samoa.
- (8) Origin and destination survey of ferryboat passengers.
- (9) Market survey for parts and machinery needed for boat repair.
- (10) Survey of ship repair facilities in American Samoa and Fiji.

The Minutes of Discussions pertaining to the basic design study was exchanged on 19 December 1986.

Upon returning to Japan, further studies were made relevant to the Project. As a result, this report "BASIC DESIGN STUDY REPORT ON THE PROJECT FOR BUILDING THE INTER-ISLAND PASSENGER/VEHICULAR FERRYBOAT" has been prepared.

CHAPTER 2 PROJECT BACKGROUND

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Nature, Society, and Economy of Western Samoa

2-1-1 Nature and Society

In 1962, Western Samoa, which had been a United Nations trusteeship under the administration of New Zealand, gained its full independence. Western Samoa is located at about 13°45'S latitude and about 172°W longitude. It is situated about 2,900 km northeast of New Zealand, about 1,300 km east of Fiji, and about 1,100 km north of Tonga.

Western Samoa consists of islands made up of volcanic rock and coral reefs. It abounds in fresh water. Most of the territory is suitable for cultivation. The total land area of the country is about 2,934 km². Savaii Island is the largest island (1,700 km²) and Upolu Island is the second largest (1,100 km²). These two islands constitute 95% of the land area of the country.

Western Samoa is in the tropical climate zone. The mean daily temperature is 27°C, with the maximum temperature around 35°C. During the trade wind season, from May to November, temperatures are moderate and relatively comfortable. The rainy season lasts from December to April and hurricanes occasionally hit the islands during this season causing damage to houses and agricultural crops. The annual precipitation fluctuates greatly between 2,300 mm and 6,500 mm due to the effects of trade winds. The mean annual precipitation is about 3,000 mm.

The estimated population in 1985 was about 160,000. Fifty (50) percent of the population is below fourteen years old. Ninety-nine (99) percent of the population live on Upolu and Savaii Islands. The ratio of the inhabitants of Upolu Island to Savaii Islands is 7:3. The population of the capital, Apia, on Upolu Island, is approximately 33,000. The population growth rate is approximately 2.9 percent annually. However, many people emigrate to New Zealand and Australia. As a result, the net

population increase is approximately 0.6% annually. About ninety (90) percent of the population is Samoan, which is classified as a Polynesian race. The official languages are both Samoan and English.

2-1-2 Economy

The gross domestic product (GDP) of Western Samoa in 1985 was 192.2 million U.S. dollars. The per capita GDP in the same year was 535 U.S. dollars.

About fifty (50) percent of GDP is from the primary sector, mainly agricultural products. The main export items in 1983 were coconut oil, cocoa, taro, coconut cream, copra, and beer. Eighty-seven (87) percent of the export items are agricultural products.

The major manufacturing industries of the country are lumbering, tobacco production, beer brewing, match and soap production, which represent about ten (10) percent of GDP.

2-2 Present Transportation

2-2-1 Land Transportation

There is no railroad system in Western Samoa. However, road networks are well developed. The main roads on Upolu and Savaii Islands are constructed along the coastal lines, and branch roads extend inland from the main roads. The main roads, including the road from Apia to Faleolo Airport in Upolu Island, are almost all paved. The south coast road between Saleologa and Asau on Savaii Island is paved, though part of the north coast road has not yet been paved. The total length of paved roads on both islands is about 230 km, while the total for unpaved roads is about 180 km.

Buses, which run between the major towns on each island, are an important means of transportation. This is especially true on Savaii Island where people rely on buses because of the shortage of automobiles and the non-existence of taxicabs. In the

capital, Apia City, taxis, minibuses, and rental cars are available.

The number of registered vehicles in 1985 was 4,500; about 4,000 on Upolu Island and about 500 on Savaii Island. In 1985, there were 1,406 sedans, 432 trucks, and 1,969 pickup trucks. These vehicles play a very important role in the transporting of commodities.

2-2-2 Sea Transportation

On Upolu Island, the main ports are Apia Port, which is used by a regular passenger liner between Western Samoa and American Samoa and for international trade, and Mulifanua Port, used by ferryboats travelling to and from Savaii Island. On Savaii Island, there are two ports: Salelologa Port for ferryboats and Asau Port for lumber shipments.

Due to the recent development of Savaii Island, the number of passengers and the volume of cargo between Upolu and Savaii Islands has been increasing yearly. During the years 1984 and 1985, the increase in the number of passengers and cargo volume was remarkable. The number of passengers in 1985 was 347,000, which was almost triple that of 1983 (121,000). The number of vehicles carried in 1980 was 8,000, while in 1985 the number increased to 18,000.

During 1984 and 1985 the channels, berthing facilities, and ferry terminals at Mulifanua and Salelologa Ports were improved using grant aid from the Japanese Government. This project has contributed greatly to the improvement of ferryboat transportation.

The port facilities at Mulifanua and Salelologa Ports do not present any problems for ferryboat operations. Port facility features are shown as follows:

(1) Channel and Turning Basin:

Mulifanua Port

Turning Basin: -3.2 m deep, 120 m diameter
Channel: From wharf to 500 m offshore:
-3.2 m deep, 50 m wide
500 m ~ 800 m offshore:
-3.5 m deep, 50 m wide

Salelologa Port

Turning Basin: -3.5 m deep, 120 m diameter
Channel: More than -3.2 m deep, wider than 50 m

(2) Berthing Facilities:

Berth Depth: -3.2 m
Berth Length: Mulifanua Port: 44.5 m
Salelologa Port: 45.5 m
Ramp: 5 m wide, two (2) ramps at each port
Mooring Dolphin: 25 tons x 3 units at each port
15 tons x 6 units at each port
Fenders: Rubber fenders for ferryboats, 400 H x
700 L x 6 Sets at each Port.

(3) Fuel and Water Supply Facilities:

Tanker trucks deliver fuel to the ferryboats at Mulifanua and Apia Ports from the oil storage tanks located on the outskirts of Apia Port. Only one type of fuel is available.

There are no water or electric power supply facilities at the ports of Mulifanua and Salelologa.

2-2-3 Air Transportation

In Western Samoa there are four (4) airports: Faleolo International Airport for both international and domestic flights; Fagalii, Maota, and Asau Airports for domestic flights. Faleolo and Fagalii Airports are on Upolu Island; Maota and Asau Airports are on Savaii Island.

All airports, except at Faleolo, are for small aircraft (approximately ten (10) passenger seat types). The runways at these airports are made of compacted coral or grass strips.

In 1985, approximately 10,000 passengers travelling between the two main islands passed through these domestic airports. The number of air passengers was approximately three (3) percent of that for ferryboat passengers.

At the Faleolo International Airport the runway has been extended to 2,700 meters in order to introduce wide-bodied jet aircraft. Presently, an airport modernization project is being carried out, with grant aid from the Japanese Government, to enlarge and rehabilitate the terminal, install an ILS system, and provide new firefighting vehicles.

2-3 Present Inland Ferryboat Transportation and Its Problems

2-3-1 Transportation Volume

Past Transportation volumes between Upolu Island (Mulifanua Port) and Savaii Island (Salelologa Port) are as follows:

	PASSENGERS	VEHICLES
1980	76,781	8,156
1981	92,762	10,125
1982	105,326	14,156
1983	120,602	14,214
1984	264,826	18,214
1985	347,044	18,263
1986	306,771	17,128

As the table shows, the number of passengers increased dramatically since 1984. Before 1983, transportation between the

two (2) islands was handled by only one (1) landing craft type ferryboat, the Pleono. The capacity of this vessel was not sufficient to meet the demand. It is believed that this latent demand caused the large increase in transportation volume during the 1984 - 85 period and that it was due to the introduction of the ferryboat Salafai in 1984, the high speed passenger boat Lady Samoa in 1985, and the port facility improvement project (1984 - 85) which was undertaken with the use of grant aid from the Japanese Government. It can be considered that the 1985 increase was only a temporary phenomenon brought on by the introduction of the high speed Lady Samoa.

From 1980 through 1985 vehicle transporting increased steadily. However, the increase rate is not so remarkable when compared to the increased passenger rate. Even though the number of ferryboats increased, the vehicle carrying capacity remained virtually unchanged. In 1986 one vehicle carrying ferryboat was overhauled, thereby decreasing the number of vehicles transported to a figure below the 1985 level.

During our area survey we observed that, due to the overhaul of the vehicle carrier Plaono, at least ten trucks had been waiting longer than a week to board ferries at the Salelologa and Malifanua Ports.

2-3-2 Transportation Boats

Presently, there are three ferryboats in operation. The Pleono is eleven years old and has holes in its shell caused by corrosion. Some areas of its bottom shell are only 3.7 mm thick and show signs of extreme deterioration. The Pleono has not received periodical maintenance for several years. As this is the case, it is difficult to provide safe, reliable transportation for any prolonged period of time.

The ferryboat Lady Samoa, which was introduced in 1985, is a high speed passenger boat having no vehicle carrying capability. This ferryboat is not fuel efficient. Its operating costs, including the mortgage payment, are large, and it is considered to be uneconomical. A decision has been made to sell this boat.

The ferryboat Salafai is sixteen years old, but the hull and machinery are in relatively good condition. In March, 1986, she was fitted with an overhead deck for passengers. This deck was installed in such a manner as to reduce the overhead height of the vehicle carrying deck making it insufficient for accommodating larger types of trucks.

As can be seen from the above, the Salafai will be the only ferryboat available to carry passengers and vehicles in the near future. The Salafai will not be able to handle the increasing demand. Therefore, there is an urgent need to provide a new ferryboat to establish safer and more reliable sea transportation between the two main islands.

2-3-3 Maintenance and Repair of Boats

Inspection, maintenance, and hull, machinery, and equipment repair are indispensable for retaining the boats' capabilities to conduct safe operations. However, due to insufficient repair facilities, and to the lack of parts, machinery, and repair skills, the ferryboats are not being properly maintained. Ferryboat machinery and equipment frequently malfunction and the hulls continue to deteriorate.

The inspection and repair of ferryboats is not performed in country. The neighboring countries of American Samoa and Fiji provide this service; this consumes from one (1) to (3) months, including delivery time, which significantly decreases ferryboat transportation capacity.

In order to establish and maintain safe and reliable ferryboat transportation service, it is necessary that daily maintenance related function be done "in country." A repair system must be set up that provides improved repair facilities, an adequate supply of spare parts, and upgrades the level of repair skills.

It is not economical to construct a repair slipway because of the small number of ferryboats involved. Therefore, large scale inspections and major repair work, which require such a covered

repair slipway, will continue to be conducted in neighbour countries, American Samoa, and Fiji.

