THE GOVERNMENT OF THE KINGDOM OF TONGA

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTION
OF
NEW TERMINAL COMPLEX
FOR
THE FUA'AMOTU INTERNATIONAL AIRPORT

MAY 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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P R E F A C E

In response to the request from the Government of the Kingdom of Tonga, the Government of Japan has decided to conduct a Basic Design Study on the Project for Construction of New Terminal Complex for the Fua'amotu International Airport and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Tonga a survey team headed by Mr. Koh Hasegawa, advisor of the Environmental Division, Aerodrome Department, Civil Aviation Bureau, Ministry of Transport, from January 23 to February 17, 1989.

The team exchanged views with the officials concerned of the Government of Tonga and conducted a field survey. After the team returned to Japan, further studies were made. Then, a mission was sent to Tonga in order to discuss the draft report and the present report has been prepared.

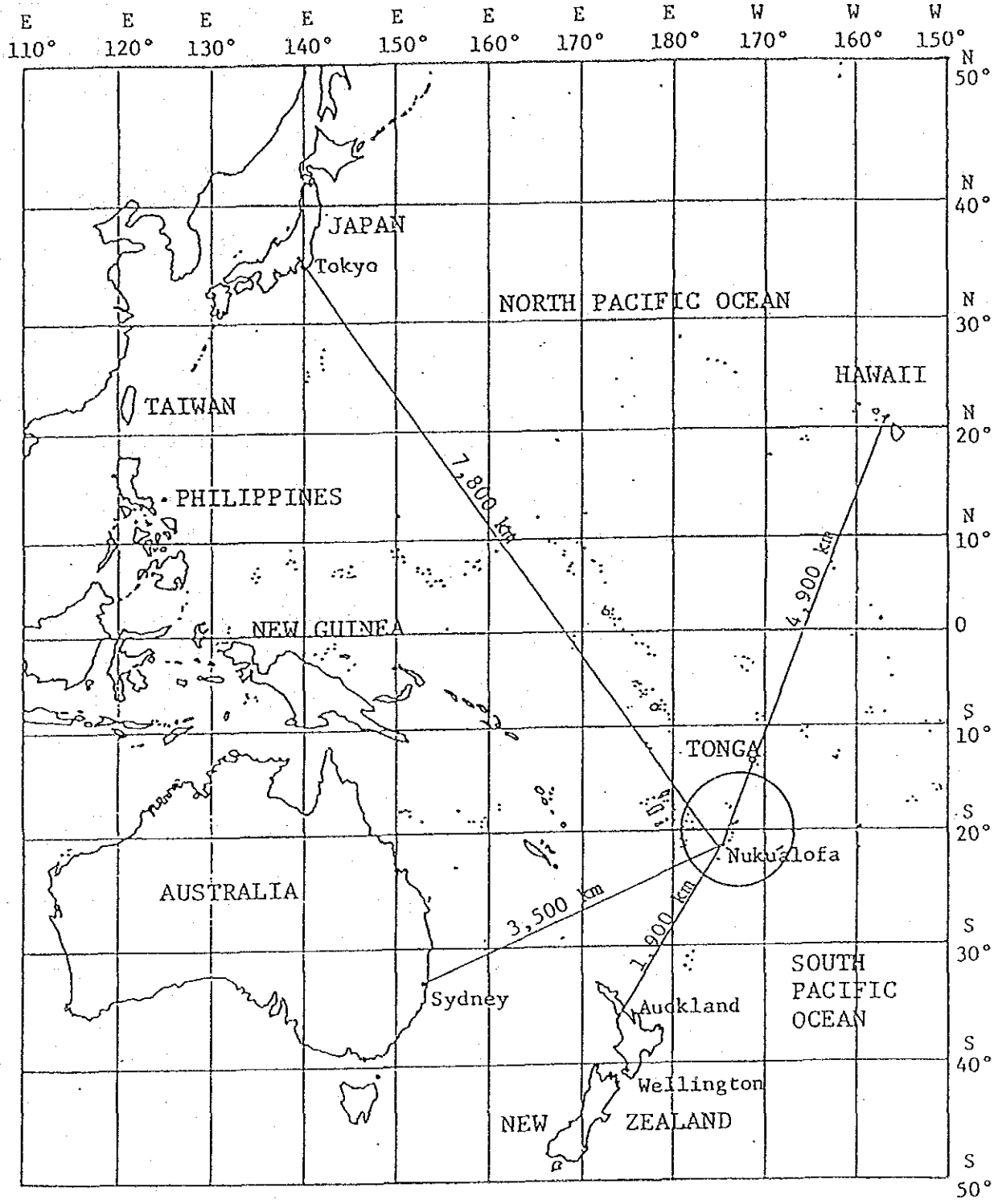
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Tonga for their close cooperation extended to the team.

May, 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency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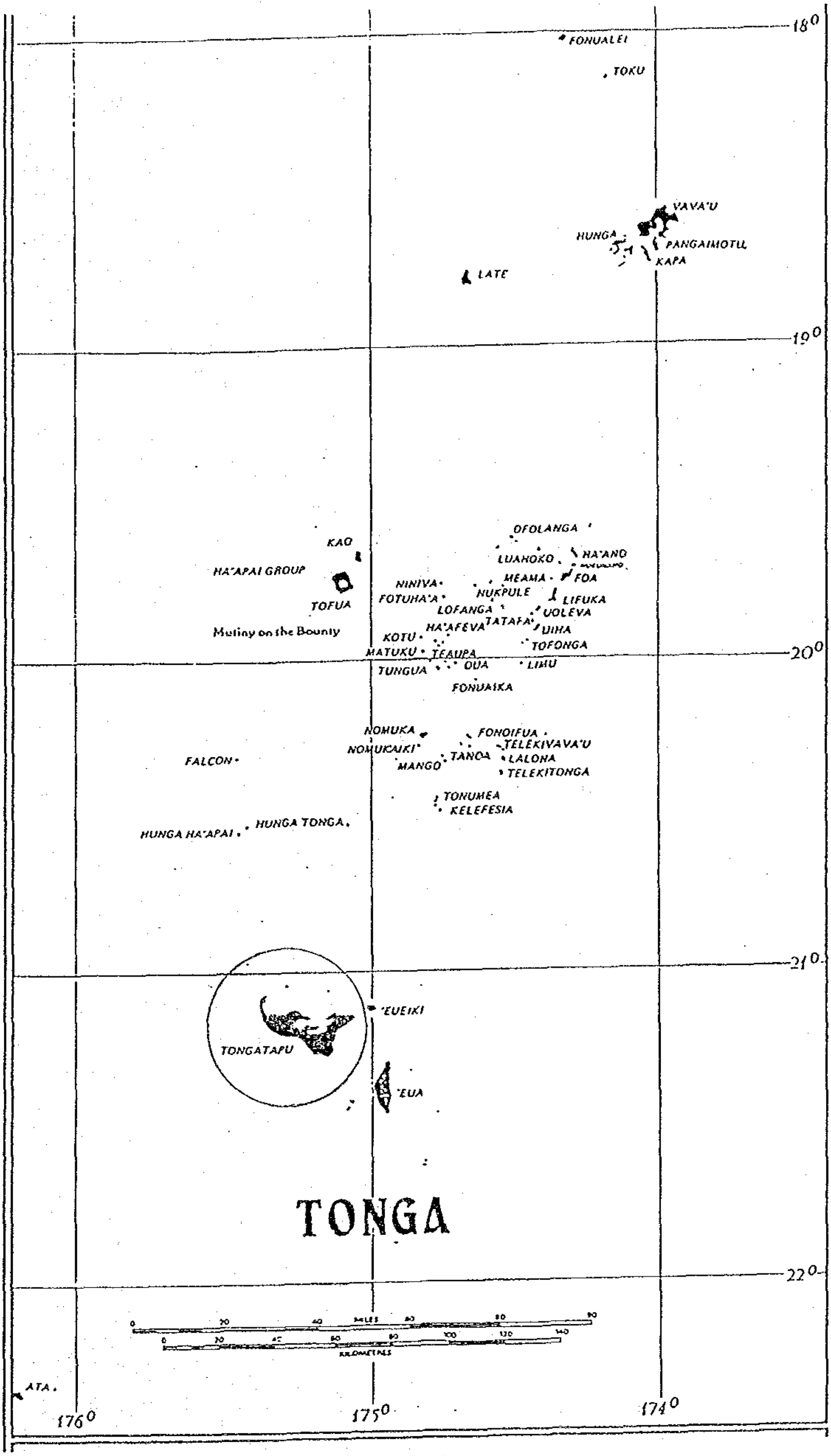
JAPAN
Tokyo
NORTH PACIFIC OCEAN
HAWAII
TAIWAN
PHILIPPINES
7,800 km
4,900 km
NEW GUINEA
TONGA
Nukuʻalofa
AUSTRALIA
3,500 km
1,900 km
Sydney
Auckland
SOUTH PACIFIC OCEAN
Wellington
NEW ZEALAND



18°
FONUALEI
TOKU
VAVA'U
HUNGA
PANGAIMOTU
KAPA
LATE
19°
OFOLANGA
KAO
LUAHOKO
HA'ANO
HA'APAI GROUP
MEAMA
FOA
NINIVA
NUKUPULE
LIFUKA
TOFUA
FOTUHA'A
LOFANGA
UOLEVA
TATAFA
Mutiny on the Bounty
HA'AFEVA
UIHA
KOTU
TOFONGA
MATUKU
TEAUPA
20°
TUNGUA
OUA
LIMU
FONUAIKA
NOMUKA
FONOIFUA
NOMUKAIKI
TELEKIVAVA'U
FALCON
TANOA
LALONA
MANGO
TELEKITONGA
TONUMEA
KELEFESIA
HUNGA TONGA
HUNGA HA'APAI
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TONGATAPU
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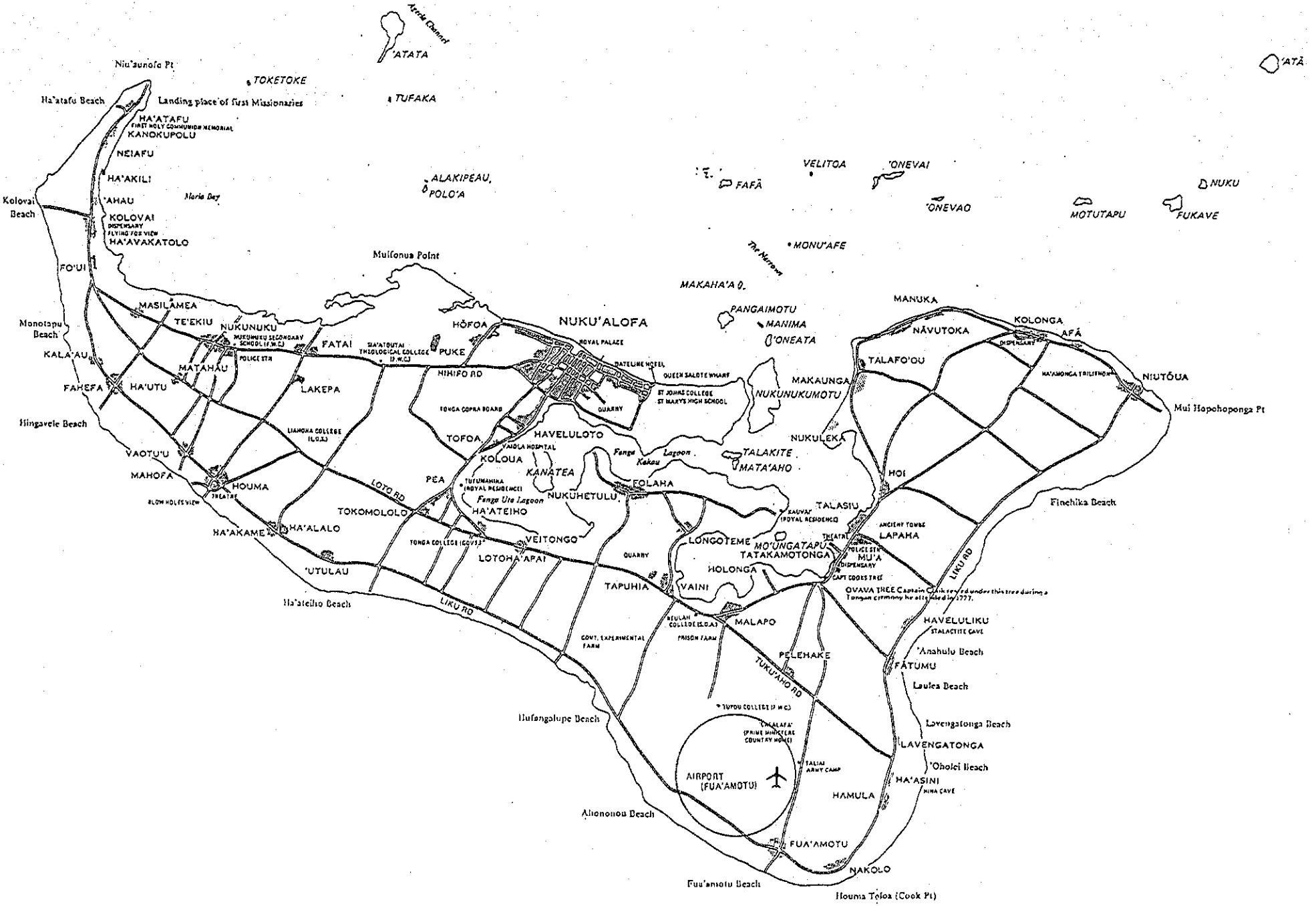

Niu'aunofo Pt
Ha'atafu Beach
Landing place of first Missionaries
HA'ATAFU
FIRST HOLY COMMUNION MEMORIAL
KANOKUPOLU
NEIAFU
HA'AKILI
'AHAU
KOLOVAI
DISPENSARY
FLYING FOX VIEW
HA'AVAKATOLO
Kolovai Beach
Maria Bay
FO'UI
Monotapu Beach
KALA'AU
FAHEFA
HA'UTU
Hingavele Beach
MASILAMEA
TE'EKIU
NUKUNUKU
NUKUNUKU SECONDARY SCHOOL (F.W.C.)
POLICE STN
MATAHAU
FATAI
LAKEPA
LIAHONA COLLEGE (L.D.S.)
VAOTU'U
MAHOFA
HOUMA
THEATRE
BLOW HOLES VIEW
HA'AKAME
HA'ALALO
'UTULAU
Ha'atafu Beach
LIKU RD
TOKETOKE
TUFAKA
'ATATA
Arrow Channel
ALAKIPEAU
POLO'A
Mulfonua Point
HŌFOA
HA'ATOUTAI THEOLOGICAL COLLEGE (F.W.C.)
PUKE
NIHIFO RD
TONGA COPRA BOARD
TOFOA
HAVELULOTO
VAIOLA HOSPITAL
KOLOUA
KANATEA
PEA
TUFUNAHINA (ROYAL RESIDENCE)
Fanga Uta Lagoon
HA'ATEIHO
LOTO RD
TOKOMOLOLO
TONGA COLLEGE (GOVT.)
VEITONGO
LOTOHA'APAI
QUARRY
TAPUHIA
Hufangalupe Beach
NUKU'ALOFA
ROYAL PALACE
DATELINE HOTEL
QUEEN SALOTE WHARF
ST JOHNS COLLEGE
ST MARY'S HIGH SCHOOL
QUARRY
NUKUHETULU
FOLAHA
VAINI
MALAPO
BEULAH COLLEGE (S.D.A.)
PRISON FARM
GOVT. EXPERIMENTAL FARM
PELEHAKE
TUKU'AHO RD
Ahononou Beach
AIRPORT (FUA'AMOTU)
TAUFA'AHAU (PRIME MINISTER'S COUNTRY HOME)
TAUFA'AHAU ARMY CAMP
HAMULA
FUA'AMOTU
NAKOLO
Fuu'amotu Beach
Houma Tofoa (Cook Pt)
VELITOA
'ONEVAI
FAFĀ
'ONEVAO
MOTUTAPU
NUKU
FUKAVE
MONU'AFE
The Narrows
MAKAHA'A 0
PANGAIMOTU
MANIMA
O'ONEATA
MANUKA
NĀVUTOKA
KOLONGA
AFĀ
DISPENSARY
TALAFO'OU
HA'AMONGA TRILITHON
NIUTŌUA
Mui Hapohoponga Pt
MAKAUNGA
NUKUNUKUMOTU
NUKULEKA
TALAKITE
MATA'AHO
Fanga Kakau Lagoon
HOI
TALASIU
ZAUVA' (ROYAL RESIDENCE)
Finehika Beach
ANCIENT TOMBS
LAPAHA
THEATRE
POLICE STN
MU'A
DISPENSARY
CAPT COOKS TREE
LONGOTEME
MO'UNGATAPU
TATAKAMOTONGA
HOLONGA
OVAVA TREE Captain Cook rested under this tree during a Tongan ceremony he attended in 1777.
LIKU RD
HAVELULIKU
STALACTITE CAVE
'Anahulu Beach
FĀTUMU
Laulea Beach
Lovengatonga Beach
LAVENGATONGA
'Oholei Beach
HA'ASINI
MINA CAVE

SUMMARY

SUMMARY

The Kingdom of Tonga (hereinafter called the "Kingdom") comprises approximately 170 scattered islands in the central South Pacific Ocean. Its socio-economic activities are highly dependent on Australia, New Zealand and the European Community (EC). Due to those geographical socio-economic characteristics, air transport plays a key role in the Kingdom.

The Government of the Kingdom of Tonga (hereinafter called the "Government") has been planning the expansion of Fua'amotu International Airport, which is the gateway to the Kingdom. The Government has requested Grant Aid of the Government of Japan for construction of a new passenger terminal building and associated facilities. Grant Aid requests have also been made to the Government of Australia for a 600m extension of the main runway, to the Government of New Zealand for a new control tower and to the EC for improvements of rescue and fire fighting facilities.

In response to the request, the Government of Japan decided to conduct a Basic Design Study on a project for the construction of a New Terminal Complex at Fua'amotu International Airport (hereinafter called the "Project"). The study was carried out by the Japan International Cooperation Agency (JICA), who dispatched a study team, headed by Mr. Koh Hasegawa, advisor of the Environmental Division, Aerodrome Department, Civil Aviation Bureau, Ministry of Transport, Japan, to the Kingdom and other neighbouring countries (Australia, New Zealand and Fiji), from January 23 to February 17 1989. The team held discussions on the requested Grant Aid with officials concerned of the Tongan Government, and conducted necessary field surveys, data collection and analysis.

Following the study, the scope of work for the Project was determined as follows:

(1) Construction of new terminal building.
(2) Construction of new apron and taxiway including lighting facilities.
(3) Construction of new car park including lighting facilities.
(4) Installation of stand-by power supply for the new terminal building and apron floodlights.
(5) Supply of ground service equipment.