(1) Repair Facilities in Western Samoa

a. Boat Repair Facilities:

The present repair yard (approx. 3,000 m²) has one covered building without walls (about 100 m²), one wooden warehouse (about 30 m²), and two modified 20 foot containers which are being utilized as tool boxes. There is one 14 tons capacity mobile crane and two 4 ton capacity forklifts, however, only one forklift is operative. There is a welding machine, air compressor, and a battery charger. No lathe unit exists. A number of small tools are on hand. There are no new spare parts available, and the supply of used spare parts is very poor.

Although an overhaul can be performed on a diesel engine at this facility, the level of repair expertise is very limited.

b. Repair Facilities at the Fishery Center:

A repair shop belonging to the Fishery Center is located near the Apia Fishing Port. The shop's main functions are to repair small fishing motor boats and to build small aluminum boats. It is a comparatively well equipped shop and has a fishing boat lifting hoist, a lathe, milling machine, shaper, and drilling machine. However, this shop is not capable of repairing ferryboats.

c. Repair Facilities of the Public Works Department:

The Public Works Department's repair shop is located near Apia and is used mainly for the construction machinery. In an area of 40 acres, there is a repair building, a warehouse, and a machine shop. The machine shop is well equipped and has a sufficient supply of

spare parts. It appears that this shop can affect repairs on just about any kind of construction machine. It is possible that ferryboat parts could be repaired in this shop as the basic processes are very similar to those of construction machinery repair. However, it must be realized that it would be an impossibility for this shop to repair all types of ferryboat parts. Furthermore, as this facility comes under a different administrative organization, it may be difficult to utilize its services.

d. Other Privately Owned Repair Facilities:

Although there are automobile repair garages within the city area, there are no other types of repair shops available. Each government organization, therefore, has its own repair shop as previously mentioned.

The procurement of repair machinery, equipment, tools, and parts from the domestic market is difficult. Only small quantities of materials which are limited to such items as steel plates and pipes are available. If ordered, it could take from one week to two months to obtain delivery.

There are a few vendors from whom certain spare parts may be purchased. However, it is highly improbable that every necessary spare part could be obtained on the domestic market.

(2) Neighboring Countries:

a. Repair Facilities in American Samoa:

In American Samoa there is the Pago Pago Repair Yard of Southwest Marine Inc., whose main office is located in San Diego, California, U.S.A. This yard was owned by the American Government until it was subsidized by the above company in May 1985. The yard is located on the northeastern shore at the end of Pago Pago Bay. It has two (2) covered slipways; 3,000 ton and 800 ton

capacities. Adequate machinery and repair facilities are available giving the yard the capability to handle boats equivalent in size to the slipways. During 1985 about 60 to 65 boats were repaired here. Revenues during that period were nearly 400 million yen.

b. Repair Facilities in Fiji:

The Suva marine Slipways, which is located in Suva Port, was established about twenty years ago with funding from the Fiji Government. It is presently controlled by the Ministry of Transport.

The shipyard has four (4) covered slipways having 1,000 ton, 500 ton, 200 ton, and 100 ton capacities, respectively.

Machinery at the shipyard is not sufficient, but it is possible to repair boats equivalent in size to the slipways. During 1985, 58 boats were repaired in the yard.

When the study team visited this facility, a cargo ship of approximately 1,000 DWT was under construction. Due to improper facilities and level of shipbuilding skills, construction work on this ship has been going on for more than one year.

2-4 Request for the Project

The number of passengers and vehicles ferried between Upola and Savaii Islands increased dramatically in 1984 and has been steadily on the rise since.

Two of the three ferryboat are on the verge of being out of service; one for the deterioration of the hull and machinery, and the other for poor economical operation. The remaining ferry only has the capacity to carry 120 passengers and four (4) light vehicles. This boat is a relatively small landing craft type; expecting it to transport trucks is almost impossible. It is,

therefore, quite obvious that, considering the present situation, the future needs for ferryboat service will not be met unless positive remedial action is taken.

Periodic ferryboat maintenance is not being carried out. Inadequate repair facilities combined with the low level of repair skill are the main factors contributing to this deficiency. As the lack of proper maintenance leads to equipment breakdowns and possible suspension of operations, it is imperative that a well-planned and workable maintenance system be established to support the effort to provide safe and reliable ferryboat transportation.

In light of the above, the Government of Western Samoa requested grant aid from the Japanese Government for the purpose of procuring a ferryboat meeting the following requirements:

- Passenger Capacity: 400
- Speed: Not less than 13 knots/hr
- Draft: 2.15 m max.
- Hull Structure: Steel
- Length: 45.7 m
- Main Engine: Twin diesel engines
- Vehicle Carrying Capacity: (Roll-on/Roll-off Capability)
10 each 10 ton trucks
12 each Light vehicles
(average 3 tons each)
- Number of Crew Members: Less than 10
- Service Distance: Approximately 16 miles
(between Salelologa and
Mulifanua Ports)

CHAPTER 3 PROJECT DESCRIPTION

CHAPTER 3 PROJECT DESCRIPTION

3-1 Objectives

Western Samoa consists of two main islands and seven small islands. Ferryboat service between the main islands of Upolu and Savaii, where 99 percent of the population is concentrated, is a vital transportation link urgently needed by the nation for the furtherance of rural development and economic progress.

In the Fifth Development Plan, the Government of Western Samoa listed five important objectives which aim at increasing the nation's productivity, promoting economic independence, etc. In order to achieve these objectives, it is essential that safe, reliable, and effective ferryboat service be provided to afford the people greater mobility and to increase the movement of commodities between the main islands.

Of the three existing ferryboats, the Pleono is expected to be decommissioned because of its deteriorated condition, and the Lady Samoa is to be sold because poor fuel efficiency and high mortgage payments make it uneconomical to operate. The third ferry, the Salafai, is the only boat available for future use.

Alone, the Salafai will be unable to meet the anticipated demand to handle more passengers and vehicles. Therefore, it is mandatory that a new passenger/vehicle ferryboat be introduced to improve sea transportation service.

Also, there is a necessity to establish a means whereby daily ferryboat inspection and repair can be performed within the country. Pursuing this, the Government of Western Samoa sought the cooperation of the United Nations Development Programme (UNDP) to improve shipping maintenance system. The UNDP issued the project document "Establishment of a Shipping Maintenance Programme" which emphasizes the need to train repair technicians and engineers to perform ferryboat maintenance and repair work,

and stresses the importance of improving servicing capacity, facilities, availability of repair parts and machinery. Grant aid from UNDP is schedule to implement the programme outlined in their project document.

The purpose of this Inter-island Passenger/Vehicular Ferryboat Project is to solve the present transportation problems by introducing a new passenger/vehicle ferryboat and by providing repair parts and machinery. This Project, which is to be financed by grant aid, will enable the ferryboat transportation service to meet anticipated future needs.

3-2 Evaluation of the Requested Financial Assistance

(1) Requested Financial Assistance:

The Government of Western Samoa has requested one passenger/vehicle ferryboat for use between the islands of Upolu and Savaii, and for a supply of spare parts necessary for maintaining the boat.

(2) Evaluation of the Requested Financial Assistance:

The transporting of people and commodities between Upolu and Savaii islands is virtually completely dependent on ferryboat service.

There is air transportation service between the two islands, but the aircraft (10 seaters) have a very limited capacity, and the fare for passengers is expensive.

Ferryboats, on the other hand, can carry large amounts of cargo, including items of daily necessity and agricultural products, and can accommodate many passengers economically. The great majority of people rely heavily on this mode of transportation.

While the volume of transportation between the two islands has been increasing each year, two of the three ferryboats

are planned to be decommissioned. The boat that is to remain in service is a small landing craft type; it can not be expected to meet future ferry service needs on its own.

In view of the above, it is considered that grant aid should be given in accordance with the request of the Government of Western Samoa, to provide one new passenger/vehicular ferryboat and the appropriate spare parts for the purpose of establishing a more efficient sea transportation service between the islands of Upolu and Savaii.

3-3 General Description of the Project

3-3-1 Project Agency and Its Organization

The executive agency of the Project is the Ministry of Transport of the Government of Western Samoa. The new ferryboat will be owned by the Government of Western Samoa.

Upon receiving the new ferryboat, its management, operation, and maintenance will be entrusted to the Western Samoa Shipping Corporation, a firm fully financed by the Government. The Minister of Transport is the corporation's chairman of the board.

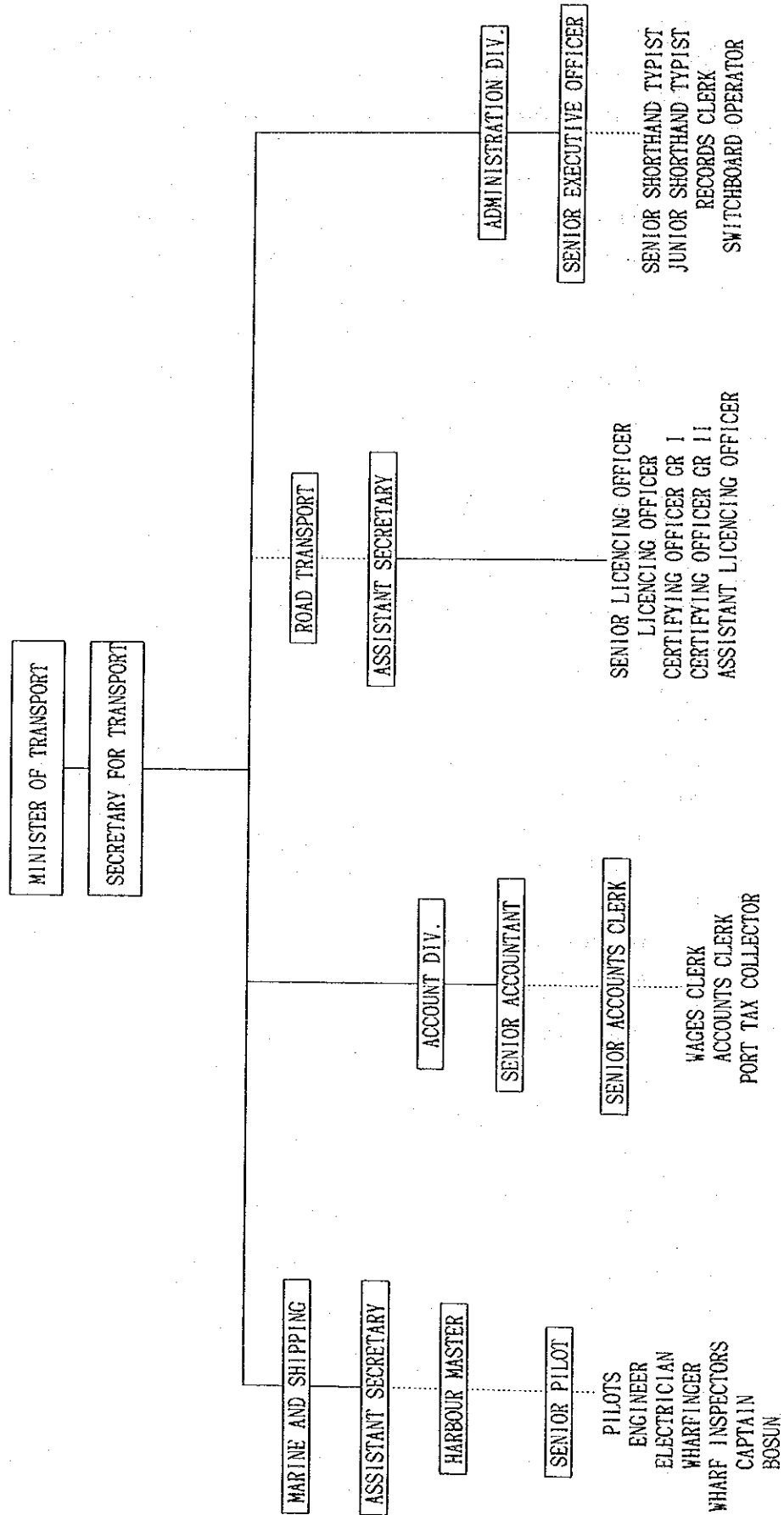
General statistics pertaining to the Samoa Shipping Corporation are as follows:

Data of Establishment:	December 1944
Capital:	1,000,000 Tala
No. of Directors:	7
No. of Employees:	104

(Organizational Charts are shown in Fig. 3-1 and Fig. 3-2)

Fig. 3-1

GOVERNMENT OF WESTERN SAMOA
ORGANIZATION CHART : MINISTRY OF TRANSPORT

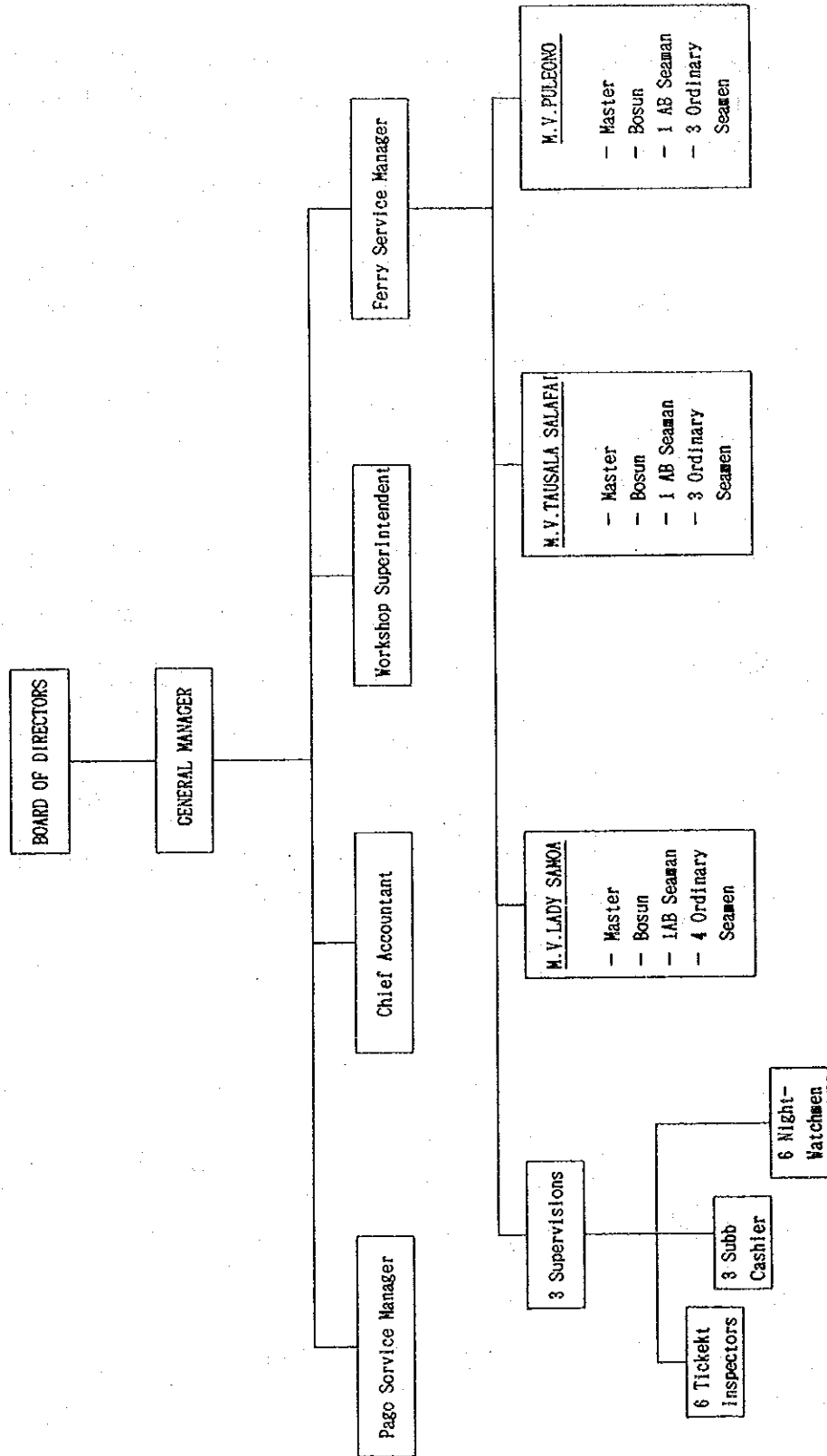


NOTE : CIVIL AVIATION REPLACED BY AIRPORT AUTHORITY
SINCE EFFECTIVE JANUARY 1. 1986

Fig. 3-2

ORGANIZATION CHART - WESTERN SAMOA SHIPPING

CORPORATION 1986

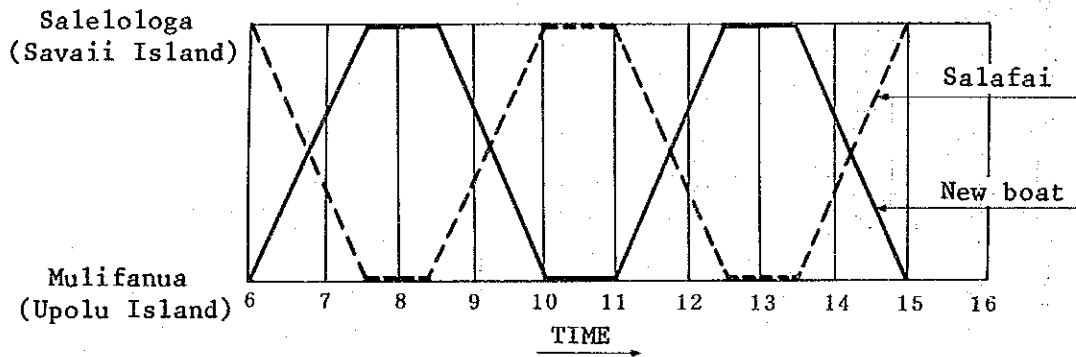


3-3-2 Operating Schedule

Presently, there are three ferries operating between the main islands during daylight hours. As there are no channel marking lights, night operations are not suitable. Due to mechanical failures, one boat out of three is frequently inoperative. In this case remaining each ferryboat makes two round trips daily. When only one ferry is available, it makes two and one half round trips daily. In the future, the Salafai and the new ferryboat will handle the ferrying service. Based on present operating system and passenger and vehicle transporting demand (daytime demand only), the new boat will make two or three round trips daily, while the Salafai will make two.

The proposed ferryboat operating schedule is shown in Fig. 3-3 below.

Case 1: Two daily round trips by Salafai and new boat



Case 2: Two round trips by Salafai and three round trips by new boat

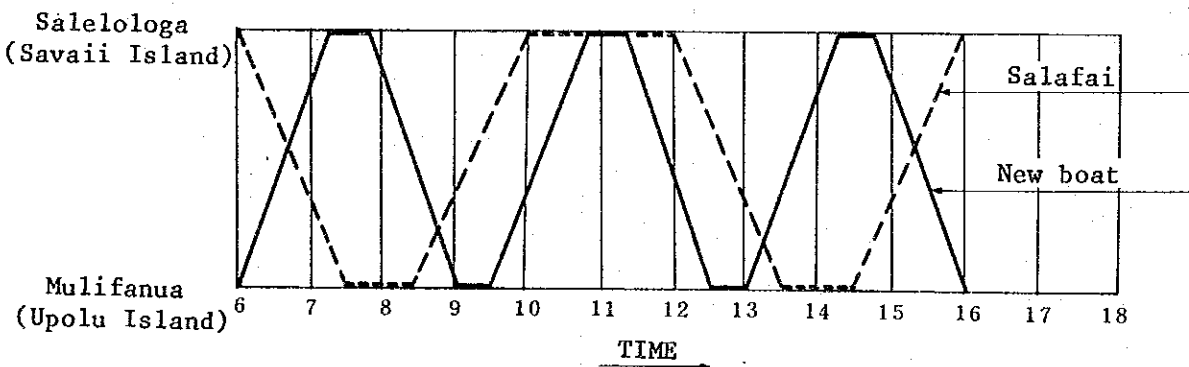


Fig. 3-3 Operating Schedule

3-3-3 Ferryboat and Repair Machinery

The features of the new ferryboat and major repair machinery are shown below:

1) Ferryboat:

Overall Dimensions: (Length) (Width) (Depth) (Draft)
38.6 m x 11.5 m x 3.9 m x 2.25 m

Tonnage: Approx. 999 tons

Speed: 13.0 knots

Main Engine: 1,200 PS x 2

Capacity: 300 passengers
10 light weight vehicles
(average 3 tons each)
7 trucks (10 tons each)

Loading System: Roll-on/Roll-off

Crew: 10

Spare Parts: two (2) year supply

2) Repair Machinery:

One each of the following:

Lathe

Milling Machine

Drilling Machine

Grinder

Arc Welding Machine

Gas Cutter

Air Compressor Unit

Battery Charger

Steam Cleaning Machine

Chain Block

3-3-4 Management Plan and Staff

(1) Management Plan and Staff:

The Western Samoa Shipping Corporation will provide the staffing, necessary supplies, fuel, management, and repair and maintenance for the new ferryboat.

The Corporation has 36 land workers and 68 crew members (listed below):

Captains (including first class navigators)	8
Chief Engineers:	4
Engineers	4
Boatswains	8
Deck Officers	3
Deck Hands	33
Firemen	8
<hr/>	
TOTAL	68

Present crew members will be assigned to the new ferryboat.