The Project will be implemented in the following two stages:

Stage 1 : Construction of New Terminal Building
Stage 2 : Construction of Apron, Taxiway, Road, Car Park and Provision of Ground Service Equipment (GSE)

The executing agency will be the Ministry of Civil Aviation. Management, operation and maintenance of the completed facilities will also be the responsibility of this ministry.

The Project is to provide sound and efficient air transportation to the Kingdom , and, as a result, will make a great contribution to the development of the national economy through improvement of the tourism industry which is a major foreign exchange earner.

TABLE OF CONTENTS

Page

Page

APPENDICES

ABBREVIATIONS

ABN :	Aerodrome Beacon
AC :	Alternating Current
ACC :	Area Control Centre
ACCA :	Airport Consulting and Construction Australia (Pty) Ltd
ADAB :	Australian Development Assistance Bureau
AIDAB :	Australian International Development Assistance Bureau
A/G :	Air to Ground Communication
AKL :	Auckland (New Zealand)
ALS :	Approach Lighting System
AMS :	Aeronautical Mobile System
APP :	Approach Control
APRON F.L. :	Apron Floodlight
APT RX :	Automatic Picture Transmission Receiver
APW :	Apia (Western Samoa)
ATC :	Air Traffic Control
CBR :	California Bearing Ratio
CCU :	Communication Control Unit
C.I.Q. :	Customs, Immigration and Quarantine
CPI :	Consumer Price Index
DC :	Direct Current
DME :	Distance Measuring Equipment
EC :	European Community
E/N :	Exchange of Notes
EUA :	'Eua (Tonga)
FAA :	Federal Aviation Administration
FIA :	Friendly Island Airways (Tonga)
F/C :	Flight Information Centre
Fig. :	Figure
FJI :	Air Pacific (Fiji)
GDP :	Gross Domestic Product
GS :	Glide Slope
GSE :	Ground Service Equipment
HAL :	Hawaiian Airlines (USA)
HAP :	Ha'apai (Tonga)
HF :	High Frequency

ICAO :	International Civil Aviation Organization
IEC :	International Electrotechnical Commission
IM :	Inner Marker
INT.COM :	Intercommunication System
IWDI :	Illuminated Wind Direction Indicator
JASS :	Japan Architectural Standard Specification
JIS :	Japanese Industrial Standard
JICA :	Japan International Cooperation Agency
LLZ :	Localizer
LTY :	Landline Teletype
MAS :	Manual Al Simplex
mill. :	Million
MIC.LINK :	Microwave Link
MM :	Middle Marker
MSS :	Message Switching System
NA :	Not Available
NAN :	Nadi (Fiji)
NDB :	Non-Directional Radio Beacon
OM :	Outer Marker
PPG :	Pago Pago (American Samoa)
RCAG :	Remote Centre Air to Ground
REIL :	Runway End Indication Light
RTTY :	Radio Teletype
RVR :	Runway Visual Range Measuring Equipment
RWCL :	Runway Centreline Light
RWEL :	Runway End Light
RWTL :	Runway Threshold Light
RWYL :	Runway Edge Light
SALS :	Simple Approach Lighting System
SMC :	Surface Movement Control
SPEC :	South Pacific Bureau for Economic Co-operation
Sta. :	Station
SUV :	Suva (Fiji)
TACAN :	Tactical Air Navigation System
TDZL :	Touchdown Zone Light
TMS :	Constant Current Transformer
TPEL :	Turning Pad Edge Light

T-VASIS :	Terminal-VASIS
TWCL :	Taxiway Centreline Light
TWYL :	Taxiway Edge Light
UHF :	Ultra High Frequency
VASIS :	Visual Approach Slope Indicator System
VAV :	Vava'u (Tonga)
VFR :	Visual Flight Rules
VHF :	Very High Frequency
VOR :	VHF Omni-Directional Radio Range
WIND :	Windvane and Anemometer
WX FAX :	Weather Facsimile
WX RADAR :	Weather Radar
WX TELEX :	Weather Telex

CHAPTER 1. INTRODUCTION

CHAPTER 1 INTRODUCTION

The Kingdom of Tonga, as a member of the British Commonwealth, is closely linked to other Commonwealth countries such as Australia and New Zealand. The Kingdom is very dependent on these countries for its technical and manpower resources development. At the same time, a considerable portion of the workforce has sought employment in these developed countries, as well as the United States. It is a unique feature of the Kingdom that the foreign exchange earnings of these workers contribute greatly to the national economy. Accordingly, air transport plays a very important role in such geographical and socio-economic situations. In the Fifth Five-year Development Plan, the Government places strong emphasis on the development of tourism to increase foreign exchange income and employment opportunities. As a substantial step toward achieving this objective, the Government has been planning the expansion of Fua'amotu International Airport, which is the gateway to the Kingdom. The Government of Tonga has requested Grant Aid from the Government of Japan for construction of a new passenger terminal building and associated facilities.

The request to the Government of Japan may be summarized as follows:

(1) Construction of a new passenger terminal building

(2) Construction of a new apron and taxiway

(3) Construction of road and car park

(4) Provision of GSE

In response to this request, the Government of Japan dispatched a preliminary study team to Tonga in October 1988 headed by Mr. M. Yoshida, Deputy Director of the Economic Co-operation Bureau in the Ministry of Foreign Affairs. The team held discussions with officials concerned of the Government of Tonga and conducted site surveys. They also met with officials of the South Pacific Bureau for Economic Cooperation (SPEC) and the Government of Australia. It was apparent that all these officials were actively studying the airport

development proposals. It has been determined that this airport upgrading project would improve air transport services in Tonga substantially and thereby enhance tourism development. It is therefore considered suitable as a Grant Aid project.

On the basis of this preliminary study, the Government of Japan decided to conduct a basic design study. The Japan International Cooperation Agency (JICA) dispatched a basic design study team headed by Mr. K. Hasegawa, advisor of the Environmental Division, Aerodrome Department, Civil Aviation Bureau, Ministry of Transport, to the Kingdom and neighbouring countries including Australia, New Zealand and Fiji from January 23 to February 17, 1989. The team met with officials of the Government of Tonga and surveyed and confirmed the following matters:

(a) Background of the request for this financial assistance

(b) Details of the request for this financial assistance

(c) Details of the financial assistance from other countries.

(d) Topographic survey and soil investigation of the proposed site

(e) Airport operation and maintenance programme

(f) Physical and socio-economic conditions in the Kingdom

(g) Existing situation of Fua'amotu International Airport

(h) Overall development plan of Fua'amotu International Airport

(i) Traffic survey at the existing passenger terminal building and car park

(j) General conditions of construction

Based on the survey results, major points of understanding between the study team and the Tongan government officials were agreed upon on February 1, 1989 as shown in Appendix E.

After the study team returned to Japan, the team examined in detail the request of the Government of Tonga and conducted basic design, and were dispatched again to the Kingdom from April 16 to 27, 1989 to explain the Draft Final Report. As a result, the study team and the Tongan government officials were principally agreed on the report, and the Minutes of Discussions on the basic design study were exchanged between the both parties on April 24, 1989, as shown in Appendix G.

This Final Report has incorporated necessary alterations which were examined after the team returnd to Japan.

The organization of the study team, study itinerary, list of personnel visited, minutes of discussion, etc are given in Appendices.

CHAPTER 2. BACKGROUND OF THE PROJECT

CHAPTER 2 : BACKGROUND

2.1 PHYSICAL AND SOCIO ECONOMIC CONDITIONS

2.1.1 Physical Conditions

The Kingdom of Tonga comprises approximately 170 islands scattered in the south central Pacific Ocean between latitudes 15°00' and 23°30' south and between longitudes 170° and 177° west. The country is situated approximately 700 km south-east of Fiji and 800 km south of Western Samoa and the islands are divided into 4 major groups. These are Niuas at the northern tip, Vava'u in the north, Ha'apai in the centre and Tongatapu in the south. The total land area is approximately 700km^2 and the country is surrounded by 700,000 km^2 of territorial waters.

The islands in the northern and western regions are volcanic. The highest volcanic mountain (1,030m) is on the island of Kao at the north-west extremity of the Ha'apai group. Coral islands are located in the central and southern regions and are relatively flat. The maximum altitude on the largest island, Tongatapu, is 65m.

Tonga has a sub-tropical climate and temperatures range from 10°C in July/August to 30°C between January and April. Annual average temperatures are 23.5°C in the northern regions and 21°C in the southern regions. Annual rainfall for the northern region is 2,500mm and 1,500mm for the southern region.

2.1.2 Population

The population of Tonga is approximately 100,000 and the population density is 138 per km^2. Only 36 of the 170 islands are inhabited. Many of the islands are not inhabited as they are geographically too isolated and do not provide a reasonable living environment. In recent years there has been a population drift to Tongatapu Island, and particularly to the capital city Nuku'alofa. Relatively high wages and a higher standard of living in this area have caused this drift.

2.1.3 National Economy

The Tongan economy is heavily dependent on primary industries. In recent years the value of imports has far exceeded exports. In an attempt to redress this situation, the Government of Tonga has placed a high priority on tourism development on the basis of the Kingdom's abundant natural resources.

Table 2.1. Gross Domestic Product

	1980/81	1981/82	1982/83	1983/84
Gross Domestic Product (T$ mill.)	53.5	59.9	66.2	78.0
GDP Per Capita (T$)	567	625	680	809

The recurrent budget has been kept under control and the development budget has been financed largely through grant aid.

The Tongan currency is the Pa'anga (Tongan dollar), which is approximately equivalent in value to the Australian dollar. As of February 1989, T$ 1 was approximately equivalent to US$ 0.91 or ¥118.

Recent Consumer Price Index is shown below.

Table 2.2. Consumer Price Index

	1976	1980	1981	1982	1983	1984	1985
Consumer Price Index (CPI)	100	168.6	197.6	221.2	222.9	239.9	267.3
Annual Increase Rate (%)		11.8	17.2	11.9	3.9	4.3	11.4

In order to maintain the economic independence of Tonga it is vital that the tourism industry be developed. Upgrading of the international airport is an essential basic infrastructural improvement for this development.

With the value of imports far exceeding exports, the trade deficit has worsened steadily over the years. Tonga's main trading partners are Australia and New Zealand. These two countries together take 90% of Tongan exports and provide 60% of her imports.

Table 2.3. Balance of Trade

Unit: T$ mill.

	1966~70	1971~75	1976~80	1981~85
Import	25.6	46.5	108.0	206.5
Export & Re-export	17.1	16.6	28.7	33.4
Trade Balance	- 8.5	- 29.9	- 79.3	- 173.1

Table 2.4. Foreign Exchange Reserve

	1980/81	1981/82	1982/83	1983/84
Foreign Exchange Reserves (T$ mill.)	14.8	16.1	16.0	22.4
Annual Increase Rate (%)		8.8	- 0.1	40.0

The main export products are coconut oil, copra, bananas and vanilla. The main imports are electrical appliances, food, fuel and machinery. Although there is a large trade deficit, the foreign payments situation is balanced by remittances from Tongan nationals living and working abroad, by grant aid funding for development projects and by revenue from tourism. The net result is that foreign exchange reserves have continued to grow, although only marginally.

The Tongan government is now placing a strong emphasis on tourism development in an effort to increase foreign exchange earnings, as the country has abundant natural resources.

The number of visitors to Tonga during the period of the Fourth Five-Year Development Plan (1981-1985) is shown in Table 2.5 below.

Table 2.5. Visitors to Tonga

	1981	1982	1983	1984	1985
No. of Visitors	81,016	82,000	92,494	84,769	81,199
Annual Growth Rate (%)		1.2	12.8	▲ 8.4	▲ 4.2

An increasing trend in the number of visitors over the past 5 years cannot be observed. Visitors by ship account for 51-56% of the total number and visitors by air 15-18%. The number of visitors by air has increased marginally.

As of March 1988, 20 accommodation facilities were being operated on Tongatapu and the smaller islands, but many of them were not suitable for international visitors.

According to the Fifth Five-Year Development Plan, in 1985 the total capacity of hotels was 145 rooms and that of motels/guest houses was 158 rooms in 1985. The numbers of rooms in 1980 and 1985 are shown in Table 2.6 below.

Table 2.6. Number of Rooms on Tongatapu

Unit: Room

	1980	1985
Hotel	104	145
Motel/Guest House	82	158
Total	186	303

The total number of rooms has increased by 60%, while high standard rooms have increased by 40% and budget type accommodations by 90%.

Tourism administration is a function of the Ministry of Labour, Commerce and Industry (MLCI). Tourism development is implemented following agreement between the MLCI and the Tonga Visitors Bureau.

Areas designated for conservation, such as certain coastal regions and historical sites, are administered by the Ministry of Lands, Surveys and Natural Resources, supervised by the Tonga Tradition Committee.

During the Fourth Five-Year Development Plan, foreign earnings from tourism were as follows:

Table 2.7. Foreign Exchange Earnings from Tourism

	1980/81	1981/82	1982/83	1983/84	1984/85
Earnings (T$ MILL.)	5.7	5.4	5.3	6.7	7.0
Annual Growth Rate (%)	—	▲ 5.3	▲2.9	26.4	4.5

2.1.4 National Development Plan

The Kingdom's development strategy is planned on the basis of consecutive 5-year planning periods. The Fifth Five-Year Development Plan is currently being implemented and covers the period from 1986 through 1990. The Fifth Five-Year Development Plan defines the priorities and objectives of the long-term economic and social development of the Kingdom.

The main objectives of this long-term economic and social development are to:

- promote continuous economic growth and an even distribution of wealth.
- increase the standard of living, quality of life and security of the people.
- promote indigenous culture and preservation of the environment.
- establish a society where individual effort and endeavour will be rewarded.

The primary objective of the Fifth Five-Year Development Plan is to promote the development of the private sector and encourage its participation in the economic development of the Kingdom. It is envisaged that this can be accomplished by providing the necessary infrastructure to allow the people of Tonga to expand the agriculture, fisheries and tourism industries.

Table 2.8 shows the planned sectoral allocation of development expenditure for the period of the Fifth Five-Year Development Plan. The budget for this period represents a 20% increase over that for the Fourth Five-Year Development Plan. The table indicates that investment in tourism will increase by 50% and investment in civil aviation, telecommunications, roads and water supply will also increase significantly. In sectors where planned investment is expected to decrease, this is caused generally by the completion of particular projects which constitute a significant proportion of that sector's budget.

The major investment planned in the financial field is the T$ 13.5 million funding for the Tonga Development Bank.

Table 2.8. Allocation of Development Budget in DP V

Unit: T$ mill.

	DP IV		DP V		
	Total Expenditure Plan Period	Share (%)	Total Expenditure Plan Period	Increase over DP IV (%)	Share (%)
Agriculture/Forestry	8.8	7.1	10.7	21.6	7.2
Fisheries	12.5	10.0	12.5	-	8.4
Manufacturing/Industry	8.2	6.6	5.2	- 37.6	3.5
Banking/Finance	4.4	3.5	15.1	343.2	10.1
Tourism	0.4	0.3	6.2	1,550.0	4.1
Sub-total (Economic Services)	34.3	27.6	49.7	44.8	33.2
Construction/Housing	7.6	6.1	6.4	- 15.8	4.3
Energy	5.3	4.3	2.1	- 60.4	1.4
Water	2.5	2.0	4.9	96.0	3.3
Marine	20.1	16.1	8.8	- 56.3	5.9
Roads	5.1	4.1	9.8	92.1	6.6
Civil Aviation	3.8	3.1	22.4	589.5	15.0
Telecommunications	2.2	1.8	11.1	504.5	7.4
Broadcasting	-	-	2.1	-	1.4
Sub-total (Infrastructure & Transport)	46.6	37.4	67.6	45.1	45.3
Education	20.3	16.3	18.4	- 9.4	12.3
Health	10.4	8.4	6.9	- 33.7	4.6
Sub-total (Social Services)	30.7	24.7	25.3	- 17.6	16.9
Miscellaneous Government Services	5.6	4.5	3.6	- 35.7	2.4
Staffing & Administration	7.3	5.9	3.3	- 54.8	2.2
Sub-total (Government Services)	12.9	10.4	6.9	- 46.5	4.6
Total Development Expenditure	124.5	100.0	149.5	20.1	100.0

The bulk of the investment planned in the field of civil aviation is for :

(a) procurement of aircraft for Friendly Island Airways
(b) re-sealing of the runway at Fua'amotu Airport
(c) extension of the runway at Fua'amotu Airport

The total investment in these projects is estimated at T$ 15 million.

Investment in the telecommunications sector is largely for improvement of the communication system between the islands (T$ 7.47 million) and for improvements to the rural telecommunications system (T$ 1.88 million). These projects together account for approximately 84% of this sector's allocation.

The Government of Tonga has recognized the need to reduce the country's dependence on primary industries and places top priority on development of the private service sectors. The Government plans to promote the tourism sector through utilization of the Kingdom's abundant natural resources, with a view to generating increased foreign exchange and improving the employment situation.

All the aforementioned developments, viz. procurement of aircraft, improvements to airports, improvements to telecommunications facilities and development of tourism facilities, as well as improvement of the road network, will contribute to promotion of the tourism industry. This development trend should be continued in the future.

2.2 TRANSPORTATION

2.2.1 Road Transportation

As mentioned previously, Tonga is made up of approximately 170 scattered islands lying roughly in a north-south orientation. Road transportation can not be inter-island and is confined to certain islands only.

It is estimated that there were approximately 3000-3500 registered vehicles in Tonga in 1986, although precise data is not available. Of this total, 60% were passenger vehicles and light trucks.

For public transport there are bus and taxi services. Between the airport and the capital city of Nuku'alofa, bus and taxi services are provided by hotels.

The following tables are taken from the 1985 road inventory of the Ministry of Works:

Table 2.9. Road Inventory (1986)

Function	Required Standard	Planned Length (km)	Actual Length (km)
Highway	Class A	60.9	58.7
Trunk	" B	363.6	27.1
Feeder	" C	640	117.5
Access	" D	670	129
Earth Tracks		-	1,402.2
Total		1,734.5	1,734.5

Table 2.10. Technical Standards (1986)

Class	Road Width excl. Drains (m)	Pavement Width (m)	Pavement Thickness (mm)
A	10.98	8.0	300 (1)
B	9.15	7.0	250 (1)
C	6.0	6.0	200 (2)
D	4.0	4.0	150 (2)

(1) Minimum standard is 1 prime seal plus finish coat.

(2) Paved with gravel.

As indicated in Tables 2.9 and 2.10, improvements have been effected to highways, but many other roads require widening and surfacing. There are considerable lengths of feeder and access roads and most of them are in need of attention.

2.2.2 Marine Transport

Harbours and wharves in Tonga are used for international and domestic (island and inter-island) services. A ferry service is in operation for long distance inter-island travel while small boats with outboard motors are used for travel within island groups.