Crew requirements for the new ferryboat are as follows:

Captain/Chief Engineer	2
Navigator	1
Boatswain	1
Engineer	1
Deck Hands	3
Firemen	2
<hr/>	
TOTAL	10

(2) Fare

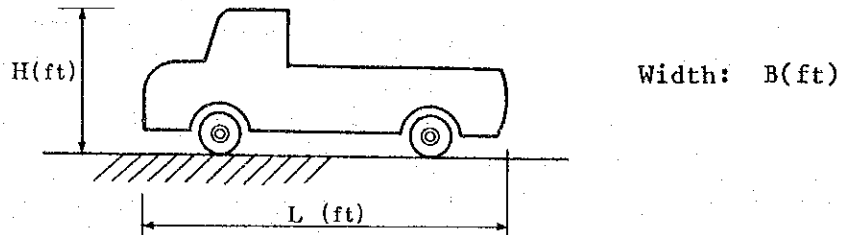
Present ferry fares are as follows:

Passengers:	4 Tala for each adult	
	2 Tala for each child	
Vehicles:	Less than 18 CT:	18 Tala
	18-20 CT:	20 Tala
	20-33 CT:	25 Tala
	33-36 CT:	40 Tala

Motorcycle

5 Tala

$$\text{Where } CT = \frac{L \times B \times H}{40} \text{ (ft}^3\text{)}$$



(3) Financial Outlook for Ferryboat Operations:

After the introduction of the new ferryboat, the financial outlook for ferryboat operations is expected to be very healthy as shown below.

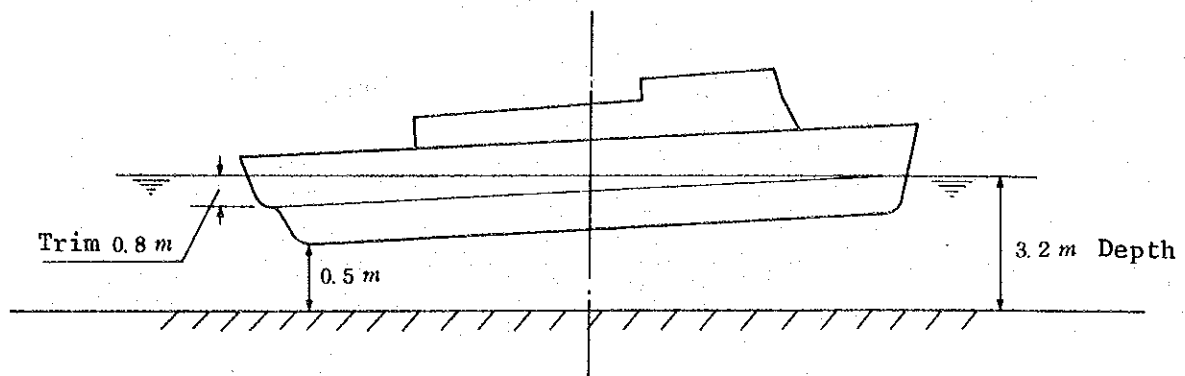
Fare Revenues:	2,000,000 Tala per year
Operating Costs:	1,700,000 Tala per year
PROFIT	300,000 Tala per year

3-3-5 Project Area, Location, and Condition

(1) Ferry Route and Ports:

Location Map 2 shows the ferry route between Mulifanua Port on Upolu Island, and Salelologa Port on Savaii Island. The ferryboat route between the two islands is approximately 16 nautical miles. During 1984 - 1985, these two ports were rehabilitated by improving channels, modernizing berthing facilities, and building ferry terminal with grant aid from the Japanese Government.

Depth of channels, turning basins, and berthing areas in these ports is -3.2 m. In order to maintain a 0.5 meters clearance between the bottom of the ferryboat and the seabed, the maximum draft of 2.3 meters can be obtained by making a 0.8 meter ballast adjustment.



The maximum boat length of approximately 40 meters is determined by the following existing conditions:

- Minimum channel width of 50 meters:
Maximum usable boat length is 42 meters.
- Turning basin diameter of 120 meters:
Maximum usable boat length is 40 meters.

Existing fenders can accommodate vessels displacing about 900 tons without difficulty.

(2) Repair Yard:

The repair yard for the new ferryboat is planned to be at the site of the existing yard which is 3,000 m² and is located behind Apia Port.

The existing repair building has a roof but no walls. The warehouse for equipment and parts is insufficient. Neither of these buildings are usable for the new ferryboat.

It is planned to modernize the repair yard in accordance with the Establishment of the Shipping Maintenance Programme prepared by the UNDP.

3-4 Related Project

To improve the safety and efficiency of sea transportation in Western Samoa, UNDP is planning to initiate the Establishment of Shipping Maintenance Programme. The immediate objectives of the Programme are as follows:

- (1) To create a core of marine mechanical and electrical engineers/technicians who can effectively handle shipping repair and maintenance work.
- (2) To improve the servicing capacity and facilities of the shipping repair and maintenance workshop to enable the undertaking of repair and maintenance services within the country.

The order to accomplish the above objectives, the Programme listed as follows.

- (1) The services of a consultant in marine engineering for a duration of two weeks to assist in the identification and preparation of detailed specifications for the necessary fixed equipment and hand tools required for the workshop.
- (2) The services of a Marine Engineer for two years.
- (3) Overseas training of a workshop superintendent for three months.
- (4) Equipment: provision of the necessary fixed equipment and hand tools required for the workshop.
- (5) The provision of the necessary fast-moving spare parts for shipping repair and maintenance.
- (6) Provision of a project vehicle.

CHAPTER 4 BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4-1 Basis of Design

4-1-1 Estimation of Transportation Demand:

1) Passenger Estimate

Table 4-1 lists number of passengers carried during 1980 - 1986.

From 1980 through 1983 the only available ferryboat was the landing craft type Pleono. During this four year period the number of passengers increased steadily (77,000 to 121,000) with an annual increase rate of 16 percent.

The landing craft type ferry, the Salafai, was introduced in March 1984. The passenger ferry, Lady Samoa, was introduced in May 1985. After these two ferries were placed into service, there was a noticeable increase in the number of passengers.

There were 265,000 passengers in 1984, a figure twice that of 1983's. The 347,000 passengers carried in 1985 were almost three times as many as those of 1983.

Table 4-1

	PASSENGERS	VEHICLES
1980	76,781	8,156
1981	92,762	10,125
1982	105,326	14,156
1983	120,602	14,214
1984	264,826	18,214
1985	347,044	18,263
1986	306,771	17,128

It is believed that the latent transportation demand between the two islands created the dramatic increase in passenger volume in 1984 - 85 and that it was caused by the introduction of two additional ferryboats, and the port facilities improvements made with grant aid from the Japanese Government.

The number of passengers carried in 1986 was less than that of 1985. It can be only assume that the higher 1985 figure was brought on by the novelty of the new high speed Lady Samoa.

In 1986 no passengers were excluded from boarding. We, therefore, assume that the ferryboat capacity in 1986 was sufficient for the demand.

In general, it is considered that the number of ferryboat passengers increases in direct proportion to the increases in population, requirements for items of daily necessity, and the nation's per capita well being needs.

As shown in Fig. 4-2 (page 4-8) the per capita GDP of Western Samoa either decreased or showed no change during 1980 - 85. However, ferryboat passengers increased during this same period and it is assumed that the increase was caused mainly by the need to obtain daily necessities. Also, the Origin and Destination survey was conducted in the Project area revealed that the majority of passengers traveled solely for the purpose of obtaining their daily necessities.

For this Project the estimation of future passenger increases was made based on the assumption that the increase would be in proportion to per capita rate of ferryboat utilization and growing population.

1991 is the target year we set for this new ferryboat project.

(1) Population Forecast:

Based on 1980 - 84 population data, it was estimated that the 1991 population figure to be 165,600, as shown in the following table (also, see Fig. 4-1, page 4-7)

Year	1980	1981	1982	1983	1984	1985	1986	1991
Population Y	155.4	156.3	157.2	158.2	159.1	160.0	161.0	165.6

Unit: 1,000 persons

Where $Y = 0.93 X + 155.4$

Y: Estimated population

X: Number of years from 1980

(2) Per Capita Rate of Ferryboat Utilization:

Based on the assumption that the per capita rate of ferryboat utilization during 1980 - 83 was an increase due to daily necessity, the rates after 1985 and 1986 was estimated as shown in Fig. 4-1, page 4-7.

(3) Passenger Estimation - Case 1 (based on 1980 - 1983 and 1986 data):

Under the assumption that the passenger rate stabilized in 1986, the per capita rate of ferryboat utilization after the year 1986 was estimated by extrapolation; starting from 1986 using the 1980 - 83 rate (see Fig. 4-1, page 4-7). The 1986 rate was 1.905 (306,771 actual 1986 passenger count divided by the estimated 1986 population). The 1991 rate of 2.346 can be obtained from Fig. 4-1, page 4-7. Thus, the 1991 passenger estimate becomes 388,000 (estimated 165,600 population in 1991 multiplied by 2.346).

(4) Passenger Estimation - Case 2 (based on 1980 - 1983 and 1985 data):

Based on an assumption that the sudden increase of ferryboat passengers reached a peak in 1985, the per capita

rate of utilization after the year 1985 was estimated by extrapolation; starting from 1985 using the 1980 - 83 rate (See Fig. 4-1, page 4-7). The 1985 rate was 2.169 (347,044 actual 1985 passenger count divided by the estimated 1985 population of 1985). The 1991 rate of 2.698 can be obtained from Fig. 4-1, page 4-7. Thus, the 1991 passenger estimate becomes 447,000 (estimated 165,600 population in 1991 multiplied by 2.698).

Taking the average of Case 1 and Case 2, the estimated number of ferryboat passengers in 1991 was as 417,000.

2) Vehicle Estimate:

As shown in Fig. 4-2, page 4-8 the number of vehicles transported during 1980 - 1985 showed a steady increase. However, the 1986 figure fell below that of 1985's (see Table 4-1, page 4-8). This decrease was attributable to reductions in service during ferry overhaul and repair periods and to the actual physical reduction in one ferryboat's vehicle handling capacity - the Salafai, overhauled during January - March 1986, was remodeled to accommodate more passengers, thereby limiting the size and number of vehicles to be carried; the Pleono underwent repairs during October - December 1986.

Determining that the 1986 figures could not be used, estimation for future vehicle transporting demands was made by using 1980 - 85 data.

(1) Vehicle Estimate - Case 1 (based on vehicles actually transported):

During 1980 - 85 there was a steady increase in the number of vehicles transported by ferryboats. These vehicles were mainly used to haul daily necessity items.

Western Samoa's gross domestic product (GDP) showed no growth during the 1980 - 85 period. In 1981 the GDP was ten percent less than in 1980; there was no change during 1981 - 83; a

two to three percent annual increase was realized during the 1983 - 85 period. Even though the number of vehicles transported in those years increased, the increase was not in proportion to GDP changes.