Queen Salote Wharf (Nuku'alofa) has adequate capacity to handle Tonga's international trade. Extensions to this wharf were completed under an Australian aid agreement and cargo handling facilities were upgraded with EEC funding. The number of vessels using this wharf and cargo quantities handled are shown in Table 2.11 below.

Table 2.11. Queen Salote Wharf

	1981	1982	1983	1984	1985
Vessel (international)	NA	NA	NA	811	644
Vessel (domestic)	168	152	147	171	157
Cargo (import)	58,300	70,036	59,452	63,903	63,207
Cargo (export)	18,550	11,403	10,746	14,368	19,954

From the table it is evident that there was a negligible increase in cargo handled between 1980 and 1985.

Work has recently been completed on extensions and additions to the nearby Faua Fisheries Wharf which is being developed as a commercial area. The town of Neifa on Va'vau is a famous port of call for large luxury cruisers. International class facilities have been constructed at this natural harbour.

2.3 AIR TRANSPORT

2.3.1 Airports

There are 6 airports in Tonga, including 2 international - the Fua'amotu Airport on Tongatapu Island (runway length 2,071m) and the Lupepau'u Airport on Va'vau Island (runway length 1,700m). Particulars of the airports are shown in Table 2.12.

There are presently no international flight services to Lupepau'u. However it is expected that the airport will re-introduce international services after EC funded improvements, including paving of the runways, construction of a new terminal building and improvements of the air traffic control facilities, are completed in 1990.

Table 2.12. Airports in TONGA

Aerodome	Length (m)	Surface	Aircraft Suitability
Fua'amotu (Tongatapu)	2,071	asphalt	L-1011
Lupepau'u (Vava'u)	1,700	sealed	DHC 6
Salote Pilolevu (Ha'apai)	1,145	coral	DHC 6
Kaufana ('Eua)	731	grass	BN 2A
Mata'aho (Niuetopotapu)	729	coral	BN 2A
Lavinia (Niuenofo'u)	1,065	grass	BN 2A

2.3.2 Flight Services

Fua'amotu International Airport is the hub of domestic flight operations. It is also the gateway to the Kingdom for international flights, and owing to its convenient location situated between New Zealand and Western Samoa, it is a key transit airport in this region. A unique feature of the airport is that a relatively large number of large aircraft movements is recorded as compared to the number of passengers.

Fig 2.1 shows the international airline network connecting with Fua'amotu International Airport. Fig 2.2 shows the domestic airline network within Tonga.

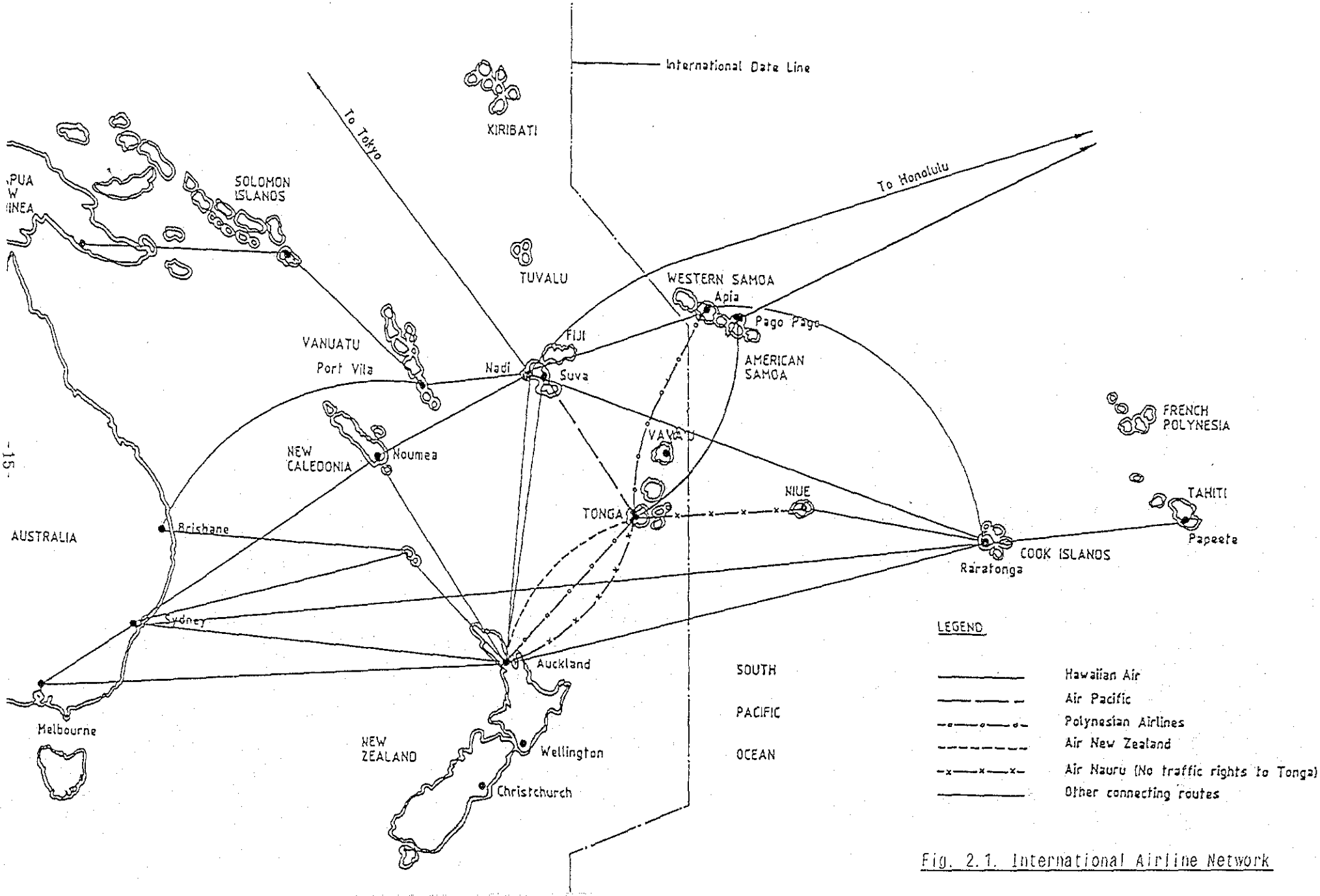


Fig. 2.1. International Airline Network

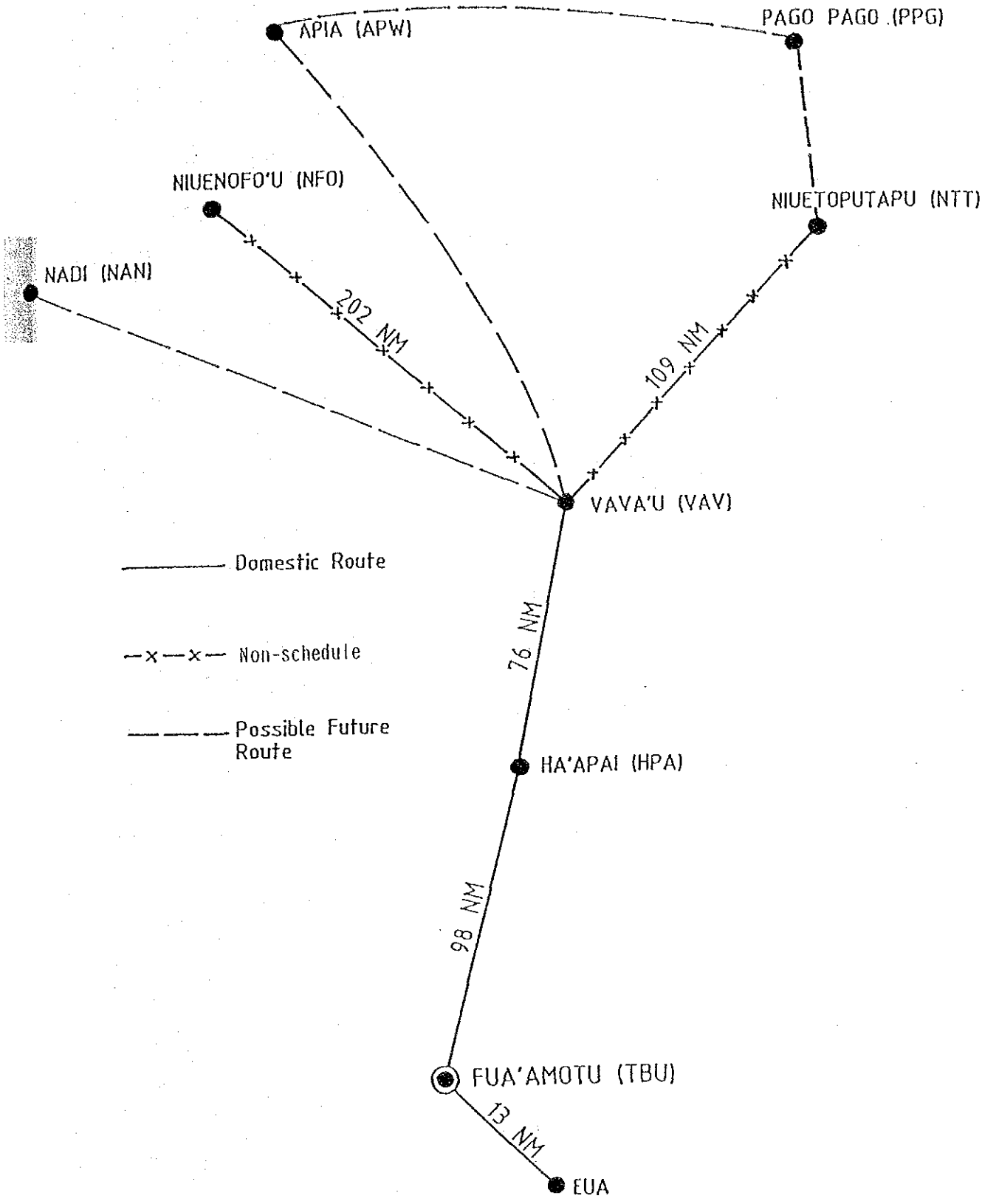


Fig. 2.2. Domestic Airline Network

There are currently 4 international carriers serving Tonga, namely, Air New Zealand, Air Pacific, Hawaiian Air and Polynesian Airlines, which provide a total of 16 flights a week, as shown in Table 2.13.

Friendly Island Airways provides a domestic service of 24 flights a week, as shown in Table 2.14.

2.3.3 Passenger Movements

2.3.3.1 General

Passenger movements at Fua'amotu Airport are shown in Fig 2.3. The figures show a decrease in passengers for 3 years after 1979. This trend was reversed in 1983 and since 1984 has increased significantly. International and domestic passenger movements show similar trends indicating that domestic passenger movement is originated by non-resident Tongan nationals entering and leaving the country.

Fig. 2.3. Annual Passenger Movements

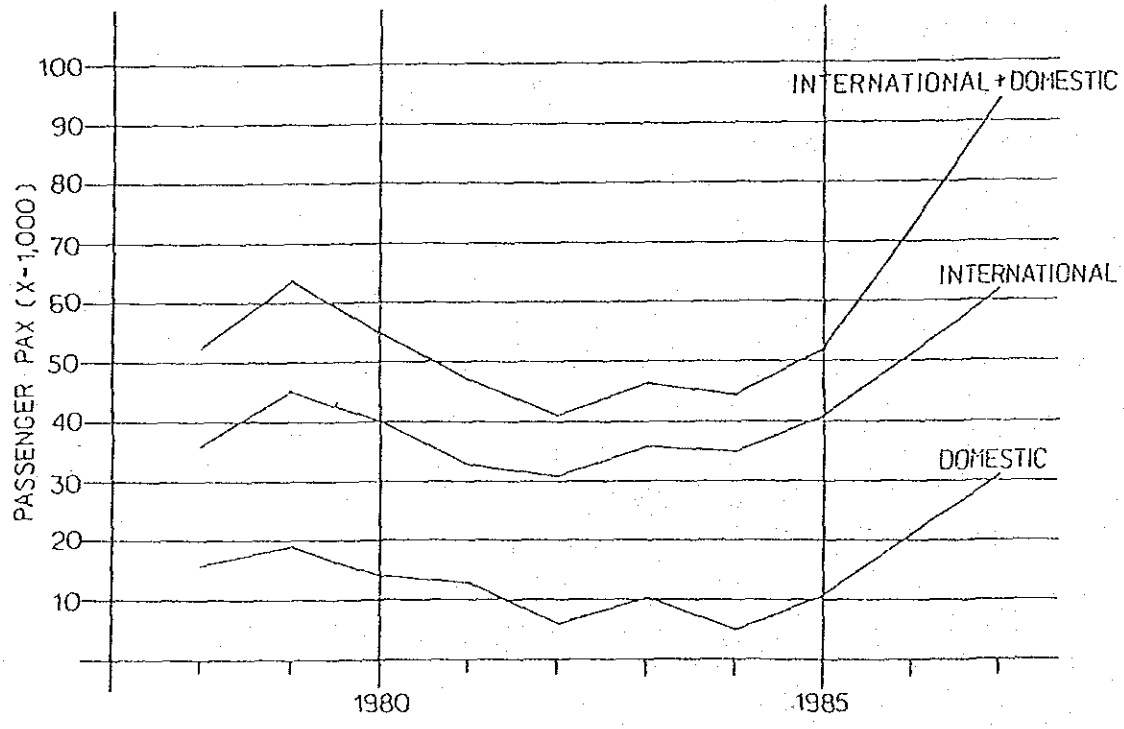


Table 2.13. International Flights

AIRLINE	AIRCRAFT TYPE	SERVICES
Air New Zealand	B-737	Two services per week Auckland - Fua'amotu - Auckland
	B-737	One service per week Auckland - Fua'amotu - Apia - Fua'amotu - Auckland
Air Pacific	ATR 42	Three services per week Nadi - Fua'amotu - Suva
	ATR 42	Two services per week Nadi - Fua'amotu - Nadi
	AIR 42	Two services per week Suva - Fua'amotu - Nadi
Hawaiian Air	DC-8/L-1011	Two services per week Honolulu - Pago Pago - Fua'amotu - Pago Pago - Honolulu
Polynesian Airlines	B-727	Four services per week Apia - Fua'amotu - Auckland - Fua'amotu - Apia

Table 2.14. Domestic flights

AIRLINE	AIRCRAFT TYPE	SERVICES
Friendly Island Airways	DHC-6	Six services per week Fua'amotu - Ha'apai - Vava'u - Ha'apai - Fua'amotu
	DHC-6	Six services per week Fua'amotu - Vava'u - Fua'amotu
	BN-2	Twelve services per week Fua'amotu - Tua - Fua'amotu

2.3.3.2 Annual Movement of Passengers

Annual movement of international passengers is shown in Table 2.15.

Table 2.15. International Transport

	Passengers	Transit	Total	No. of Flights	Passengers per Flight	Proportion of Transit
1978	36,240	NA	NA	1,204	NA	NA
1979	45,210	NA	NA	1,400	NA	NA
1980	40,556	NA	NA	1,354	NA	NA
1981	33,643	NA	NA	1,419	NA	NA
1982	31,406	27,877	59,283	1,280	47	47 %
1983	36,329	32,249	68,578	1,506	46	47
1984	35,317	32,646	67,963	1,327	52	48
1985	41,430	29,113	70,543	1,302	55	42.5
1986	51,327	26,450	77,777	1,439	54	34
1987	62,683	NA	NA	1,596	NA	NA
1988	NA	NA	96,867	NA	NA	NA

NA: Not available

Passenger movement decreased between 1980 and 1982 (in 1982 due to a cyclone), but an increase of more than 10% was recorded in 1983 and there was a similar increase until 1987. It is believed that this trend is well related to the improvement of facilities at Fua'amotu Airport in 1982. The average annual transit rate is 30-45% and the average number of passengers per flight is approximately 50. Since the average number of seats available per flight is 100, the loading factor is approximately 50%.

Annual movement of domestic passengers is shown in Table 2.16. The average number of passengers per flight is approximately 9.

Table 2.16. Domestic Transport

	Passenger	No. of Flights	Passengers per Flight
1978	16,494	2,561	7
1979	19,038	2,842	7
1980	14,722	1,391	11
1981	13,620	1,733	8
1982	9,699	1,071	10
1983	10,405	1,834	6
1984	9,495	1,087	9
1985	10,756	999	11
1986	21,396	2,536	9
1987	31,033	3,050	11

2.3.3.3 Monthly Movement of Passengers

Tables 2.17 and 2.18 show the numbers of monthly passengers and the concentration ratio for international and domestic services. The peak for international services is in December. In 1986 the ratio of December passengers to total annual passengers (concentration ratio) was 1:6.8. In 1987 the ratio was 1:7.2.

The peak for domestic services is in December and January. The concentration ratio in December 1986 was 1:6.9 and in January 1987 was 1:8.7. This may be the result of non-resident Tongans returning home for Christmas holidays.

Table 2.17. Monthly International Transport

	1985		1986		1987	
	No. of Passengers	Ratio of Concent-ration	No. of Passengers	Ratio of Concent-ration	No. of Passengers	Ratio of Concent-ration
Jan.	4,333	1/ 9.5	4,814	1/10.6	7,677	1/ 8.2
Feb.	3,201	1/12.9	3,786	1/13.5	4,805	1/13.0
Mar.	3,189	1/13.0	3,508	1/14.6	3,673	1/17.0
Apr.	2,390	1/17.3	3,100	1/16.5	3,593	1/17.4
May	2,036	1/20.3	3,902	1/13.1	5,071	1/12.3
Jun.	2,892	1/14.3	3,413	1/15.0	4,042	1/15.5
Jul.	3,679	1/11.2	4,798	1/10.6	4,752	1/13.2
Aug.	4,076	1/10.1	4,493	1/11.4	4,913	1/12.7
Sep.	3,110	1/13.3	4,271	1/12.0	4,389	1/14.3
Oct.	3,092	1/13.4	3,578	1/14.3	3,960	1/15.8
Nov.	4,204	1/ 9.8	4,229	1/12.1	7,175	1/ 8.7
Dec.	5,228	1/ 7.9	7,435	1/ 6.8	8,633	1/ 7.2
Total	41,430	-	51,327	-	62,683	-

Table 2.18. Monthly Domestic Transport

	1986		1987	
	No. of Passengers	Ratio of Concentration	No. of Passengers	Ratio of Concentration
Jan.	1,690	1/12.6	3,569	1/ 8.7
Feb.	1,296	1/16.5	1,747	1/17.7
Mar.	1,194	1/17.9	1,762	1/17.6
Apr.	1,782	1/12.0	2,210	1/14.0
May	1,852	1/11.5	3,251	1/ 9.5
Jun.	1,387	1/15.4	2,585	1/12.0
Jul.	2,053	1/10.4	2,496	1/12.4
Aug.	1,951	1/10.9	2,818	1/11.0
Sep.	1,929	1/11.0	2,326	1/13.3
Oct.	1,778	1/12.0	2,380	1/13.0
Nov.	1,393	1/15.3	2,484	1/12.4
Dec.	3,091	1/ 6.9	3,410	1/ 9.1
Total	21,396	-	21,396	-

2.3.4 Aircraft Movements

International and domestic aircraft movements are shown in Tables 2.19 and 2.20. On an average, between 4 and 8 international flights per day are provided at Fua'amotu Airport depending on aircraft scheduling and passenger demand. There is one instance between 21:00 and 23:00 on Friday when an ATR 42 and a DC 8 use the apron almost simultaneously.