The Government of Western Samoa has several future development projects in the making. However, we feel that, even though the Savaii north road project and the few small scale agricultural development projects are to be undertaken, they may not increase the demand for greater vehicle transporting service.

In consideration of the above, it is assumed that the future requirements for vehicle transporting will mainly increase in proportion to the volume of the people's necessity items. Based upon this, the number of vehicles to be transported in 1991 was estimated as 32,000 (see Fig. 4-4, page 4-10).

(2) Vehicle Estimate - Case 2 (based on vehicles actually transported and the number of vehicles registered in the country):

In spite of foreign currency regulations, there was a steady increase in the number of vehicles registered in Western Samoa during the 1980 - 85 period. It was assumed that this increase was brought on by the same reasons as noted in the Vehicle Estimate Case 1 section, namely the increased demand for daily necessity items.

Assuming that the number of vehicles continues to grow, it is estimated that there will be 30,000 registered vehicles in the year 1991 (see Fig. 4-4, page 4-10).

The vehicle estimates in Case 1 and Case 2 are almost same. Therefore, for the ferryboat design purpose, the number of vehicles to be transported in 1991 was decided as 31,000.

There was no classification data available for vehicles transported during the 1980 - 83 period. Although 1984 - 86 data was available, the 1986 figures are not usable for

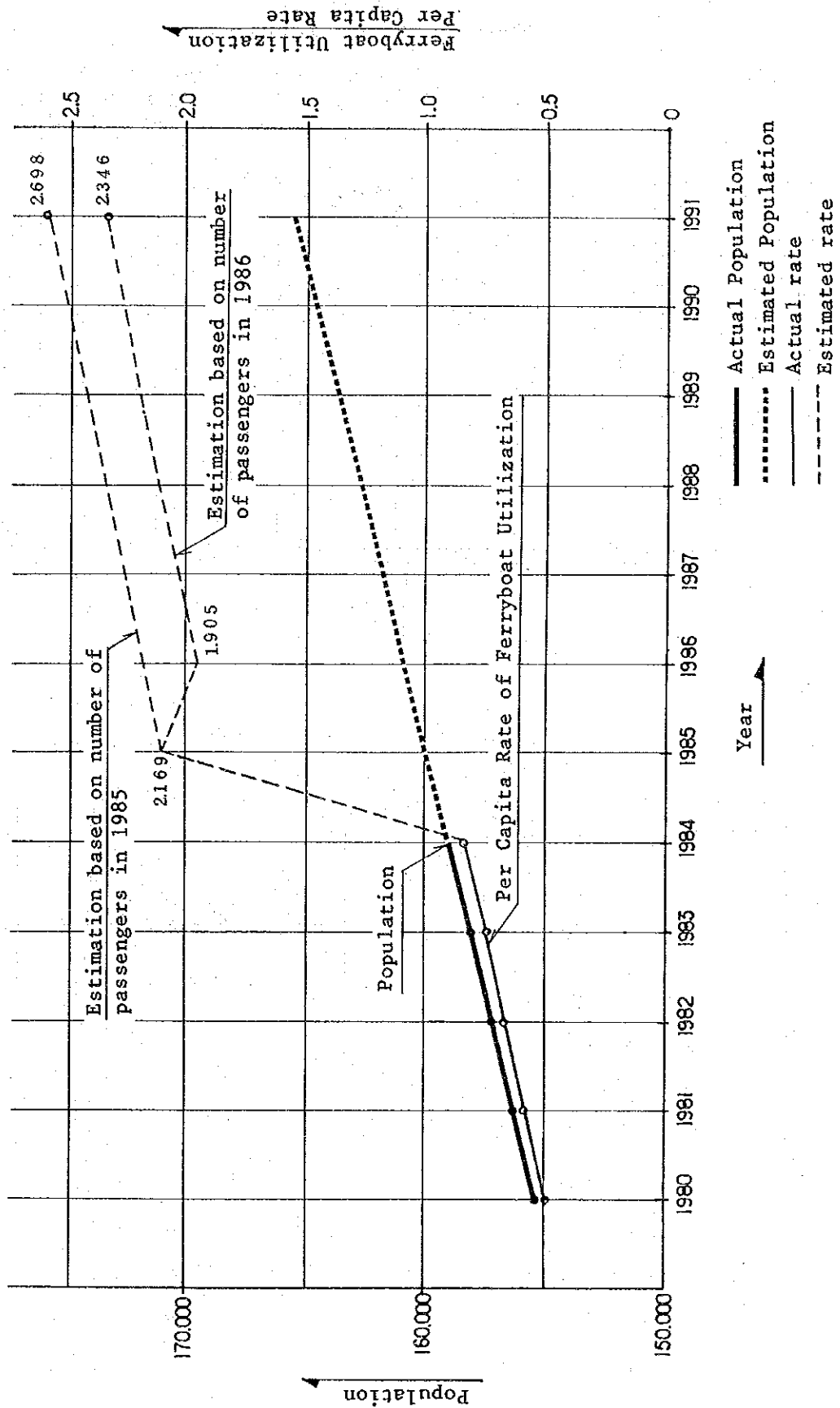
making future estimations. In 1986 the existing demand for vehicle transporting was not met due to a frequent number of interruptions in the ferrying service and because of one ferryboat's vehicle carrying capacity being reduced. Thus, using the 1984 - 85 data, the number of vehicles in each classification to be transported was estimated as shown in Table 4-2.

Table 4.2 Class of Vehicles Transported

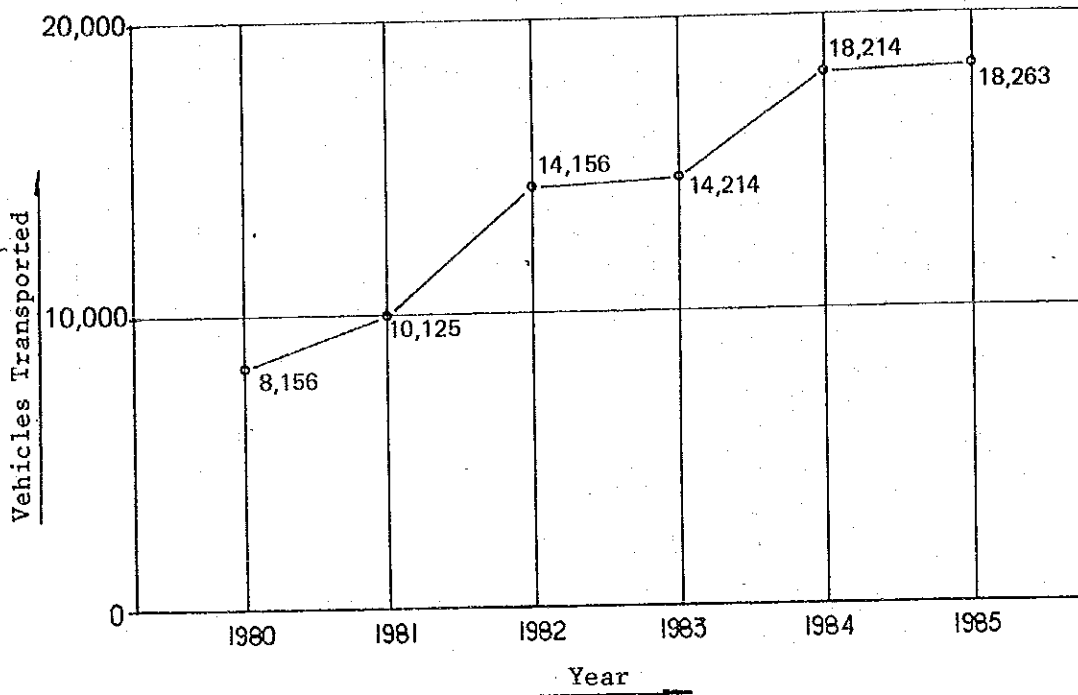
	LIGHT VEHICLES (Sedans/Pickup Trucks)	TRUCKS	TOTAL
1984	11,562 (63%)	6,701 (37%)	18,214 (100%)
1985	11,522 (63%)	6,692 (37%)	18,263 (100%)
1991 (estimated)	19,500 (63%)	11,500 (37%)	31,000 (100%)

Note: The estimated number of vehicles transported in 1986 can be read as 21,000 on the graph shown in Fig. 4-4, page 4-10. Using the same percentages shown in Table 4-2 above, the number of light vehicles and trucks transported in 1986 can be found to be 13,200 and 7,770, respectively.

Fig. 4-1 Capita Rate of Ferryboat Utilization



Number of Vehicles Transported



GDP Per Capita (Base Year: 1980)