There are 8 domestic flights per day on weekdays. A BN-2 and a DHC-6 of Friendly Island Airways take off at around 8:00 on every weekday.

There are no flights on Sundays, as stipulated in the Constitution of the Kingdom of Tonga.

The present flight schedules are given in Tables 2.19 and 2.20.

Table 2.19. International Flight Schedule

Day \ Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Mon.												NAN SUV ATR 42										PPG PPG DC 8		
Tue.			NAN SUV ATR 42								AKL AKL B 737													
Wed.												SUV NAN ATR 42							AKL APW B 727		NAN SUV ATR 42			
Thu.												NO FLIGHTS												
Fri.											APW AKL B 727								AKL APW B 727		NAN SUV ATR 42	DC 8		
Sat.									AKL AKL B 737		SUV NAN ATR 42				AKL APW B 737			NAN SUV ATR 42				PPG	PPG	

Table 2.20. Domestic Flight Schedule

Day \ Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Mon.	BN 2						EUA →	← TBU							EUA →	← TBU								
	DHC 6						HAP/VAV →	BN 2	DHC 6		VAV ⇄ TBU		DHC 6		← TBU	BN 2								
Tue.	BN 2						EUA →	← TBU							EUA →	← TBU								
	DHC 6						HAP/VAV →				VAV ⇄ TBU				← TBU									
Wed.	BN 2						EUA →	← TBU							EUA →	← TBU								
	DHC 6						HAP/VAV →				VAV ⇄ TBU				← TBU									
Thu.	BN 2						EUA →	← TBU							EUA →	← TBU								
	DHC 6						HAP/VAV →				VAV ⇄ TBU				← TBU									
Fri.	BN 2						EUA →	← TBU							EUA →	← TBU								
	DHC 6						HAP/VAV →				VAV ⇄ TBU				← TBU									
Sat.	BN 2						EUA →	← TBU							EUA →	← TBU								
	DHC 6						HAP/VAV →				VAV ⇄ TBU				← TBU									

2.4 AIRPORT FACILITIES

2.4.1 General

Fua'amotu International Airport, situated 20 km south-east of the capital city, Nuku'alofa, at an elevation of 30m above sea level, is the only gateway to the Kingdom, and also acts as an important transit point for flights between New Zealand and Western Samoa. The airport was constructed by the U.S. military during the Second World War.

The main runway, 2,071m long and 45m wide, lies in an east-to-west direction. Pavement work was carried out in 1974, and again in 1988 with Australian financial assistance when the entire runway was resurfaced to withstand the load of L-1011 class aircraft.

The terminal area is situated at the east end of the main runway on the north side. The area is comprised of a 2-berth apron, a single storied 1600m^2 terminal building, re-fueling facilities, a car park for 100 vehicles, a hangar for small aircraft, a maintenance workshop and a royal VIP building. Facilities including a control tower, fire-fighting facilities, VOR/DME and NDB are located on the south side of the runway.

The topography of the airport area is generally flat with no obstructions to flight operations. Instrumental landing is currently conducted by means of VOR/DME and NDB.

Features of the airport are that large numbers of well-wishers usually spend considerable time in the terminal building, and passenger and visitor movements are not clearly separated in the terminal building, which is creating very congested situations.

Since the existing terminal building is located on the north side of the eastern end of the main runway, and as aircraft must frequently take off from the opposite western end due to the prevailing wind, a lot of time is spent by aircraft taxiing on the runway.

Particulars and a layout of the existing airport facilities are shown in Fig 2.4 and Table 2.21

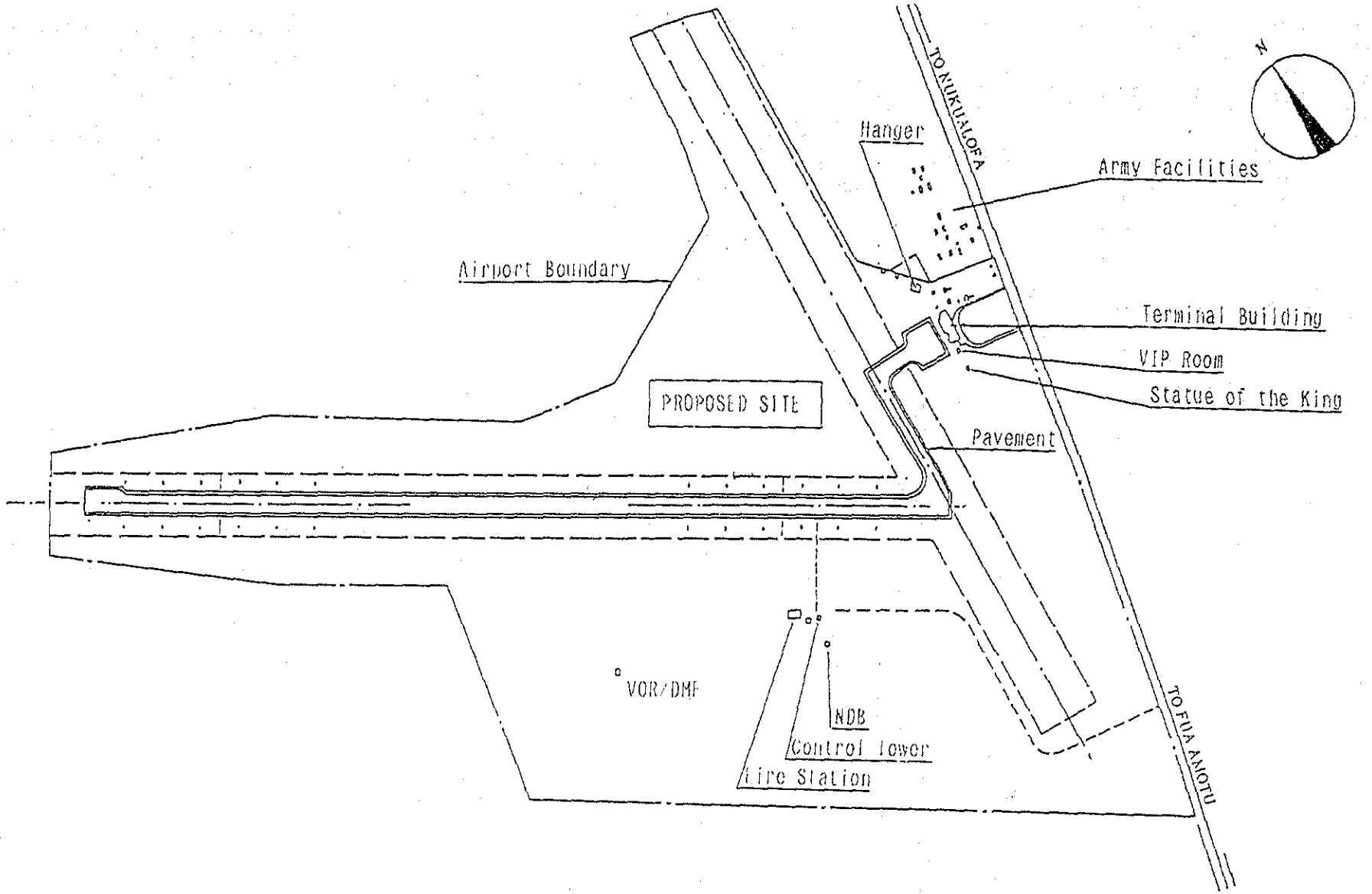


Fig. 2.4. Present Situation of Fua'amotu International Airport

Country	INTL/DOM	Position of the Reference Point	Magnetic Variation	Aerodrome Ref. Temp	Administration Authority
Kingdom of Tonga	INTL/DOM	S 21° 14.5' W 175° 08.8'	14° 10'	28.10°C	Ministry of Civil Aviation

Name of Airport	ICAO Code	Elevation	Runway Direction	Operation Hours
Fua' amotu	4D	30m	TN 122° E	Service available to meet operation requirement

Basic Facilities		Passenger Terminal Building	Other Facilities	
Runway Strip	2,190m x 150m 1,800m x 150m	One-Storied Building with corrugated steel sheet roof and reinforced concrete Total Area of Floor : 1,600m2 Arrival Area : 431m2 Departure Area : 1,091m2 Other : 78m2 Extension completed in 1985	Control Tower	Concrete block structure. Floor area : 81m2
Runway	2,070m x 45m 1,680m x 30m		Hanger	For Friendly Airways. Floor Area : 644m2 For small aircraft : 1 aircraft. completed in 1987
Taxiway	440m x 23m		Refueler Facilities	JET : 115,000ℓ AVGAS : 35,000 ℓ Hydrant Fuel Facility : 2pits
Apron	for L-1011 /B737 : 2 Berths : 7,200 m2		Fire Fighting	Fire Vehicle : 2 RIV : 1
			Water Supply	City Water (well)
			Electricity	Commercial Power : 11kv, 415v - 240v Stand-by Generator : 50KVA x 2. 25KVA x 2
Pavement	PCN 45	VIP Building One-storied building with corrugated sheel sheet roof Floor area : 140m2	Telephone	Available
			Car park	Parking capacity : approximate 100
			Other	Storage and Maintenance shed

Condition of Neighbouring City

Name of City	Population	Location	Transportation
Nuku'alofa	65,000	20km north-west of Airport	30 Minutes by Taxi

Air Navigation Facility	NDB	VOR	DME	LLZ	GS	IM	M.M.	O.M.	TACAN
	○	○	○	×	×	×	×	×	×
Control Facility	CCU	RADAR	APP	RIC	ACC	AMS	SMC	A/G	RCAG
	×	×	×	×	×	×	×	×	×
Communication Facility	INT.COM	HF	VHF	UHF	RTTY	LTY	MAS	MSS	MIC.LINK
	×	○	○	×	×	×	×	×	×
Lighting Facility	ALS	SALS	REIL	T-VASIS	TPEL	TDZL	RWTL	RWEL	RWYL
	×	×	11/29 ○	11/29	○ 11	×	11/29	11/29	○
	RWCL	TWYL	TWCL	ABN	APRON, F.L.	IWDI			
	×	○	×	×	○	○			
Meteorological Observation Facility	WIND	RVR	CEILOMETER	WX FAX	WX RADER	APT RX	BAROMETER	RAIN GAUGE	WX TELEX
	○	×	×	×	×	×	×	×	○
	RAIN SONDE	RADIO SONDE							
	×	×							

Air Transport

		1983	1984	1985	1986
International	Arrival & Departure	36,329	35,317	41,192	51,327
	Transit	32,249	32,646	30,424	26,450
	Total	68,578	67,963	71,616	77,777
	No.of Flight	1,506	1,327	1,302	1,439
Domestic	Arrival & Departure	10,405	9,495	10,756	21,395
	No.of Flight	1,834	1,087	999	2,536

Table 2.21. Present Facilities of Fua'amotu International Airport

2.4.2 Runway and Landing Strip

A 600m extension to the west of the main runway is scheduled to commence from June 1989 with Australian financial assistance. This followed the entire main runway overlay work which was carried out in 1988. The ACCA report indicates that this work will allow the alleviation of weight restrictions presently imposed on L-1011, and will also introduce the possibility of catering to B-767s and ultimately B-747s.

The secondary runway crosses the main runway at a 60° angle at RWY 29 threshold. It is 1680m long and has a 150m width landing strip. Almost all parts of the runway surface are grass. Only a 330m x 23m section, where there is a taxiway linking the main runway and the apron, is paved. Although the secondary runway is designed as a cross-wind runway for small aircraft, it has frequently been used by aircraft serving Va'vau, Ha'apai and other islands' airfields because of its favourable north-south orientation.

Although there are no drainage facilities in these airfields, rainwater drains satisfactorily because of the sub-stratum of coral rock lying 2m below the surface.

2.4.3 Apron

The apron has been expanded recently to an area of 120m by 60m. It has been marked for self-parking for a L-1011 and a B-727. However these angled parking positions would only allow a 4.5m tolerance between aircraft wingtips and surrounding obstacles. In February 1989 a flight schedule was prepared to avoid simultaneous parking. However, there is an instance when there is only a 15 minute time interval between one aircraft leaving and another arriving at the parking area. If there was a slight delay in departure or arrival, this would easily result in simultaneous parking.

Flights to Fua'amotu from other countries often arrive late. The Hawaiian Airlines flight from Honolulu via Pago Pago frequently arrives late at Fua'amotu because of delays at Honolulu with connecting flights from Anchorage and Los Angeles. A similar situation occurs with the Air New Zealand B-737 service and the Polynesian Airlines B-727 service which both use the

airport as a stop-over for flights between Western Samoa and New Zealand. The apron is therefore often occupied by delayed aircraft at unscheduled times. As a result, airport authorities frequently have to request neighbouring airport authorities to delay the departure of flights to Fua'amotu until parking space on the apron is available to them. Provision of an emergency parking spot is desirable so as to accommodate a disabled or unscheduled aircraft.

2.4.4 Passenger Terminal

2.4.4.1 General

The existing passenger terminal building has a floor area of 1,600 m^2, a reinforced concrete structure built in 1978 with a section of steel construction extended in 1985. The building consists of a 1,090 m^2 departure zone, a 430 m^2 arrival zone and a 80 m^2 common use zone. The building appears to have been designed for 100 departing and 100 arriving passengers a day. At peak hours when a DC-8 (or L-1011) arrives at the airport, the terminal building is very crowded with passengers and well-wishers. The layout is shown in Fig 2.5.

2.4.4.1.1 Departure Zone

Both international and domestic passengers use the same departure zone. There are three (3) check-in counters in, this area. Frequent congestion occurs during normal departure processing. Half of the building is used as a departure lobby, which was expanded in 1985 and furnished with air conditioning, with no internal walls around the lobby.

Checked baggage is manually handed to the baggage handling area, and then delivered to the aircraft either on a cart towed by a tractor or on a 2-ton truck. Passenger body checks are done by a portable type metal detector and passengers' hand baggage is checked visually.

There is a beverage and snack stand located in the departure lounge.

The departure lounge has eighty (80) seats, and a duty free shop and a bar are also provided.

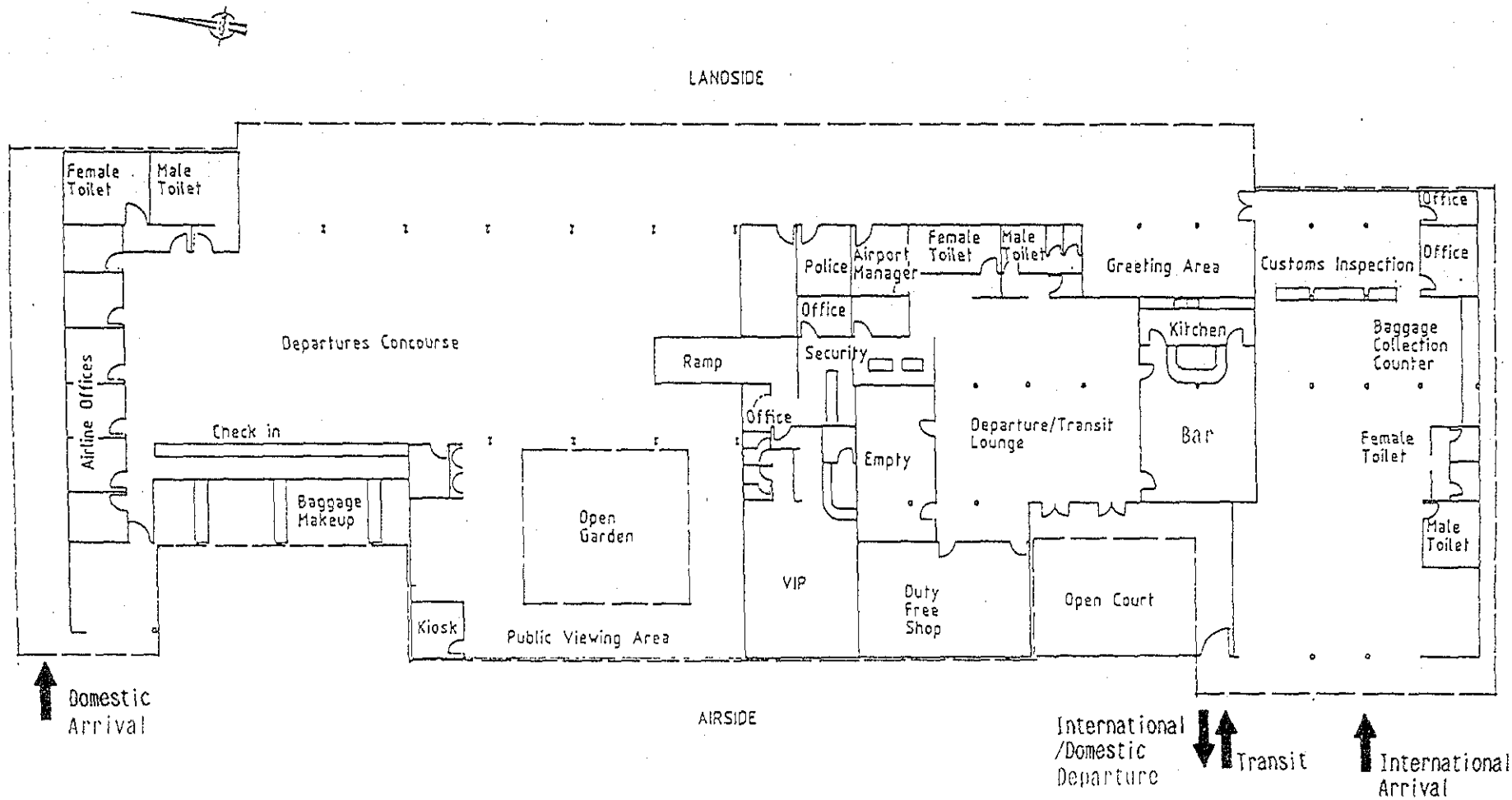


Fig. 2.5. Existing Terminal Building

2.4.4.1.2 Arrival Zone

Arrival facilities for international and domestic services are separated. International arrival facilities consist of immigration control and customs clearance. The area easily becomes congested when shuttle flights arrive. especially on rainy days. There are one immigration control counter and three (3) customs inspection counters, but no mechanical turntable in the baggage claim area. All baggage delivered by cart or 2-ton truck from the aircraft is manually handled and carried to the baggage claim area.