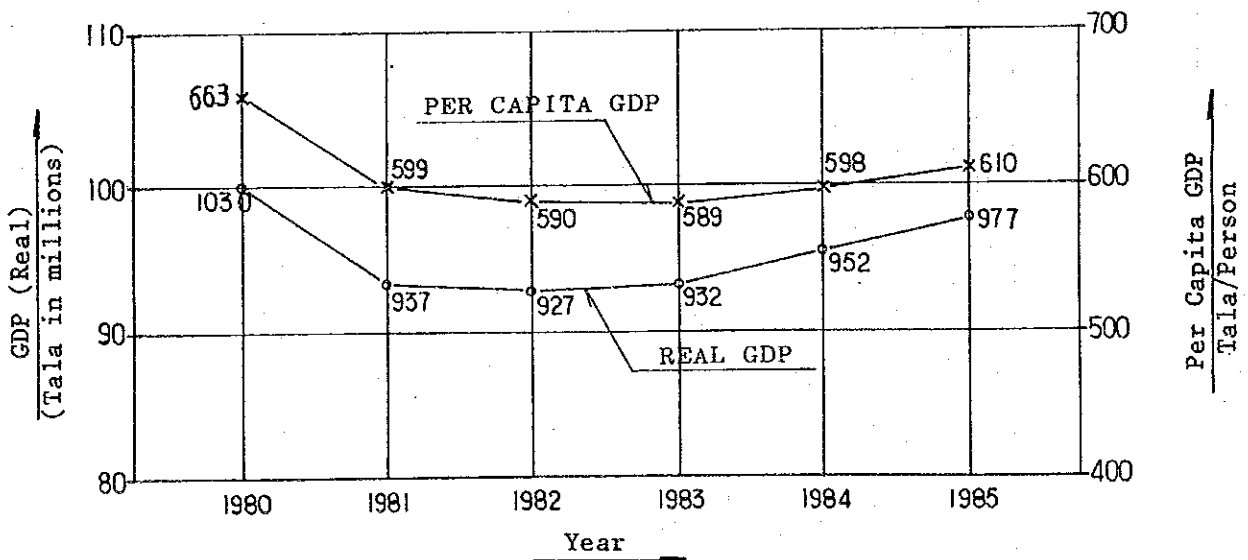
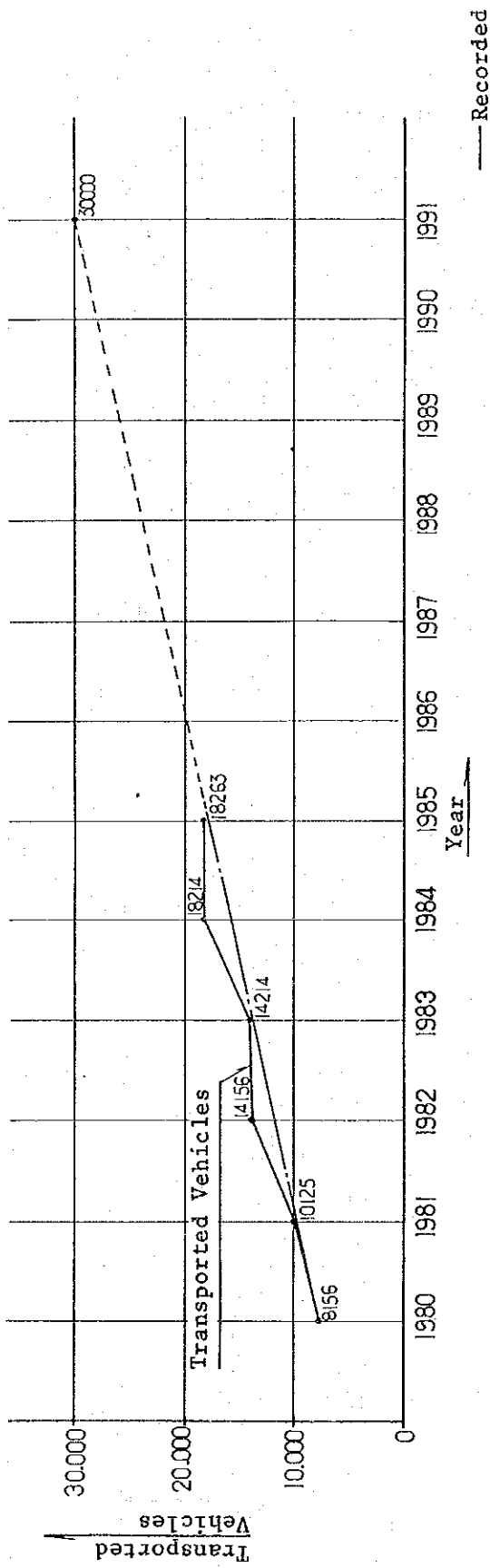


Fig. 4-2

VEHICLES TRANSPORTED BY FERRYBOATS



NUMBER OF REGISTERED VEHICLES

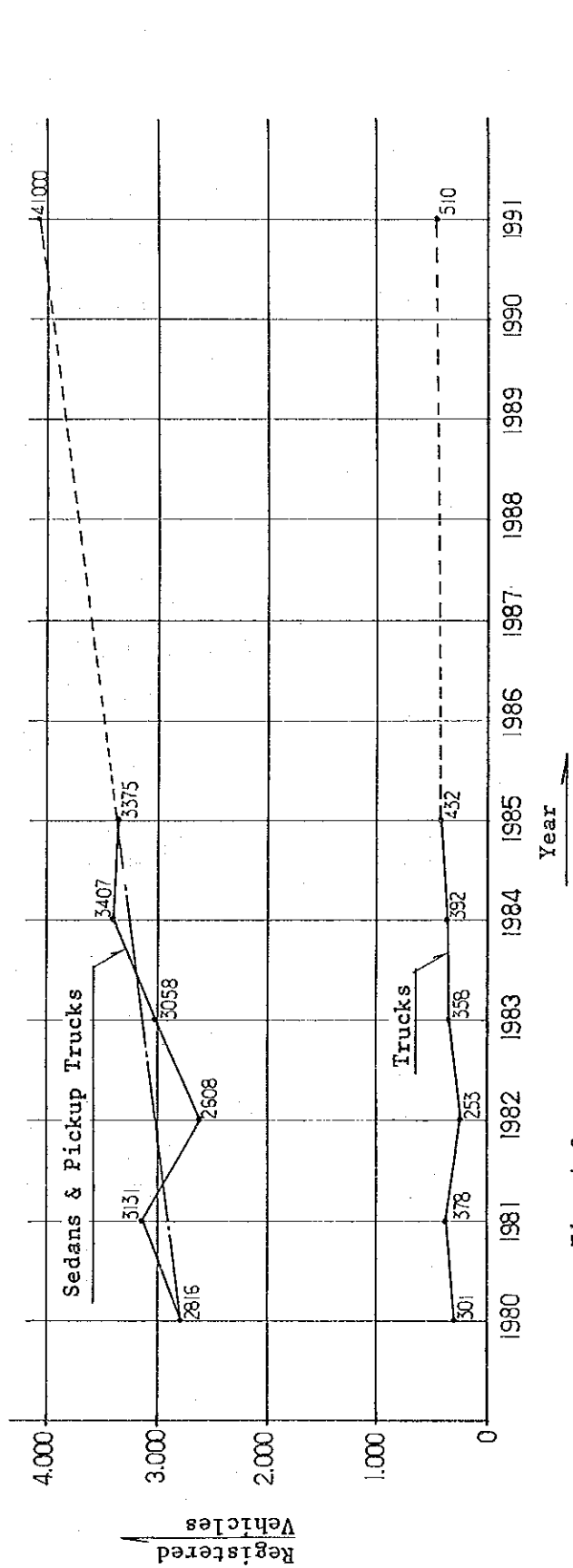
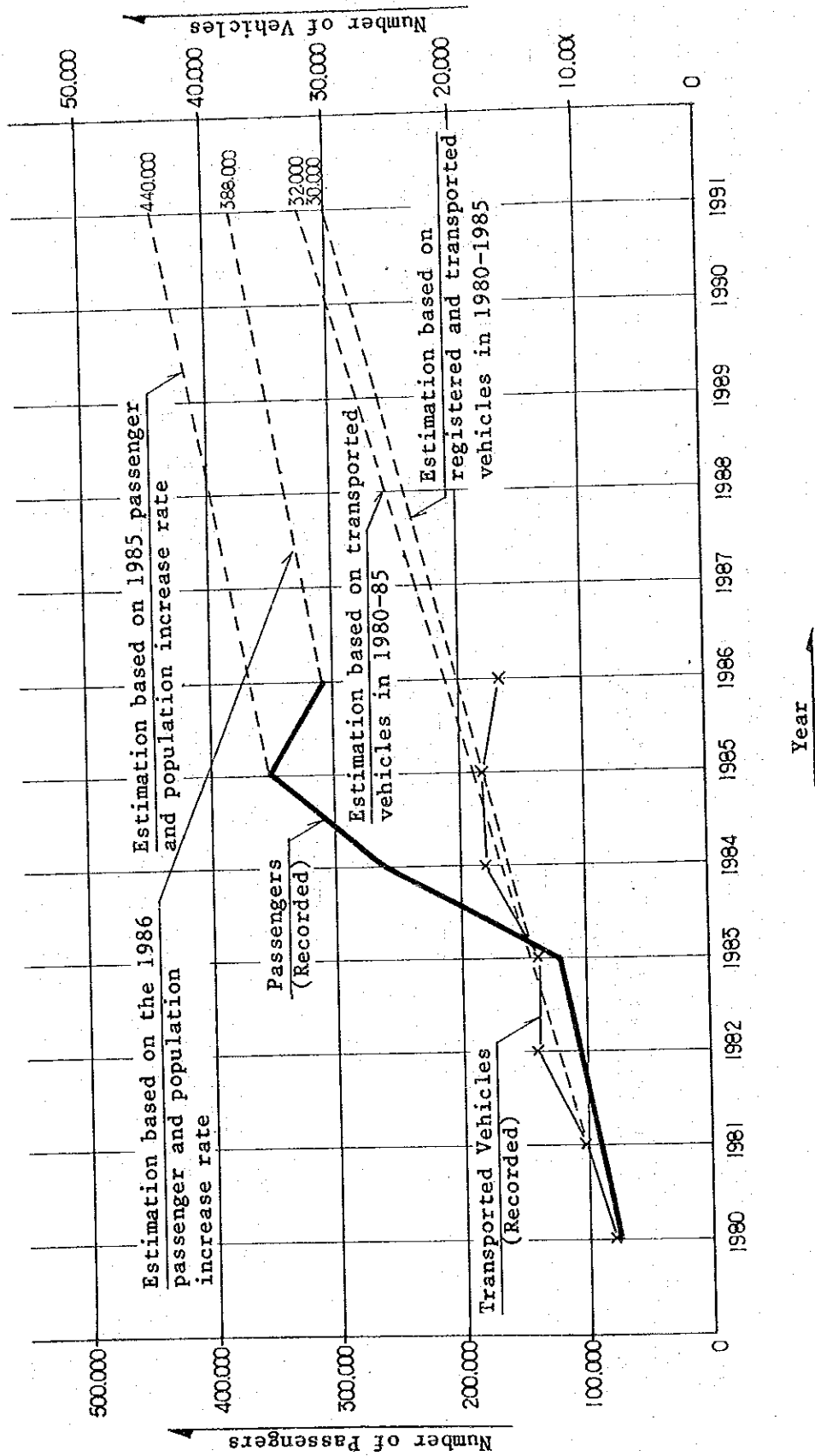


Fig. 4-3

Fig. 4-4 Number of Passengers and Vehicles Transported by Ferryboats



4-1-2 Ferryboat Size

1) Passenger Accommodations:

(1) Under Normal Demand Conditions:

Due to the expected decommissioning of the Pleono and the sale of the Lady Samoa, the estimated 417,000 passengers in 1991 shall be carried by the Salafai and a new ferryboat.

Based on the assumption that the Salafai will be able to make two (2) round trips daily in 1991, she will carry about 163,200 passengers assuming that there are 340 operating days annually;

$$120 \text{ (passenger capacity)} \times 2 \text{ (round trips)} \times 2 \times 340 \text{ (days)} = 163,200.$$

The remaining 253,800 passengers shall be transported by the new ferryboat. Thus, the necessary passenger carrying capacity of the new boat shall be as follows:

Case 1: Two round trips daily
 $(417,000 - 163,200)/340(\text{days})/4 = 187$

Case 2: Two and one half round trips daily
 $(417,000 - 163,200)/340(\text{days})/5 = 149$

Case 3: Three round trips daily
 $(417,000 - 163,200)/340(\text{days})/6 = 124$

(2) Under Peak Demand Conditions:

The number of passengers are subject to daily, seasonal, and other factor changes. The distribution of daily passengers was calculated by using the Poisson's Distribution formula, as follows:

$$F(X) = e^{-\lambda} \frac{\lambda^X}{X!}$$

Where λ = Average daily passengers (expected)

X = Number of passengers

e = Napierian base

Because the Poisson's Distribution is dispersing distribution, the variable λ shall be chosen as 0, 1, 2, 3

There were 306,771 passengers in 1986. Therefore, the average daily number of passengers during the year λ was 902 (306,771 divided by 340).

About one week before and after the country's national holidays (Independence Day in June, White Sunday in October, and Christmas) the number of passengers increases extremely. The maximum daily passenger count in 1986 was 1,700.

By introducing the average daily passengers $\lambda = 902$ for 1986, the Poisson's Distribution Graph (probability distribution function) was obtained as shown in Fig. 4-5, page 4-19. From this graph it can be seen that the probability of having less than 1,700 passengers daily is 97.6 percent.

In the same manner as mentioned above, the Poisson Distribution Graph for the year 1991 was obtained by introducing the average daily passengers $\lambda = 1.226$ (see Fig. 4-5). From this graph, it can be seen that the daily maximum number of passengers attaining the 97.6 occurrence probability level will be 2,160.

(2) Under Peak Demand Conditions:

The estimated number of light vehicles to be transported under peak demand conditions was calculated in the same manner as for passengers. (See Fig. 4-6, page 4-20). In this case, however, we used λ in the Poisson's Distribution equation to indicate the average number of light vehicles to be transported daily:

- Average daily light vehicles to be transported in 1986: $13,200/340 = 38.8$

- Average daily light vehicles to be transported in 1991: $19,500/340 = 57.4$

In 1986, if there were no suspensions to service, the number of transported light vehicles was estimated to be 13,200. For 1991 the estimated number is 19,500 (See Table 4-2).

The maximum number of light vehicles transported daily in 1986 was 70. Introducing this figure into the graph (Fig. 4-6), it can be found that the maximum daily number of vehicles to be transported under peak demand conditions in 1991 will be 96.

The ferryboat Salofai will be able to carry 16 light vehicles daily (4 (capacity) x 2 (round trips) x 2 = 16).

Hence, light vehicles to be transported by the new ferryboat during peak demand conditions shall approximate the numbers shown in the following table:

Number of Light Vehicles to be Transported
under Peak Demand by New Ferryboat

	3 Daily Round Trip	3.5 Daily Round Trip	4 Daily Round Trip
Number of Vehicles	$(96-16)/6 = 13$	$(96-16)/7 = 11$	$(96-16)/8 = 10$

If the new ferryboat is to make three round trips daily, it can be found, by averaging the number of vehicles to be carried under normal conditions (7) and the vehicles to be carried under peak demand conditions (13), the new ferryboat should have the capability to accommodate ten (10) light vehicles.

The combined total number of light vehicles to be carried by the Salafai and the new ferryboat is calculated as follows:

$$10 \text{ (capacity)} \times 3 \text{ (round trips)} \times 2 + 4 \text{ (capacity)} \times 2 \text{ (round trips)} \times 2 = 76/\text{day}$$

To meet the demand of peak periods, the new ferryboat will be able to carry 96 light vehicles daily by making four (4) round trips (see table above).

3) Accommodations for Trucks (larger than 6 ton capacity):

(1) Under Normal Demand Conditions:

An estimated number of 11,500 trucks are to be transported in 1991 (see Table 4-2, page 4-6). As the Salafai does not have truck carrying capabilities, the new ferryboat shall handle the demand for truck transporting.

The number of trucks to be transported is calculated as follows:

$$11,500/340 \text{ (service days per year)} = 34$$

The number of trucks to be transported per trip are shown in the following table:

	2 Daily Round Trip	2.5 Daily Round Trip	3 Daily Round Trip
Number of Trucks	$34/4 = 8$	$34/5 = 7$	$34/6 = 6$

(2) Under Peak Demand Conditions:

The Poisson's Distribution graph (probability distribution function) (Fig. 4-7, page 4-21) was obtained by introducing the following average daily number of trucks to be transported:

- Average daily number of trucks to be transported in 1986: $7,770/340 \text{ (days)} = 23$
- Average daily number of trucks to be transported in 1991: $11,500/340 \text{ (days)} = 34$

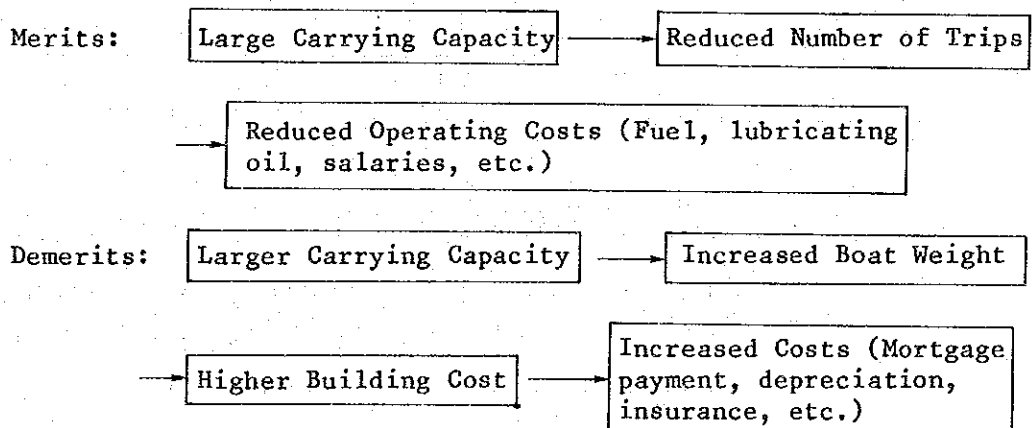
The daily maximum number of trucks transported in 1986 was 45. From the Poisson's Distribution graph it can be seen that there will be a maximum of 63 trucks requiring

transportation daily in 1991 and it is assumed that this figure will represent the total peak demand for that year. The following table reflects the number of trucks the new ferryboat to be accommodated on each of its trips:

	2 Daily Round Trips	2.5 Daily Round Trips	3 Daily Round Trip	3.5 Daily Round Trips
Number of Trucks	$63/4 = 16$	$63/5 = 13$	$63/6 = 11$	$63/7 = 9$

As the area taken up by a truck is greater than that of a light vehicle, it would not be economical to provide space on the new ferryboat to meet the peak truck transporting demand. To do so, would only cause wasted space during normal demand times. Unlike the peak passenger carrying demand, the peak period for trucks will not last more than a few days. From an operational point of view, it is considered that it is more rational to establish the truck handling capacity of the new ferryboat in the 6-8 range.

The correlation between ferryboat size and its merits and demerits in regards to operations is shown as follows:



Based on the above considerations, an economic analysis covering the new ferryboat's four year operations was made. For this analysis, the following information was used.

a. Estimated Transportation Volume and Fares:

Estimated transportation volume from Table 4-2 on page 4-6. (Class of Vehicles Transported), and the following current ferryboat fares were used for calculation;

Passenger: 3.2 Tala (60% adults at 4 Tala each, and 40% children and 2 Tala each)

Light Vehicle: 20 Tala

Truck: 40 Tala

b. Fuel Costs

Following figures were used for analysis.

Number of Round Trips	Main Engine Operating Hours	Annual Operating Hours	Main Fuel Oil Consumption	Fuel Oil Cost	Generator Operating Costs	Total Fuel Costs
	hr/day	hr	KL	1000 Tala	1000 Tala	1000 Tala
2	4.9 "	1,790 "	610 "	366 "	90 "	456 "
2.5	6.2 "	2,260 "	770 "	462 "		552 "
3	7.4 "	2,700 "	920 "	552 "		642 "
3.5	8.6 "	3,140 "	1,073 "	644 "		734 "
4	9.8 "	3,590 "	1,227 "	736 "		826 "

Note: Main engine fuel oil cost - 150 gr/ps/hr, 0.6 Tala/liter

c. Ferryboat Building Costs:

8 Truck capacity: 600,000,000 Yen (7,500,000 Tala)

7 Truck capacity: 591,000,000 Yen (7,390,000 Tala)

6 Truck capacity: 585,000,000 Yen (7,250,000 Tala)

d. Amortization:

Payment period: 15 years

Salvage Value of Ferryboat: 10% of initial value

e. Insurance:

0.7% of ferryboat value.

f. Crew Costs:

A 3% annual increase from the present crew costs and overtime cost for more than three (3) daily round trips were considered.

g. Lubricating Oil Costs:

Number of Round Trips per Day	2	2.5	3	3.5	4
COSTS (Tala)	3,300	4,200	5,000	5,800	6,700

Using the above figures, an economic comparison was made, covering a period of four years (1988 - 1991) for boats having a capacity to carry 6, 7 and 8 trucks (see Fig. 4-8, page 4-22). As this graph shows, the profitability of a ferryboat increases in proportion to its truck carrying capacity.

For the sensitivity analysis on truck transportation demand, the earnings for two cases was calculated: a demand 20% less than the estimated number of trucks to be carried, and a 20% higher demand. The sensitivity analysis shows that the profitability of a ferryboat for 120% demand is in proportion to its truck carrying capacity. On the other hand, as the demand falls below that which was estimated, the profitability of a 7-truck capacity ferryboat will be higher than for one able to carry 8-truck.