2.4.4.2 Water Supply, Sewerage, Fire Fighting Equipment and Air Conditioning

2.4.4.2.1 Water Supply

Water is supplied by the Ministry of Civil Aviation from a deep well at the northern end of the airport through a 2.5inch pipe. There are two (2) pumps, each with a capacity of 50 gallons/minute, and two (2) elevated water tanks, each with a capacity of 2,500 gallons, at an elevation of approx. 10 metres. The depth of the deep well is approx. 30 metres.

2.4.4.2.2 Sewerage

The sewage from the terminal building is treated at two (2) sets of septic tanks by soakaway, which is the most common system of sewage treatment in Tonga.

2.4.4.2.3 Fire Fighting Equipment

The terminal building is equipped with portable fire extinguishers but no fire hydrant.

2.4.4.2.4 Air Conditioning

The VIP lounge and the duty free shop are provided with air conditioning (2 units each), and all the other areas have ceiling fans which give adequate ventilation.

2.4.4.3 Electrical

2.4.4.3.1 Power Supply

The power to the terminal building is supplied by an 11 kV, 50 Hz overhead line which runs along the airport access road. A step-down transformer is mounted on a pole from which 415V/240V 4-wire, 3-phase power is supplied through underground lines. There is no emergency stand-by power supply for the terminal facilities. In the event of a power failure, gas lamps are used. Power supply is controlled by the Tonga Electric Power Board. The power is generated at a power station in Nuku'alofa. There are four (4) diesel powered generating units, two (2) with a capacity of 1,729 kW and two (2) with a capacity of 1,198 kW giving a total power of 5,854 kW. Maximum demand in 1989 is expected to be 3,800 kW, which proves adequate.

2.4.4.3.2 Telephone

The Tonga Telephone Commission operates and maintains telephone services in Tonga. There is an underground line for 50 circuits from the telephone exchange in Mua to the airport.

2.4.4.3.3 Public Address System

There is only one channel through which all announcements are transmitted to all zones.

2.4.4.3.4 Clocks

There are battery operated wall clocks at the check-in area and the bar beside the departure lounge.

2.4.4.3.5 Metal Detectors

There is a gate-type metal detecting equipment. Portable type metal detectors are used for cabin baggage detection.

2.4.5 Air Navigation Systems

2.4.5.1 Radio Air Navigation Facilities

Systems installed at the airport include the following:

Non-Directional Radio Beacon (NDB)
VHF Omni-Directional Radio Range (VOR)
Distance Measuring Equipment (DME)

2.4.5.2 Airfield Lighting Facilities

The existing airfield lighting facilities were installed in 1982 with financial assistance from the Government of New Zealand. These facilities include the following:

- Runway edge lights (low intensity)
- Visual approach slope indicator
- Runway threshold lights
- Runway end lights
- Runway end identification lights
- Taxiway edge lights
- Turning pad edge lights
- Illuminated wind direction indicator
- Apron floodlights

The power for the above facilities is supplied by six (6) units of TMS (constant current transformer) located in the ground floor of the control tower, which are used in the following manners:

1 unit TMS (11 kVA) for T-VASIS (11)
1 unit TMS (11 kVA) for T-VASIS (29)
1 unit TMS (9 kVA) for runway edge lights, runway threshold and end lights, illuminated wind direction indicator and turning pad edge lights.
1 unit TMS (3 kVA) for T-VASIS (nighttime)
1 unit TMS (2 kVA) for runway end identification lights

All these operations are carried out from a control panel in the VFR room at the control tower. Power supply for the apron floodlights comes from the terminal building source and is also controlled from the building.

2.4.5.3 Power Supply for Air Navigation Facilities

Low tension power is distributed from the step-down transformer behind the control tower in the same way as for the terminal building, and extended to the air navigation facilities

Four (4) stand-by generators (2 x 50 kVA and 2 x 25 kVA) are installed in the generator house behind the control tower.

At present, because of the frequent failures of the commercial power supply, these stand-by generators are in normal use whereas the commercial supply is used as a stand-by source. According to the Electric Power Board, there occurred 38 instances, totalling 50 hours, of power failure in 1988. As the power to the apron floodlights is connected to the terminal building circuit, the light goes off in case of power failures.

2.4.6 Car park

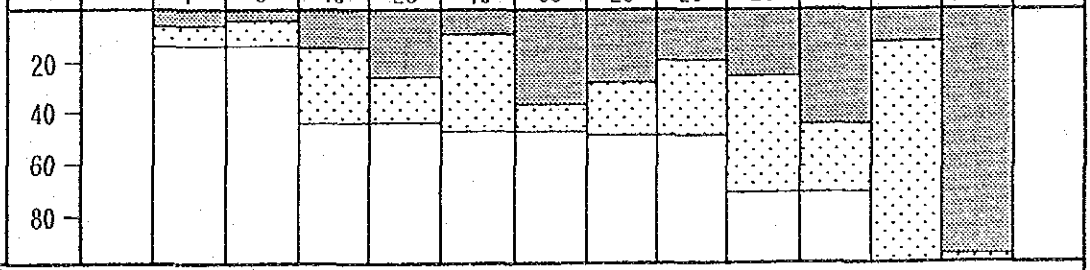
The car park has a space for 100 vehicles but it frequently accommodates many more. As shown in Fig 2.6, 147 vehicles were parked in the car park at the peak hour (around 22:00) during the traffic survey on February 3, 1989 when there were 114 international arrival passengers on flights FJ 400 and HAL 461 and 147 international departure passengers on flights FJ 402 and HAL 462. The number of parked cars per passenger was, therefore, calculated at 0.56. Incoming buses, after dropping off departing passengers, keep waiting to pick up arrived passengers. Taxis are also standing in front of the terminal building.

2.4.7 Fuel Supply

Refuelling operations at the airport are conducted by British Petroleum and Shell (Shell commenced operations in January 1989). Jet fuel is delivered from the main storage tank (500 kl) at Nuku'alofa harbour to three (3) fuel tanks installed at the airport (2 x 60 kl + 1 x 30 kl = 150 kl in total) by two (2) tank lorries. Each lorry usually makes one or two trips a day. A fuel hydrant system is provided in the apron, and two (2) fuel hydrant pits (2.5kl/min) are available. Average consumption of jet fuel is 110 kl/week, for which the storage capacity proves adequate. AVGAS fuel is carried by oil barrel for small aircraft such as the BN-2 of Friendly Island Airways. Average consumption of AVGAS is only 5 kl/month.

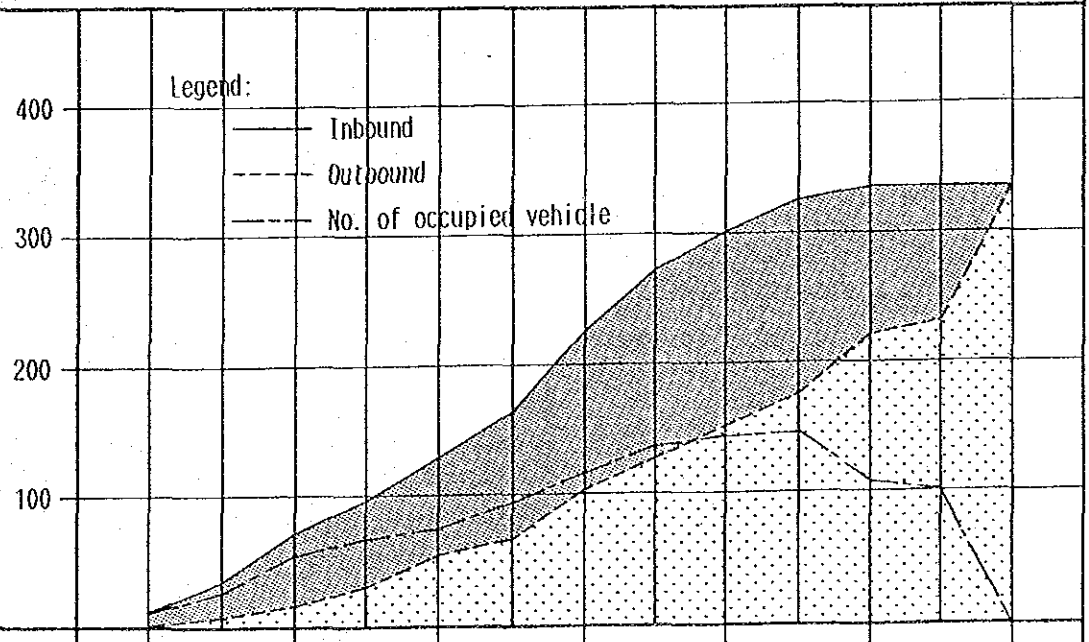
Fig. 2.6. Traffic Movement at Parking Area

1 Hour		11	57		75		119		147		112		0		
30 Min.		11	29		63		97		139		146		100		
Inbound		11	25	34	21	40	32	60	49	28	25	11	—		336
		11	59		61		92		77		36				336
Time Zone		18	19		20		21		22		23		24		
Outbound			13		43		48		49		71		(112)		336
		—	7	6	15	28	10	38	29	20	26	45	12	(100)	336



PAX

FJI 400	15
FJI 401	42
HAL 461	99
HAL 462	105
Total	261



Time Zone	18:00	19:00		20:00		21:00		22:00		23:00		24:00		
Inbound	11	36		91		163		272		325				
		70		131		223		300		336		336		336
Outbound	—	7		28		66		133		179		236		
		13		56		104		153		224		336		336
No. of occupied vehicle	11	29		63		97		139		146		100		
		57		75		119		147		112		0		

2.5 ASSOCIATED PROJECTS

Requests have been made to various countries for technical and financial assistnce as shown in Table 2.22.

Improvements of the airport commenced in 1986 with assistance from New Zealand for the construction of a new control tower and the supply of air traffic control equipment. In 1988 overlay work on the main runway, taxiway and apron was carried out by Australia, with a further pledge to commence work on extending the main runway by 600m in June 1989. A request to the EC for provision of equipment for rescue and fire fighting, telecommunications, and security has also been made in 1985.

It is a matter of course that the planning and design of the new terminal complex be coordinated with these works funded by other donor countries. Consequently, some interfacing work will be required and it is desirable to adopt uniform design standards.

Table 2.22. Relevant Projects

	Donor	Project Description	Period	Amount
Completed	Australia	Reinforcement of existing runway, taxiway & apron	1988	I$ 3.1 mill.
	New Zealand	Improvement of control tower & AIC equipment	1986	I$ 0.25 mill.
Pledged	Australia	Extension of main runway by 600 m	1989	A$ 6 mill.
Proposed	Japan	Construction of new terminal, apron taxiway, road & parking	1989/ 1990	
		Provision of GSE equipment		
	EC	Provision of rescue, f/f, telecom., security, maintenance, dormitory & training	1989	ECU 1.31 mill.

2.6 BACKGROUND AND CONTENTS OF THE REQUEST

2.6.1 Background

A request was made to the Japanese government in 1988 for the construction of a new terminal complex and the provision of ground service equipment (GSE), in conjunction with assistance from other donor countries, in an effort to achieve the national development objective of expanding the airport and improving air transportation.

The request was based on the intention of the Tongan government to upgrade the terminal facilities to meet future increasing traffic demand and the introduction of larger aircraft, the operation of which becomes possible by the runway extension to be carried out with the assistance of the Australian government. In addition, the existing terminal facilities have many drawbacks and the Tongan government has a strong desire to change the location of the terminal building.

Drawbacks of the existing terminal facilities are:

- Expansion of the terminal area is limited due to the existence of a trunk road on the east side, the secondary runway on the west side, a military complex on the north side, and the main runway strip and its transitional surface on the south side.
- As the terminal is located at the east end of the runway, the runway occupancy time of taxiing aircraft is considerably long (see 2.4.1).
- The runway is expected to be extended by 600m which will further prolong the runway occupancy time. An increase in flight operations in the future cannot be attained on account of these restraints.

A study has been made as shown in the following chapter which includes a review of all the above conditions at the airport for optimum airport planning and in order to justify the necessity for construction of a new terminal building.

2.6.2 Contents

The contents of the final request, each confirmed one by one through discussions between the Government of Tonga and the survey team, are identified as follows:

(a) Construction of new terminal building.

(b) Construction of new apron and taxiway including lighting facilities.

(c) Construction of new car park including lighting facilities.

(d) Installation of stand-by power supply for the new terminal building and apron floodlights.

(e) Provision of the following ground service equipment (GSE):

(1) Ground power supply 115V AC and 28V DC suitable for wide bodied jet aircraft requirements and 28V 200 A DC supply capable of starting Rolls Royce Dart or Garrett TBE 331 engines.
(2) Air start unit capable of starting RB 211, JT 9D and CF 6 type engines.
(3) Air conditioning unit for wide bodied aircraft.
(4) Lavatory service vehicle.
(5) Potable water vehicle.
(6) Container loader.
(7) Belt loader.
(8) Pallet container dolly trailers.
(9) Galley service vehicle.
(10) Baggage and cargo tugs.
(11) Aircraft tugs.

CHAPTER 3. PROJECT DESCRIPTION

CHAPTER 3 : PROJECT DESCRIPTION

3.1 OBJECTIVES

The Project is a part of a coordinated overall expansion of the airport. The objectives of the Project are to develop the tourism industry, to increase employment opportunities and generate foreign exchange through the improvement of the airport facilities, and thereby to re-vitalize social and economic activities in the Kingdom.

3.2 AIR TRAFFIC FORECAST

3.2.1 Target Year

The target year for the Project will be 1996 (5 years after completion of construction) and the facilities will be designed to cater to peak-hour demand of the average day of the peak month.

3.2.2 Previous Forecasts

Several forecasts have been carried out to determine future passenger movements. The results of these studies are summarized below:

Tonga Tourist Visitors Bureau
-international passengers annual average growth rate (1988-2000) = 10%

AIDAB/ACCA
-international passengers annual average growth rate (1990-2000) = 4%.
- domestic passengers average annual growth rate (1991-2000) = 3%.

ICAO BULLETIN (July 1986) for south-eastern sub-region
-international passengers average annual growth rate (1984-1994) = 8%.

3.2.3 International Passenger Forecast

A study on the development of a tourism master plan was undertaken by the Tonga Tourist Visitors Bureau, which targeted an annual growth rate of 10% with the total number of international arrival and departure passengers in 1996 at 127,904. This figure seems rather optimistic when compared with the past record. Among the various forecasts that have been made, the one prepared by ACCA indicates the lowest growth rate (4%). The ACCA report, according to its demand forecast, took a negative view of the proposed runway extension. However, in 1989 the Australian government pledged to finance the runway extension (an extra 600m) because the number of passengers has increased at the rate of more than 10% in 1986 and 1987. The runway is to be completed for aircraft operation by the end of 1989. The past record as shown in Fig 2.3 shows significant fluctuations but indicates a generally increasing trend.

The past record of passenger movements gives the following two steady trends. One is the average annual growth rate during the peak month for three (3) years and the other is the average annual growth rate for the past ten (10) years.

Average annual growth rate of peak month (December) (1985-1987)
$= 3 \log (1+x) = \log 1.65$ where $x = 18\%$

Average annual growth rate for past ten (10) years (1978-1987)
$= 10 \log (1+x) = \log 1.73$ where $x = 5.6\%$

Only a limited record is available for the peak-month trend (the former one) which shows an 18% increase while a 5.6% increase is shown for the ten-year annual average. Considering the tourism competition from neighbouring countries, fluctuations in the future demand are to be discounted. Therefore, a 5.5% average annual growth rate was finally adopted, and international passengers in 1996 are forecast at 100,000. In the past, transit passengers have on the average constituted 40% of the total number of passengers. By adopting this rate, the number of transit passengers in 1996 is forecast at 40,000.

Table 3.1. International Passenger Movements

	Arrivals	Departures	Total	Annual Growth Rate
1978	17,659	18,581	36,240	
1979	16,394	28,816	45,210	+ 24.8 %
1980	14,031	26,525	40,556	- 10.3
1981	15,980	17,663	33,643	- 17.1
1982	14,696	16,710	31,406	- 7.0
1983	17,959	18,370	36,329	+ 16.0
1984	17,256	18,061	35,317	- 3.0
1985	19,672	21,758	41,430	+ 15.0
1986	24,458	26,869	51,327	+ 20.0
1987	29,195	33,488	62,683	+ 22.0

3.2.4 Domestic Passenger Forecast

A strong correlation appears between the numbers of international and domestic passengers. This seems to originate from the movements of approximately 40,000 non-resident Tongan nationals. The forecast figure for domestic passengers is 35,000 (35% x 100,000) based on the 1978 - 1987 data which are averaged at an annual ratio of 35% of the total of international passengers.