From a ship design point of view, the required ferryboat lengths for those having 6, 7 and 8 truck carrying capacities were calculated to be as follows:

8 Truck Capacity: LWL 42.8 m
7 Truck Capacity: LWL 40.0 m
6 Truck Capacity: LWL 37.5 m

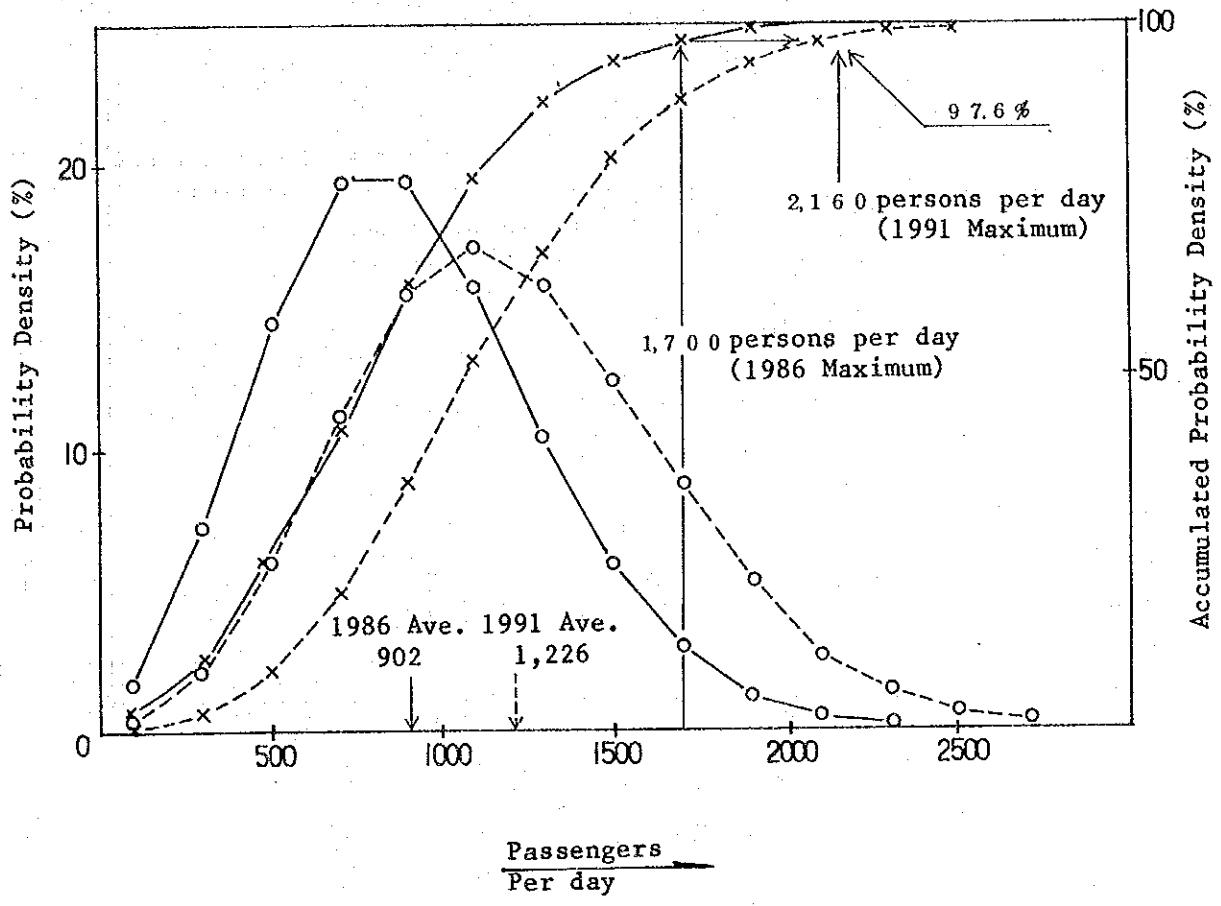
For maneuvering in channels and turning basins, the maximum ferryboat length is about 40 meters, which is equivalent to that of a ferry having the capacity to carry seven trucks.

4) Ferryboat Size:

Summarizing, the required capacity for a new ferryboat is as follows:

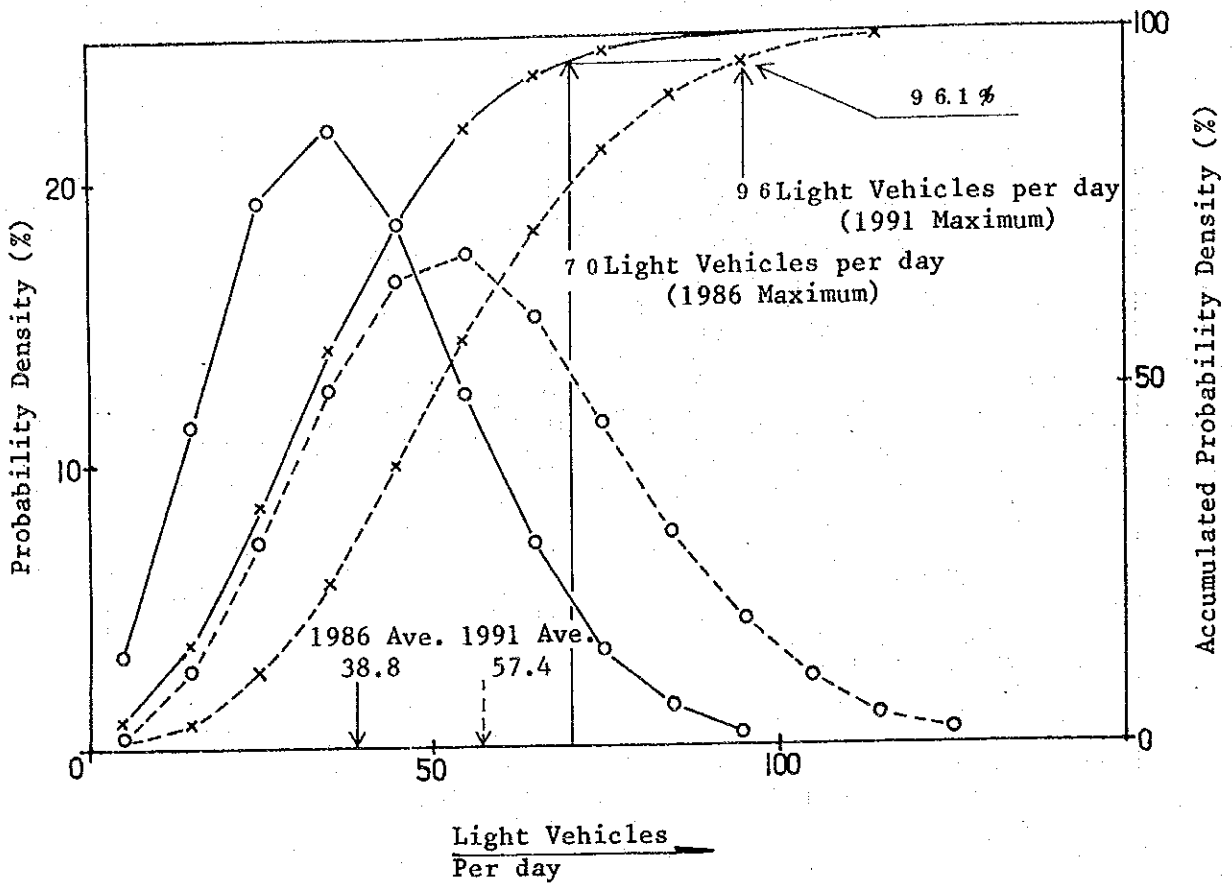
Passengers:	300 (280 passengers + 20 vehicle operators)
Light Vehicles:	10
Trucks:	7

Fig. 4-5 Estimated Daily Maximum Passengers



- 1986 Probability Density
- -○- - 1991 Probability Density
- x— 1986 Accumulated Probability Density
- -x- - 1991 Accumulated Probability Density

Fig. 4-6 Estimated Daily Maximum Light Vehicles to be Transported



- 1986 Probability Density
- -○- - 1991 Probability Density
- x— 1986 Accumulated Probability Density
- -x- - 1991 Accumulated Probability Density

Fig. 4-7 Estimated Daily Maximum Trucks to be Transported

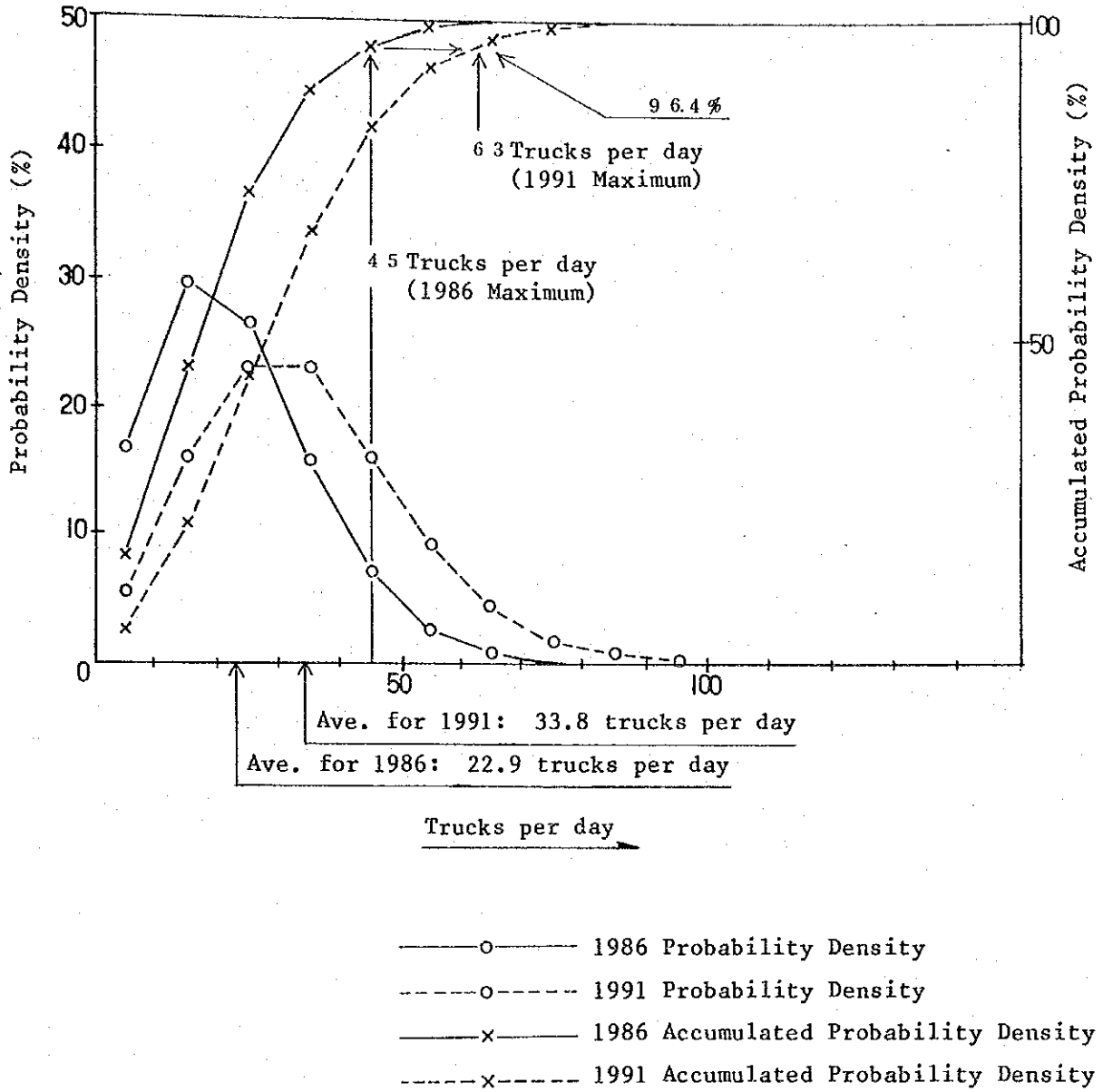


Fig. 4-8 Profitability Comparison of Truck Carrying Capacity
 Estimated Profit for 4 Years (1988 - 1991)