Table 3.2. Ratio of Passengers

	International Passengers	Domestic Passengers	Ratio
1978	36,240	16,494	45.5 %
1979	45,210	19,038	42.1
1980	40,556	14,772	36.4
1981	33,643	13,620	40.4
1982	31,406	9,699	30.8
1983	36,329	10,405	28.6
1984	35,317	9,495	26.8
1985	41,430	10,756	26.1
1986	51,327	21,396	41.6
1987	62,683	31,033	49.5

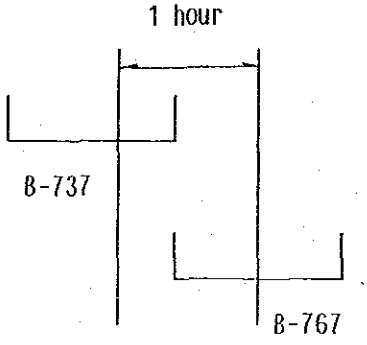
3.2.5 Peak-hour Demand

3.2.5.1 Number of Passengers on Design Day

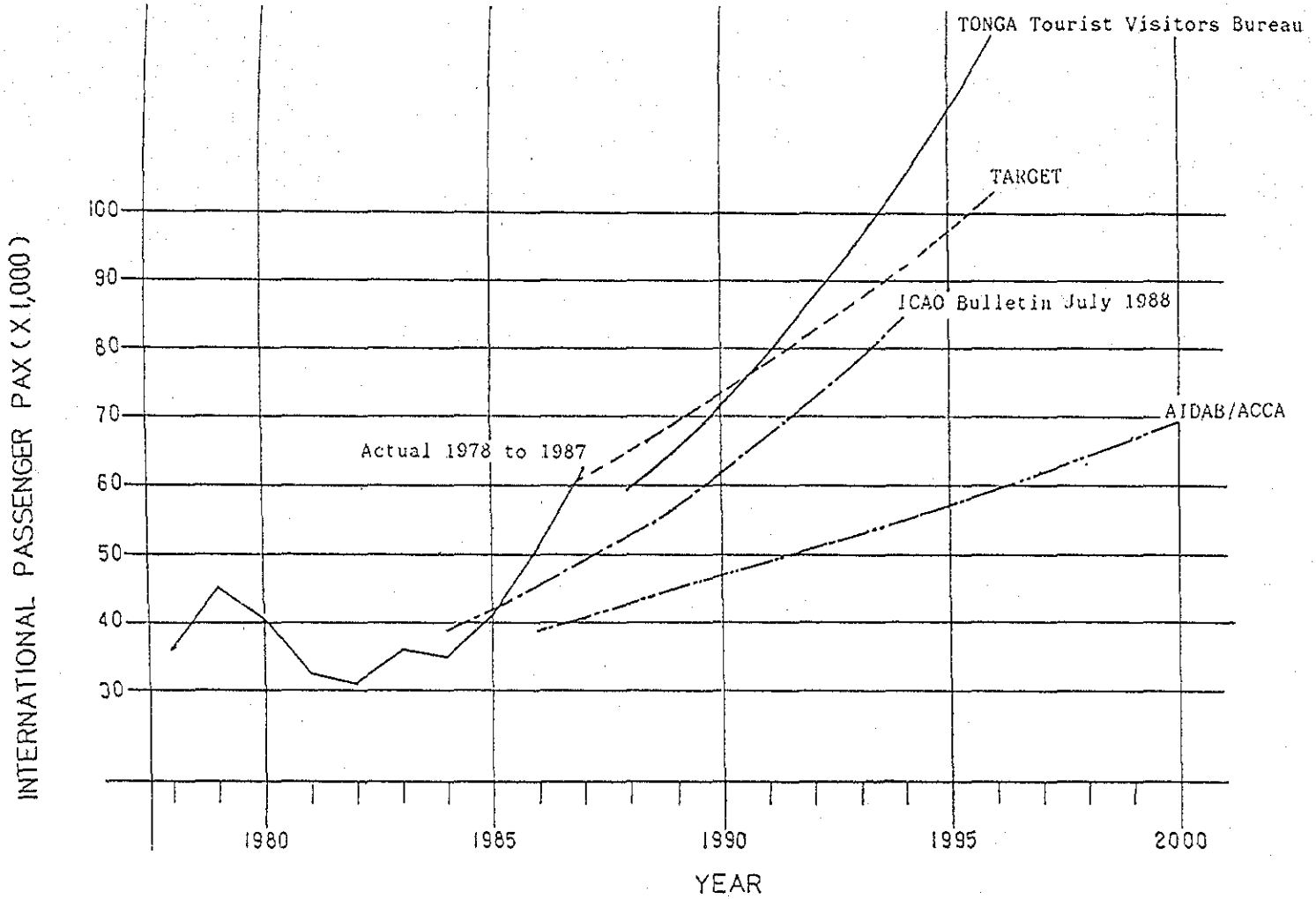
Based on the passenger movements in 1987, the peak months for the airport are December and January (Christmas holiday period). Approximately 1/7.2 of the total annual international passengers and 1/8.7 of total annual domestic passengers are concentrated in this peak month (Tables 2.17 and 2.18). Assuming that this trend continues in the future, the number of international passengers for a peak day will be 1/7.2 x 1/26 = 1/190 of the annual design total number of passengers. The peak-day number of domestic passengers will be 1/8.7 x 1/26 = 1/220. Therefore the number of passengers on the design day will be: international 530, transit 210 and domestic 150.

3.2.5.2 Number of Passengers in Peak Hour

Currently the peak hour at the airport is 22:00 to 23:00 on Friday when an ATR 42 and a DC 8 park simultaneously. The situation is assumed to be the same in the design year of 1996 when a B-737 and a B-767 will park simultaneously as illustrated below:



B-737	110 Seats
B-767	230 Seats



NOTE: ICAO: Figures 1984 to 1994 are Forecast.
AIDAB/ACCA: Figures 1986 to 2000 are Forecast.
TONGA Tourist Visitors Bureau: Figures 1987 to 2000 are Forecast.
TARGET: Figures 1988 to 1998 are Forecast.

Fig. 3.1. Annual Passenger Movements

Based on a possible passenger load factor of 60%, the number of passengers at peak hour is estimated at 400, with the aircraft assumed to be the B-737 operated by Air Pacific and the B-767 operated by Hawaiian Air. There will be no transit passengers as both operate on a shuttle basis. As for the present domestic service, each aircraft makes 2 round trip flights per day. This flight mode is not expected to be changed during the design period. Based on a loading factor of 80%, the required number of daily seats will be 188, calculated from the number of domestic passengers on the design day. In this case, 8 x DHC-6 flights and 4 x BN-2 flights are required. Peak hours will be when 2 x DHC-6s and 1 x BN-2 park simultaneously. The number of domestic passengers at peak hours will be approximately 37 for departing (19x2x80% + 9x1 80%) and 15 for arriving (19x1x80%).

3.3 STUDY OF REQUESTED PARTICULARS

3.3.1 Proposed Site Location

As described in 2.6.1, the Tongan government is requesting the new terminal complex at a proposed new site. A study has been made to confirm the suitability of the site location from the viewpoint of planning the conventional airport as well as to see that the facility requirements meet the future demand. The result of the study is summarized below.

(a) The existing secondary runway transitional surface is very close to the apron. When a L-1011, a DC-8 or a B-727 is parked on the apron, the tail of the aircraft protrudes above the transitional surface. If the existing apron is still used with only some expansion, the secondary runway will either have to be closed or the existing terminal building will have to be demolished and removed to the east.

(b) Even if one of the above measures is adopted, expansion area is limited due to the trunk road on the east side, the military complex on the north side and the main runway landing strip and its transitional surface on the west side; and, if expansion is undertaken, it would conflict with operation of the airport.

(c) The prevailing wind at the airport is from the east. Therefore, when the 600m runway extension is completed, aircraft will be required to taxi a distance of 3.3km from the terminal building to the end of the runway for take-off. At a speed of 20 km/hr, this will take 10 minutes. The complete air clearance operation would then require 15 minutes; this results only two aircraft takeoffs and landings in maximum could be made at peak hour.

(d) The proposed site is located approx. 500m western from the existing terminal and has an advantage to reduce the aircraft taxiing distance by approx. 800m; this will increase runway capacity to be able to operate three(3) aircraft takeoffs and landings at peak hour in accordance with the apron requirement as mentioned in 3.4.2. The proposed site also has advantages to be cleared from both transitional surfaces of the runways and to have spaces to be expanded in the future.

In view of the above, the proposed location of the new terminal complex as shown in Fig 2.4 proves justifiable and in fact necessary.

3.3.2 Facilities and equipment to be provided

The details of the request are given in 2.6.2 and all the facilities are considered essential for adequate airport operation. However, certain GSE could be either provided by the airline companies themselves or are not urgently required, considering the present ground handling methods. Thus, these have been excluded from the scope of work for this Project.

The following GSE, together with all the requested facilities, is to be provided under this Project:

(a) Ground power 115V AC and 28V DC suitable for wide body jet requirements + 28V DC capable of starting Rolls Royce Dart or Garrett TBE 331 engines (28V 200A)

(b) Lavatory service vehicle

(c) Potable water vehicle

(d) Belt loader

3.4 FACILITY REQUIREMENTS

3.4.1 General

The overall development of Fua'amotu Airport is in progress with financial assistance from various countries. It is essential that planning of the new terminal complex be closely coordinated with these other facilities as well as with works to be carried out by the Tongan government such as the access road, water, electricity and fuel supply and telephone lines. Various activities will have to be interfaced and considered together for scheduling purposes.

Considering the requirements of the new facilities, the following basic conditions must be taken into account:

(a) Runway - The main runway will be extended by 600m to the west and will become 2,670m long and 45m wide.

(b) Runway Strip - As aircraft presently use an instrument (VOR/DME) landing system, the width of the main runway strip will be increased to 300m in accordance with IACO recommendations (150m at present); this will still remain within the airport boundary. The width of the secondary runway strip will remain (150m) as it is.

(c) Design Critical Aircraft - L-1011 type aircraft will still be the basis for the development planning. However, the Tongan government has a strong desire to construct terminal facilities to be capable of accommodating the B-747, particularly as the coming runway extension work is based on the future introduction of this aircraft. From the viewpoint of future traffic forecasts, it is unreasonable to justify the introduction of B-747 aircraft. However, taking current international service routes and the strategic location of Tonga into account, Fua'amotu Airport is well situated to become a refuelling/ transit point for flights from Honolulu to Auckland which are connected directly at present, and there remains some possibility of B-747s to being introduced for this purpose in peak season. Therefore, the B-747 must also be taken into account for the

apron planning. However, the terminal building will be planned only for the L-1011's passenger demands, and transit passengers on B-747s are expected to stay aboard the aircraft at peak hour.

3.4.2 Apron and Taxiway

Taking into account the passenger forecasts in section 3.2, it would be preferable to increase the number of flights rather than the size of the aircraft. This implies an increase in the frequency of parking two (2) aircraft simultaneously on the apron (presently only once a week). Considering future international services, simultaneous parking of three (3) aircraft is not anticipated in the present design period. However, at such an isolated international airport, scheduled operations are easily changed by unforeseeable factors (which happens frequently as described in 2.3.4). It is desirable to provide an additional parking spot for emergency use. The ACCA report recommends a 3-berth apron to accommodate a L-1011, a B-727 and a B-737. The request from the Tongan government is for a 3-berth apron to accommodate 2 x B-767-300s and a B-737. The B-767-300 is becoming a popular aircraft among worldwide airlines. Polynesian Airlines is apparently studying the possible introduction of this aircraft to their Auckland/Tongatapu/Apia route. However, the B-767-300 is almost the same size as the L-1011, hence the design critical aircraft will still be the L-1011 in accordance with the recommendations of the ACCA. It is normal practice that emergency spot capacity should be based on the largest aircraft expected to be used in the airport. However, as the L-1011 only uses the airport occasionally during peak seasons as mentioned previously, the B-727 spot size is appropriate for the purpose of emergency use of this airport.

Both the B-727 and B-737 are used extensively in the region. The national carrier, Friendly Island Airways, is planning to lease the MD-87 which is quite similar in size to the B-737. Therefore, the new apron will be a 3-berth apron capable of accommodating a L-1011, a B-727 and a B-737 or aircraft of a similar size.

3.4.3 Terminal Buildings

Requirements for the main facilities will be based on the number of peak-hour passengers and the following conditions:

(a) Well-wishers will not be allowed to enter the check-in lobby.

(b) The average time spent in the public area will be 30 minutes for departing passengers.

(c) The number of well-wishers per passenger is estimated to be 5.

(d) Space required per person in public areas is 1.0 m^2

(e) The unit floor area to be provided in the departure lobby will be 1.0 m^2 for standing passengers and 1.5 m^2 for seated passengers. It is planned that 75% of passengers will be seated.

(f) The period of passenger concentration and the processing time at the various facilities are shown in Table 3.3.

The results of the calculations are shown in Table 3.4, details of which are given in the Appendix.

Table 3.3. Necessary Time for Procedure

Procedure	Period of Passenger Concentration	Required Time
International		
Check in	60 min.	60 sec./person
Departure formalities	45	45
Security check	45	20
Entry Formalities	45	45
Customs	60	60
Domestic		
Check in	45	60
Security check	45	20

Table 3.4. Facilities Requirements for Passenger Terminal Building

		Facility	Requirement
International	Departure	Check-in Lobby	208 m2
		Check-in Counter	5 No.
		Immigration Counter	4 channel
		Security Check Counter	2 No.
		Departure Lounge	308 m2
	Arrival	Immigration Counter	4 channel
		Customs Counter	4 No.
		Baggage Conveyor Belt Length	23 m
Domestic		Check-in Counter	1 No.
		Security Check Counter	1 No.
		Departure Lounge	57 m2
Total Floor Area (incl. Public Area & Observation Deck)			3,800 m2

3.4.4 Car Park

It is planned to provide parking space for 200 vehicles, based on the number of peak-hour passengers (400) and the ratio of vehicles to passengers during peak hours obtained from the traffic survey as shown in Fig 2.6

3.5 EXECUTING AGENCY AND MANAGEMENT ORGANIZATION

The Executing agency for the Project will be the Ministry of Civil Aviation. Management, operation and maintenance of the completed facilities will also be the responsibility of this ministry. The total number of the present airport staff is 66, and the organization is divided into 7 departments as shown in Fig 3.2.

The airport organization does not include Customs, Immigration and Quarantine staff who are assigned by the Ministry of Finance (8 for Customs), the Ministry of Police (3 for Immigration) and the Ministry of Agriculture (2 for Quarantine), respectively. It is expected that additional personnel for the new terminal facilities are to be assigned adequately to meet increases in demand.

In summary, it is expected that there will be no major problems in the management, operation and maintenance of the new terminal building, apron, taxiway, car park, terminal building and ground handling equipment.

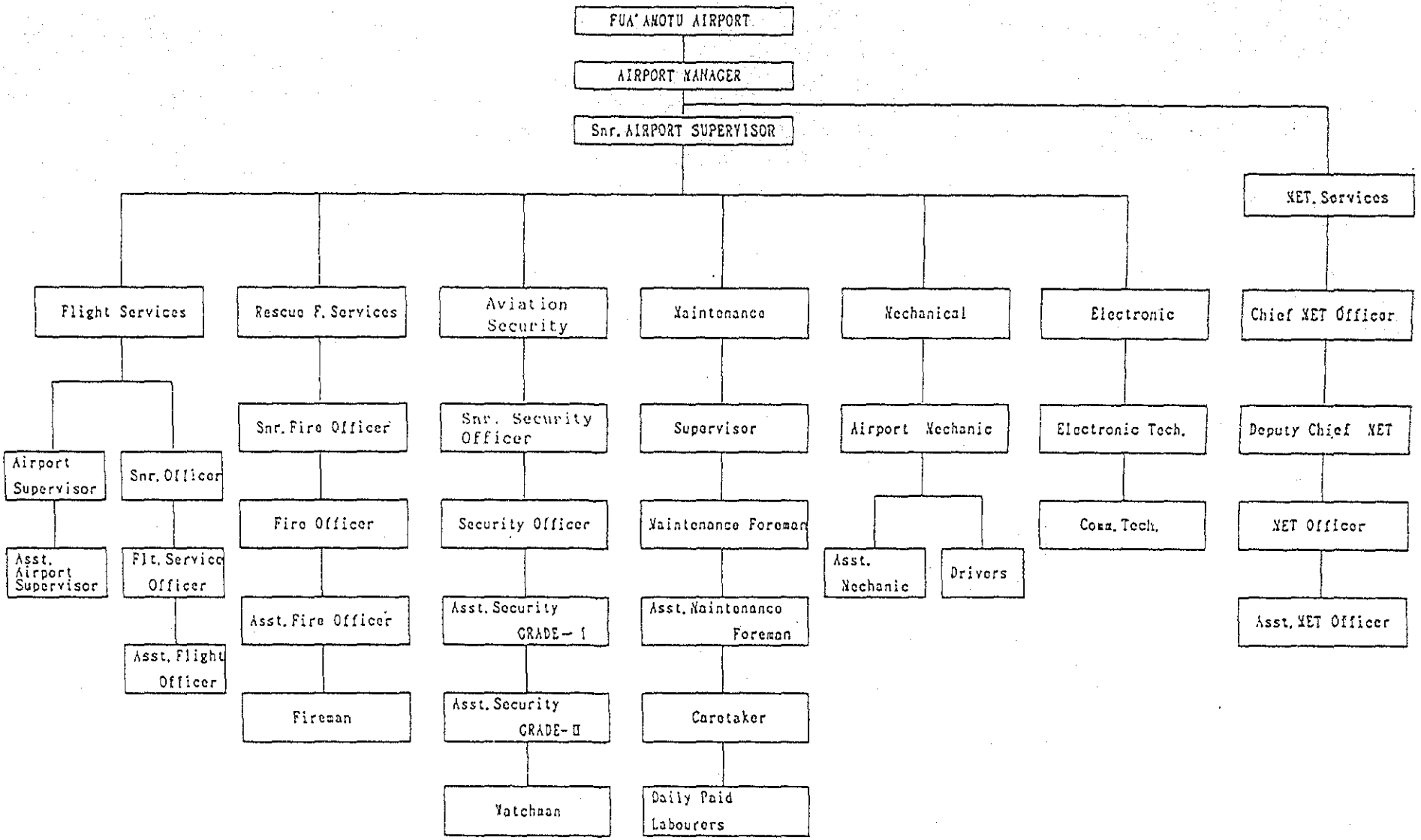


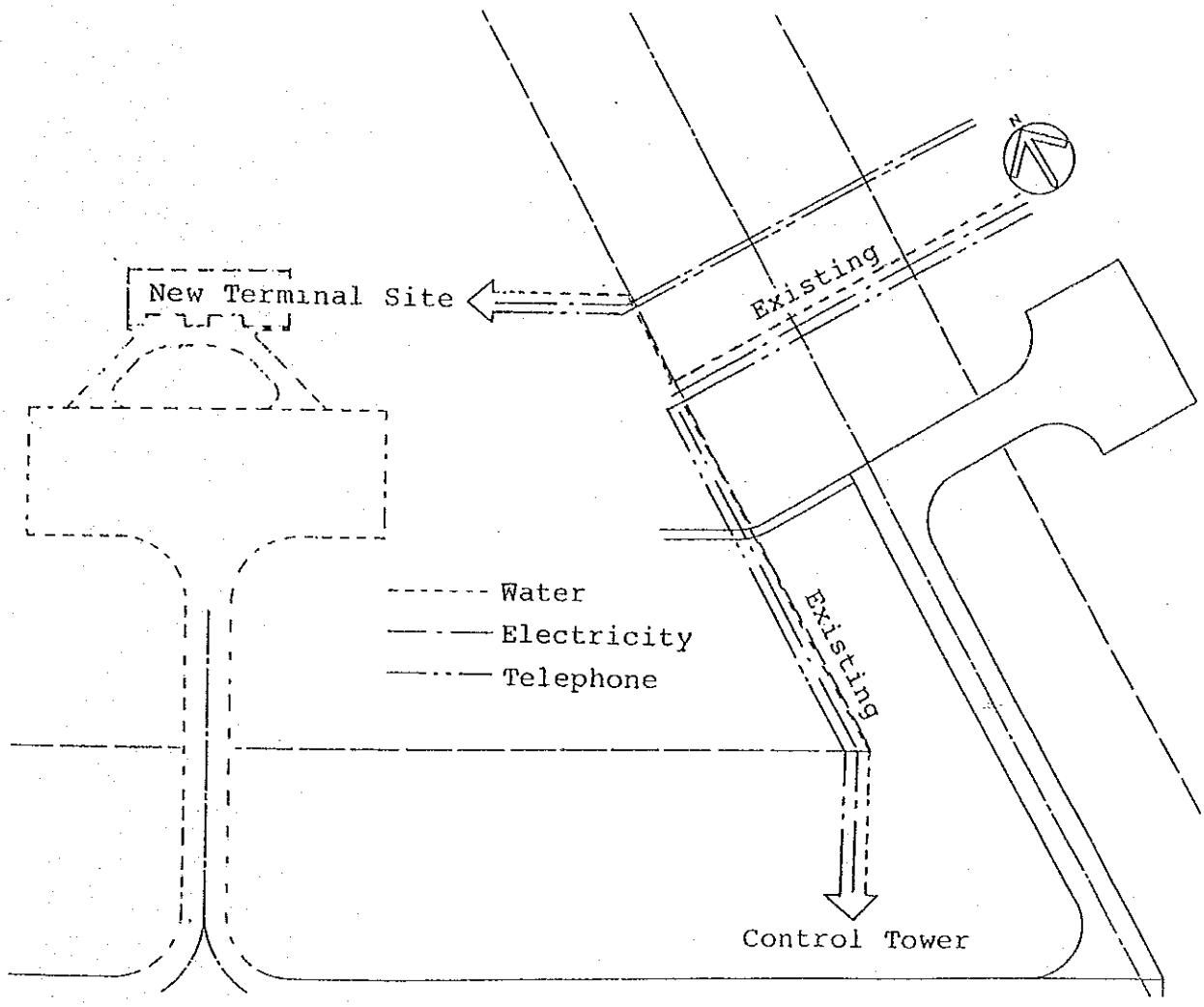
Fig. 3.2. Organization Chart of Fua'amotu International Airport

3.6 PRESENT SITE CONDITIONS

The proposed project site is on the north side of the main runway, between the secondary runway and the airport boundary as shown in Fig 2.4. The site is generally flat with no trees. After site clearance is completed, building work can be commenced immediately. Coral rock is encountered approximately 2 metres below ground surface level. Test borings did not reveal the level of the water table, but other documents show that potable water exists at a level of +0.5m (above sea level), while ground level of the site is approximately +30m. Thus drainage facilities are not considered necessary as rainwater will soak away adequately into the ground once vegetation has been established. The first 2 metres below ground level consists of stiff clay. Below this, a suitable foundation of total rock can be expected.

The Tongan government has already allocated a budget for water supply to the new terminal complex, to be extended from the existing pipe which crosses the secondary runway and leads to the control tower as shown in Fig 3.3. The budget allocation has also been made for the extension of telephone and electricity to the site from the main cables along the airport access road. In addition, the Tongan government has taken action to provide a dual lane access road to the new terminal complex.

Fig. 3.3. Electricity/Water/Telephone Pipelines



CHAPTER 4. BASIC DESIGN

CHAPTER 4 : BASIC DESIGN

4.1 DESIGN POLICY AND CONDITIONS

4.1.1 Design Policy

4.1.1.1 Passenger Terminal Building

(a) The design will be simple and logical to ensure the smoothest possible movements of both passengers and baggage from land to air and vice versa.

(b) Passenger terminal building will be designed as a single processing level concept, in view of economic feasibility compared with traffic forecasts.

(c) International and domestic passengers will be handled in the same building.

(d) The building will be designed with some flexibility for future expansion/renovation.

(e) Natural ventilation will basically be employed taking the local climate into account.

(f) The building will be designed to ensure economical and easy maintenance after completion.

(g) Locally available materials will be used wherever possible.

4.1.1.2 Apron and Taxiway

A 3-berth apron to accommodate a L-1011, a B-727 and a B-737 will be provided. Its associated taxiway and GSE road will also be provided.

4.1.1.3 Road and Car park

A car park with parking spaces for approximately 400 x 0.56 vehicles and a road to enable easy and smooth access to the terminal building will be provided.

4.1.1.4 Ground Service Equipment (GSE)

In consideration of local conditions in Tonga, ground service equipment will be selected from the viewpoint of ease of operation and minimum maintenance. Spare parts which cannot be obtained locally will also be supplied with the equipment.

4.1.2 Design Conditions

4.1.2.1 Passenger Terminal Building

The passenger terminal building will be designed in accordance with Tongan codes or practices. Should these not be available, Australian Standards, New Zealand Standards, the Japanese Architectural Standard Specification (JASS), the Japan Industrial Standard (JIS) or other applicable standards will be used.

4.1.2.2 Apron and Taxiway

Layout and sectional planning will be based on ICAO requirements. Pavement structures will be designed on the basis of geological survey results, with due consideration of the Australian design for the runway extension.

4.1.2.3 Road and Car park

The design standards of the Tongan Ministry of Works will be used as a basis for the design.

4.1.2.4 Ground Service Equipment

Electrical and mechanical performance standards for GSE will comply with the requirements of the International Electrotechnical Commission and JIS.

4.2 FACILITY LAYOUT PLANNING

The new terminal complex will be constructed at an agreed location between the two runways and the existing airport boundary, as shown in Fig 4.3, taking the following aspects into consideration:

4.2.1 Location of Terminal Building

The new terminal building will be set 385m back from the main runway centreline as shown in Fig 4.1 which ensures that the tail section of a B-747 (height 20m) will not encroach on the transitional surface even if a nose-in parking system is adopted in the future.

4.2.2 Location of the Apron

The apron will be designed to allow the parking of a B-747 as shown in Fig 4.2. The apron will be set 46m back from the terminal building position as defined above. This will allow a 7.5m clearance between the B-747's wingtips and apron floodlight poles during its self-manoeuvering.

The apron will also be set 140m (7 x 20m) back from the edge of the secondary runway strip (75m from the centreline) so as not to encroach on the transitional surface of the secondary runway, provided that the height of the lightning rod at the top of the apron floodlight pole does not exceed 20m.

4.2.3 Location of Taxiway

The taxiway centreline will be set at Sta. 550 just at the mid-point of the apron, in order to maximize the efficiency of the aircraft parking configuration (to enable the parking of two (2) B-747s simultaneously on such an apron), and to ensure that the existing T-VASIS (at Sta. 500 and Sta. 600) will not be affected by the construction.

Fig. 4.1. Location of Terminal Building

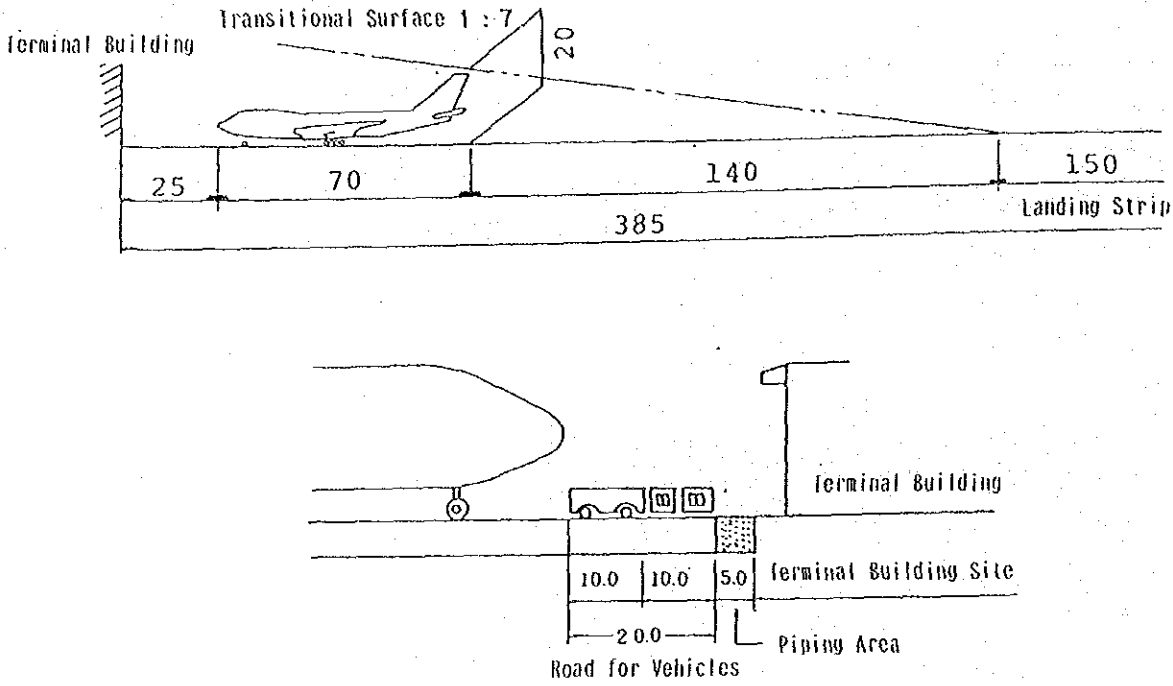


Fig. 4.2. Location of Apron

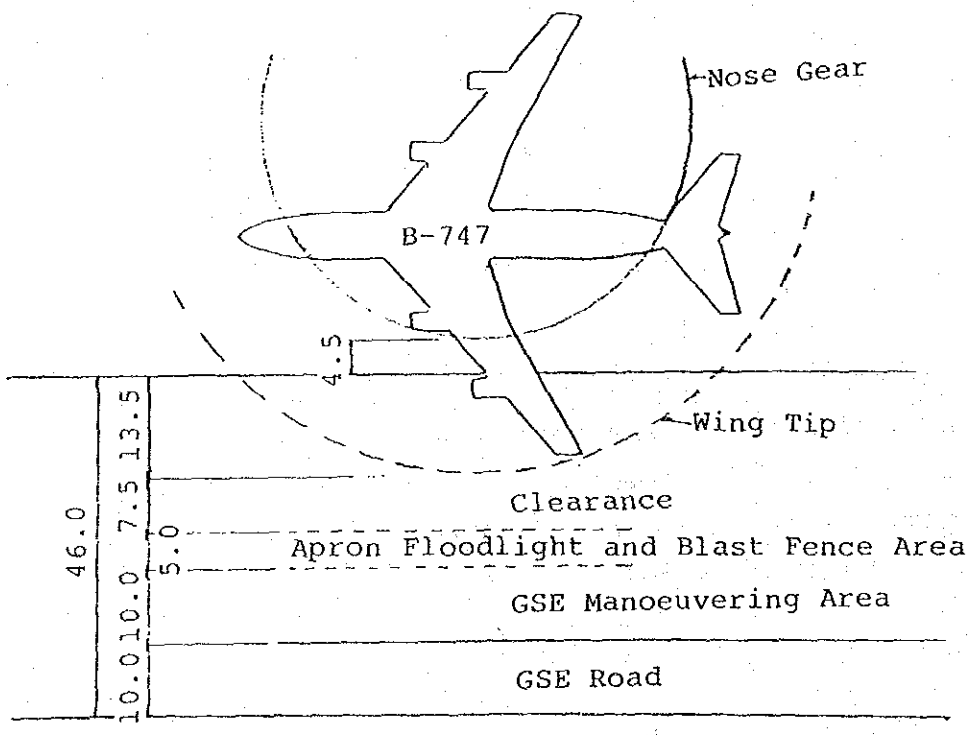
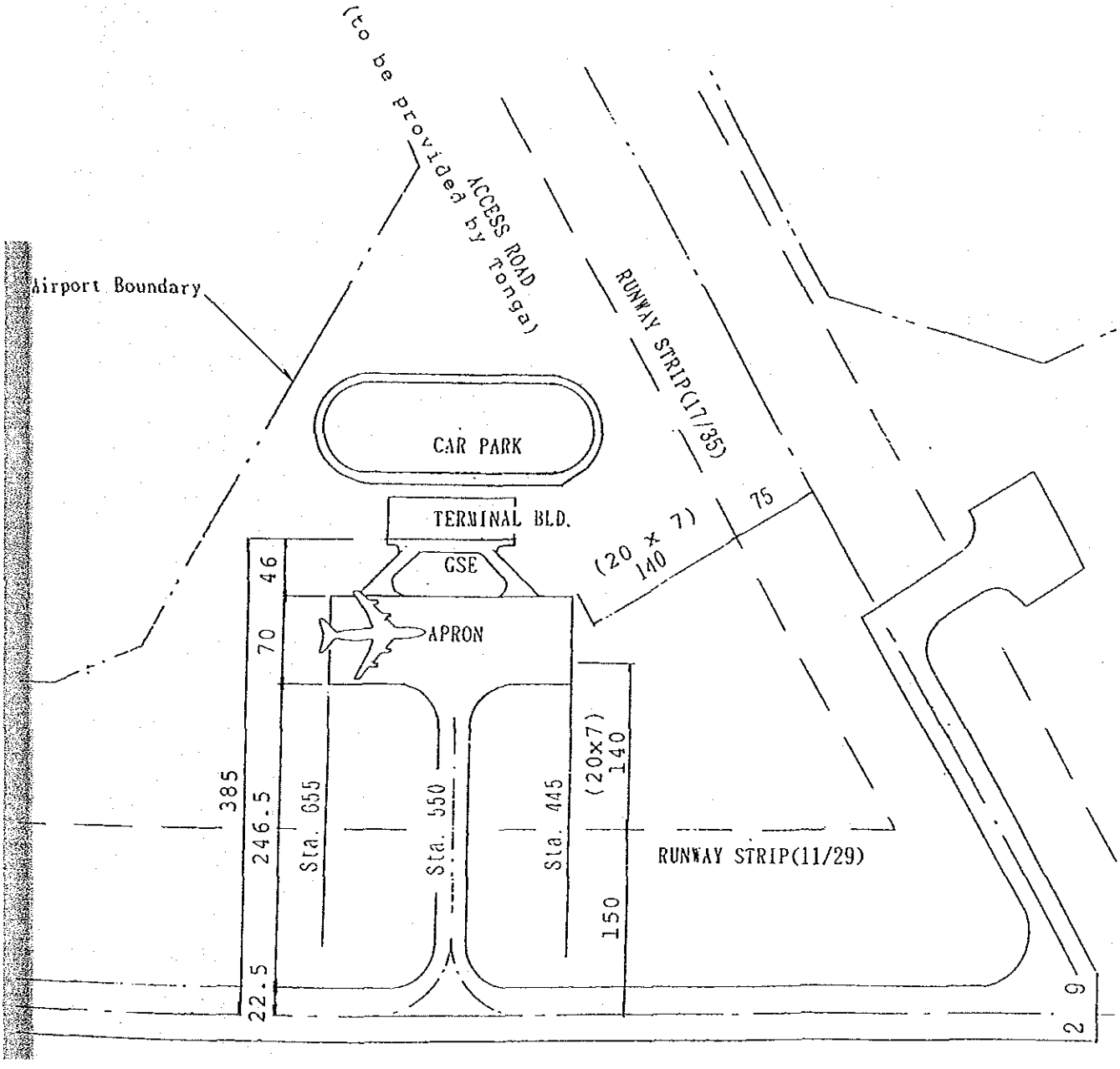


Fig. 4.3. Location of New Terminal Area



4.3 BASIC DESIGN

4.3.1 Passenger Terminal Building

4.3.1.1 Architectural Design

4.3.1.1.1 Floor Plan

(a) Basic Concept

Single storied structure catering to all the passengers and baggage on the same level will be basically adopted.

(b) Zoning

Check-in facilities will be positioned at the central part so as to separate the two different flows of international departures and arrivals for the sake of security and smooth processing. International departure and arrival facilities will be set at both sides of the above check-in facilities to allow flexible renovation/expansion because these facilities (e.g., departure lounge and baggage claim area) are the most likely to require expansion in the future.

Details of the movements of passengers and baggage are as shown in Fig 4.4.

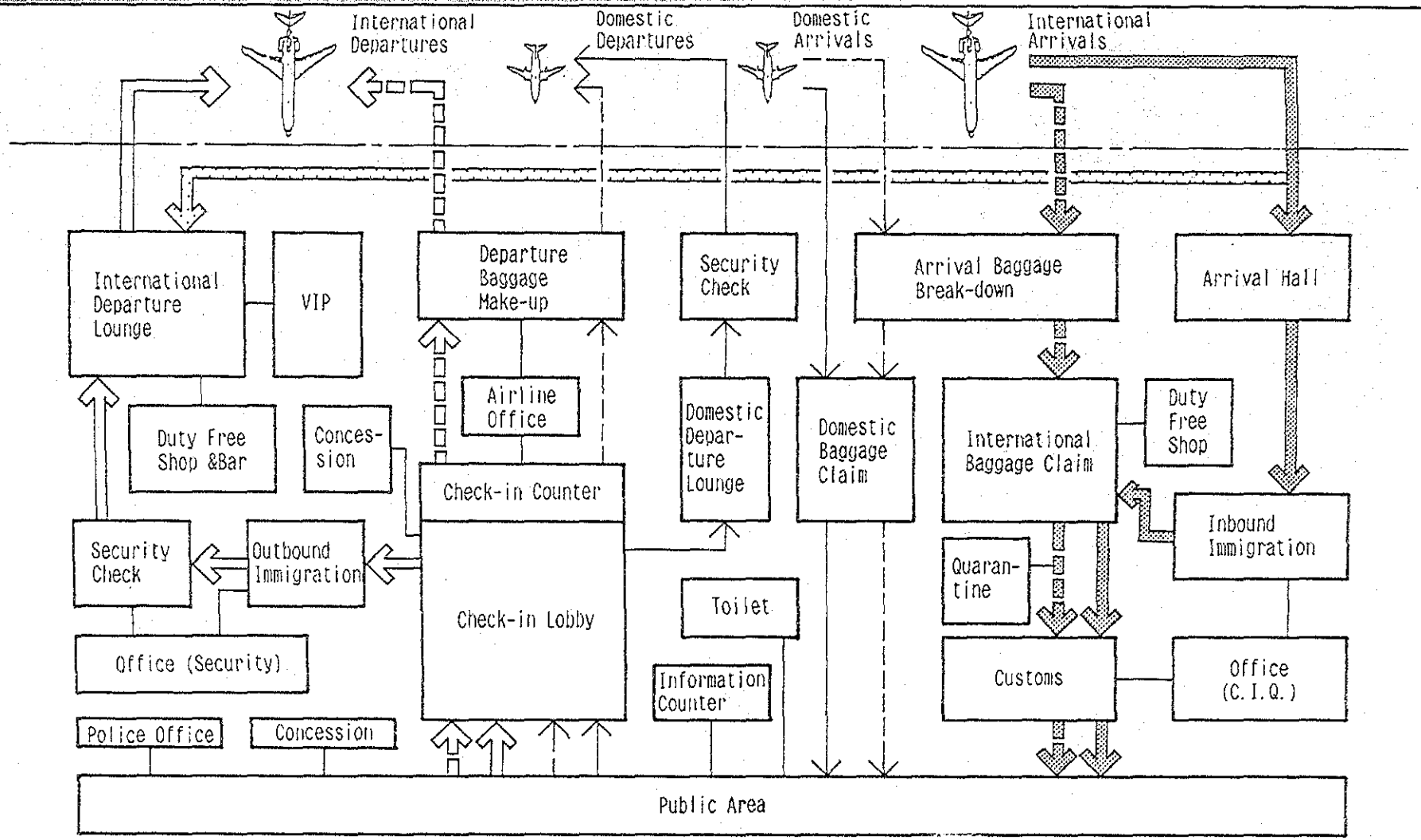


Fig. 4.4. General Flow Diagram

(c) Layout of Facilities

Requirements of the Tongan government will also be taken into account in the floor layout design.

(1) Public Area

Compared with other airports, a relatively large number of well-wishers usually come to the airport. The public area is designed to accommodate 5 visitors for every inbound and outbound passenger. An observation deck will be provided on the first floor for public use to accommodate the large number of well-wishers. A snack bar space will be installed at the corner of the observation deck.

(2) Check-In Lobby

The check-in lobby will be used by both international and domestic passengers. To minimize congestion, security counters will be provided at the entrance of the check-in lobby to restrict the entry of well-wishers. A departure lobby and corridor for domestic passengers will be located next to the check-in counter. A flight information board will be hung on the wall of the check-in lobby. Another smaller board indicating the flight(s) currently being checked in will be hung at the check-in counters.

(3) Outbound Immigration Control

Four (4) channels of immigration control will be provided.

An airport tax counter will not be installed as the tax is to be collected at the check-in counter.

(4) Security

The existing walk-through type metal detector, and X-ray machine which is also scheduled to be provided by ICAO will be installed in this area.

(5) International Departure Lounge

This will be designed to accommodate the peak-hour passengers waiting to board a B-737 and a B-767. A duty free shop and a bar will be provided.

(6) Arrival Hall and Inbound Immigration Control

Four (4) channels of immigration control will be provided. An arrival hall will be provided with benches for passengers waiting to be processed.

(7) Baggage Claim Area

International baggage will be handled by a baggage conveyor belt to achieve the highest efficiency when wide-bodied aircraft arrive, while domestic baggage will be manually handled. A quarantine control counter and a duty free shop will also be provided.

(8) Customs Control

Four (4) channels of customs inspection counters will be provided. A space for baggage carts will be provided next to the customs inspection counters. A tax collection counter will be provided separately.

(9) Customs, Immigration and Quarantine Offices

These offices will be conveniently located in the vicinity of the respective counters.

(10) Administration Office

An administration office, airport manager's office and conference room will be provided on the first floor of the building.

(11) Airline Office

An airline office space will be provided behind the check-in counter.

(12) Airport Staff Room

An airport staff room will be provided next to the airline office. It will be used as a multi-purpose room to serve as a lounge, canteen, dressing room with toilets and showers and kitchenette.

(13) Toilets

Toilets will be located in the respective areas of the building; toilets for handicapped persons will also be provided in the public area.

(14) Floor Area

The proposed floor areas of the various facilities are as shown in Table 4.1.

Table 4.1. List of Floor Areas

	Facility	Area (m2)	Remarks
Departure Area	Check-in Counter	54.0	5 No. (international) 1 No. (domestic)
	Check-in Lobby	214.6	
	International Departure Lounge	319.4	including WC (24 m2)
	Domestic Departure Lounge	72.0	including WC (20 m2)
	Sub-total	660.0	
Arrival Area	International Baggage Claim Area	166.1	including WC (18.5 m2) Baggage conveyor belt 23.5 m long
	Domestic Baggage Claim Area	40.0	
	Sub-total	206.1	
Passenger Check Area	Outbound Immigration	85.5	4 channels
	International Security Check Area	67.6	1 No. Walk-through 1 No. X ray machine
	Domestic Security Check Area	12.0	1 No. Counter
	Inbound Immigration	113.1	4 channels
	Arrival Hall	72.6	including WC (11.4 m2)
	Customs	149.9	4 No. Counter
	Sub-total	500.7	
Office	C.I.Q. Office	50.1	
	Security Office	21.0	
	Airline Office	81.0	
	Police Office	10.2	
	Administration Office	46.9	
	Airport Manager Room	16.5	
	Conference Room	24.4	
	Met. & Crew Briefing Room	13.6	
	Sub-total	263.7	

Table 4.1. List of Floor Areas (cont'd)

	Facility	Area (m2)	Remarks
Baggage Handling	Departure Baggage Make-up	126.8	
	Arrival Baggage Break-down	147.9	
	Sub-total	274.7	
Other	Concession	188.8	
	Airport Staff Common Room	60.8	
	First Aid	9.8	
	VIP Room	80.3	
	Sub-total	339.7	
Common Area	Public Area	951.6	
	Observation Deck	348.4	
	Store	11.9	
	Toilet	33.9	
	Corridor, Stair & Other	289.3	
	Sub-total	1,635.1	
	TOTAL	3,880.0	

4.3.1.1.2 Finishing Schedule

The proposed finishing schedule is as shown in Table 4.2

Locally procurable materials will be used as much as possible; however, most finishing materials are expected to be procured from neighbouring countries and Japan. Consequently, the finishing schedule has been duly considered to standardize the materials to be used.

Table 4.2. Finishing Schedule (1)

Location	Part	Material	Alternative	Reason for Selection
A. Exterior	Roof	Coloured steel sheet with insulation	Cement sheet	Durability
	Water-proof	Polyurethane	Asphalt	
	Wall	Concrete block Mortar & paint	Wooden partition Paint	Durability
	Window	Aluminium	Wooden window	Durability
	Floor	Motar steel trowel Concrete broom finish (partially)	Concrete broom finish	Durability
B. Interior				
B.1. Passenger Area				
a) Check-in Lobby	Floor	Mortar steel trowel	PVC tile	Durability
	Base	Mortar steel trowel	PVC	Durability
	Wall	Concrete block Mortar & Paint	Wooden partition Paint	Durability
	Ceiling	Insulation	Wood & Paint	Easy Construction
b) Immigration/ Departure Lounge	Floor	Mortar steel trowel	PVC sheet	Easy Maintenance
	Base	Mortar steel trowel	Wood w/oil stain	Easy Maintenance
	Wall	Concrete block Mortar & Paint	Wooden partition Paint	Durability
	Ceiling	Cement board w/paint	Wood w/paint	Easy Construction
c) Arrival Hall				
Baggage Claim	Floor	Mortar steel trowel	PVC tile	Durability
	Base	Mortar steel trowel	PVC	Durability
	Wall	Concrete block Mortar & paint	Wooden partition Paint	Durability
	Ceiling	Insulation	Wood w/paint	Easy Construction

Table 4.2. Finishing Schedule (2)

Location	Part	Material	Alternative	Reason for Selection
B.2. Office				
a) CIQ Office	Floor	Mortar steel trowel	PVC sheet	Easy Maintenance
b) Administration	Base	Mortar steel trowel	Wood w/oil stain	Easy Maintenance
c) Airline Office	Wall	Concrete block Mortar & Paint	Wooden partition Paint	Durability
	Ceiling	Plaster board w/paint	Wood w/oil stain	Easy Construction
B.3. Wet Rooms				
a) W.C.	Floor	Mortar steel trowel	Tile	
b) Kitchen	Base	Mortar steel trowel	Tile	
	Wall	Mortar w/paint	Tile	
	Ceiling	Cement board w/paint		

4.3.1.1.3 Structural Design

A steel superstructure will be used to obtain maximum space utilization. Foundations will be reinforced concrete with tie beams to accommodate seismic loading.

4.3.1.2 Mechanical and Electrical Systems

4.3.1.2.1 Air Conditioning and Ventilation

A natural ventilation system will basically be employed to maximize the advantage of the open structure of the building. Ceiling fans will be installed in the arrival hall, inbound immigration control area, baggage claim area, check-in area and offices to supplement the natural draught. The air conditioning system will be provided in closed areas including outbound immigration control, the departure lobby, VIP room and offices on the first floor. Air conditioning units will maintain a temperature difference of 5-7° between the inside and the outside. Ventilation fans will be installed in toilets and kitchenettes.

4.3.1.2.2 Plumbing System

(a) Water Supply System

Fua'amotu Airport will require a new water reservoir tank and pressure pump will be required to guarantee the necessary water quantity and pressure. Daily water consumption and required tank capacity are estimated from the number of peak-day passengers as follows:

(1) Daily Water Consumption

Airport Staff	100 persons x	200 l/day	= 20,000 l
Passengers	890 persons x	20 l/day	= 17,800 l
Visitors	4,450 persons x	5 l/day	= 22,250 l
		Total	= 60,050 l

Allowing for concurrent use, design consumption is set at 500 l/min.

(2) Water Reservoir Tank Capacity

The tank will have a two-day reservoir capacity.

60,050 l x 2 = 120,100 l say 120 m^3

(b) Drainage and Waste Water Discharge

Sewage and waste water will be discharged to septic tanks and soakaway in accordance with the normal practice in Tonga.

(c) Sanitary Fixtures

For reasons of airport security, flush valve type sanitary fixtures will be used rather than cisterns.

(d) Septic Tanks

The requirements of the septic tanks are shown in Table 4.3. The retention time of the septic tanks will be two (2) days and the permeability of the soakaway is assumed for design purposes to be 0.15 m^3 / m^2 day.

Table 4.3. Septic Tank

	Septic Tank	Soak Field
New Terminal Building	60 m3 x 2 No.	200 m2 x 2 No.
Aircraft Foul Drain	10 m3 x 1 No.	70 m2 X 1 No.

4.3.1.2.3 Fire Hydrant System

Three (3) indoor fire hydrants will be installed.

4.3.1.2.4 Electrical System

(a) Installed Capacity

200 kVA based on Table 4.4

Table 4.4. Transformer Capacity

Load	Load Capacity (KVA)	Demand Factor (%)	Installed Capacity (KVA)
Lighting	107	90	97
Receptacles	80	30	24
Air conditioner/ Ceiling fan	40	80	32
Belt conveyor	9	100	9
Outdoor lighting	15	100	15
Apron flood light	10	100	10
Septic tank (pump)	3	70	2
Water Supply (pump)	10	70	7
Total			196

(b) Power Supply

A new sub-station will be located on the east side of the terminal building. The sub-station will contain a generator room and a low voltage switchgear room. Power will be supplied via 415-240V, 50Hz, 3-phase, 4-wire, lines from an outdoor type transformer installed adjacent to the sub-station by the Tongan government.

(c) Stand-by Generator

A 200 kVA stand-by generator will be installed in the generator room to supply power to the terminal building in the event of a power failure. As mentioned in 2.4.5, commercial power supply frequently fails, and it stops for a long period when a cyclone attacks Tonga. Stand-by generator will supply sufficient power to the whole terminal building. An outdoor fuel tank will be supplied with sufficient capacity to allow the generator to operate continuously for 48 hours.

(d) Distribution Boards

The main distribution board will be installed in the low voltage switchgear room. Distribution boards will also be installed in the terminal building.

(e) Lighting and Receptacles

Table 4.5 shows the illuminance to be used in the design of the lighting. Lighting fixtures under the higher ceilings and in the public area are designed to be controlled by airport staff from 3 points. Apart from receptacles for general use, receptacles for air conditioners and ventilation fans will be installed where necessary.

Table 4.5. Average Illuminance

Room	Average Illuminance (lx)
Office & Shop	300
Other	150

(f) Telephone System

The telephone exchange including switchboard will be installed in the administration office. Cables with piping and extension cables will be installed.

(g) Public address system

Zoning of the public address system will be as follows:

(1) whole area
(2) departure area
(3) arrival area
(4) public area and observation deck
(5) office area

Among the above five areas, the departure area will be addressed from the check-in counter and departure lounge, while the others will be addressed from the administration office.

4.3.1.2.5 Miscellaneous Equipment

(a) Baggage Conveyor Belt

Baggage conveyor belts driven by electric motors will be installed in the check-in counter and baggage claim areas.

(b) Weighing Scales

Six (6) electrical weighing scales will be installed at the check-in counters.

(c) Metal Detectors

Two (2) portable type metal detectors will be provided.

(d) Information Boards

These will be provided in the terminal building in accordance with ICAO requirements. Boards will be acrylic, and characters will be printed or stuck on boards.

(e) Master Clock System

A master clock will be provided in the Administration office, and four (4) slave clocks will be provided in departure and arrival areas.

4.3.1.2.6 External Works

External work such as fencing and landscaping shall be carried out by the Tongan government

4.3.2 Apron and Taxiway

4.3.2.1 Layout Plan

As mentioned in section 3.4.2, the apron will be designed to accommodate three (3) aircraft together, namely, a L-1011, a B-727 and a B-737. The practice of angled self-parking presently employed is expected to be continued , with regard for passenger safety.

The turning radius of each aircraft is fixed as follows by setting the nose gear angle at approximately 50° during manoeuvering in accordance with Japanese design practice.

L-1011	R=27m	(nose gear angle 52°)
B-727	R=25m	(nose gear angle 50°)
B-737	R=15m	(nose gear angle 49°)

The width of the taxiway is set at 23m in accordance with IACO recommendations. Turning radii for taxiing aircraft are 60m on the runway and 40m on the apron, which are normally used for large aircraft.

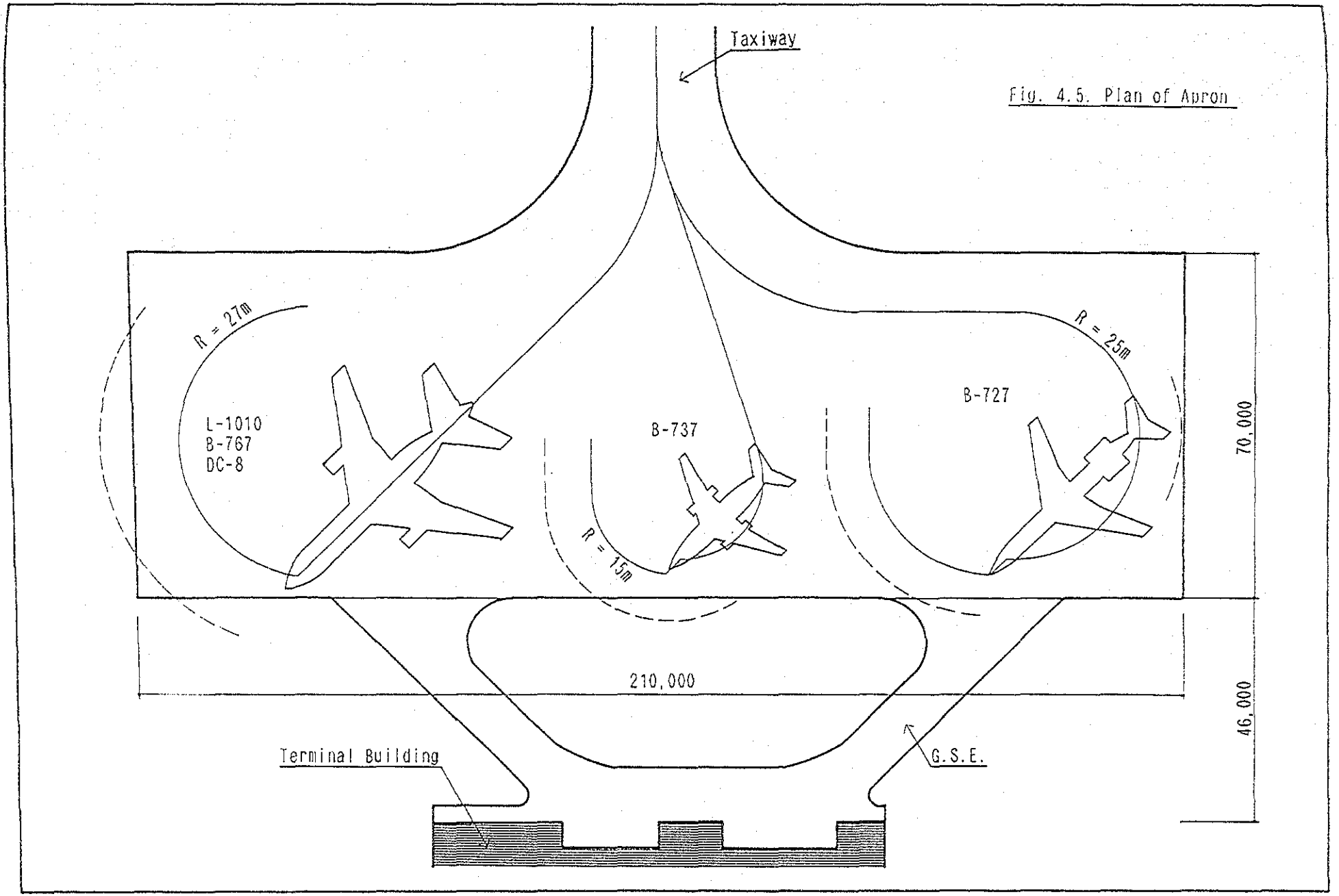


Fig. 4.5. Plan of Apron

4.3.2.2 Sectional Planning

Sectional planning will be carried out with due regard for minimizing earthwork volume and for adequate drainage condition. The following ICAO criteria will be used.

Taxiway :	longitudinal gradient	max 1.5%
	transverse gradient	max 1.5%
	longitudinal arc radius	min 3000m
Apron :	composite gradient	max 1%
Grass Area :	composite gradient	max 5%

4.3.2.3 Pavement

The results of the soil investigation conducted are presented in a separate report and may be summarized as follows:

- average thickness of topsoil is approx. 20cm.
- coral rock is encountered 2m below ground surface level.
- stiff clay exists between topsoil and coral rock.
- CBR tests conducted at two (2) test pits have revealed that the clay has a nearly optimum moisture content with CBR values of 8-11%.
- dynamic cone penetration tests gave variable values for the sub-soil reaction of the clay which indicate that a CBR value of 5-6% is adequate to be assumed as safe.
- subsoil clay is, once disturbed, not available for filling use.

The design will use a value of 6% provided that areas with a lower value could achieve 6% with additional compaction.

The runway extension project to be executed by the Australian government will also adopt a design CBR value of 6% and pavement structure as shown in Fig 4.6.

The taxiway pavement structure is designed as shown in Fig 4.6 on the basis of the foregoing Australian design, in consideration of the following:

- The in-situ coral rock has good drainage characteristics, so that it is expected that the present near optimum moisture content of the clay layer will be maintained

- Crushed coral rock to be used for the base and subbase course has better self-hardening characteristics than conventional crushed gravel.

In order to minimize rutting, the Ports and Harbours Research Institute of the Ministry of Transport in Japan has made the following recommendations:

- asphalt with penetration values of 40-60 should be used, rather than 60-100
- asphalt content should be 5-5.5%
- the mixing design should be based on the Wheel Tracking Method, in addition to the Marshall Stability Test.

These recommendations should be incorporated in the detailed design at a later stage.

Fig. 4.6. Pavement Structure for Runway Extension by Australia