JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF CIVIL AVIATION
MINISTRY OF TOURISM AND CIVIL AVIATION
KINGDOM OF NEPAL

THE STUDY
OF
TRIBHUVAN INTERNATIONAL AIRPORT
MODERNIZATION PLAN
IN
NEPAL

FINAL REPORT

VOLUME I : SUMMARY

JUNE 1994

PACIFIC CONSULTANTS INTERNATIONAL

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF CIVIL AVIATION
MINISTRY OF TOURISM AND CIVIL AVIATION
KINGDOM OF NEPAL

THE STUDY
OF
TRIBHUVAN INTERNATIONAL AIRPORT
MODERNIZATION PLAN
IN
NEPAL

FINAL REPORT

VOLUME I : SUMMARY

JUNE 1994

PACIFIC CONSULTANTS INTERNATIONAL

NOTE

The following exchange rate was adopted throughout this report :

US$ 1.00 = Rs.49.0 = Yen 109 (November, 1993)

Rs. 1.0 = Yen 2.3

PREFACE

In response to a request from the Government of the Kingdom of Nepal, the Government of Japan decided to conduct the Study on Tribhuvan International Airport Modernization Plan in Nepal and entrusted the study to the Japan International Cooperation Agency (JICA) .

JICA sent to Nepal a study team headed by Mr. Shota Morita, Pacific Consultants International, four times between July, 1993 and March, 1994.

The team held discussions with the officials concerned of the Government of Nepal, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement 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 Nepal for their close cooperation extended to the team.

June 1994

Kensuke Yanagiya

Kensuke Yanagiya

President
Japan International Cooperation Agency

June 1994

Mr. Kensuke Yanagiya

President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Yanagiya

Letter of Transmittal

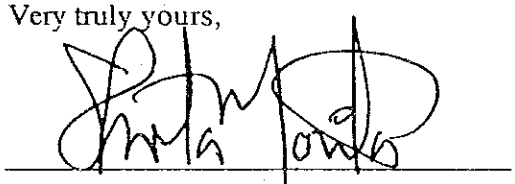
We are pleased to submit to you the final report on the Study of Tribhuvan International Airport Modernization Plan in Nepal.

This study has been conducted by Pacific Consultants International based on a contract with JICA, from July 1993 to June 1994. Throughout the study, we have taken into full consideration the present situation of Tribhuvan International Airport and have recommended that His Majesty's Government of Nepal implement this project as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of Transport. We also wish to express our deep gratitude to the Ministry of Tourism and Civil Aviation and other authorities concerned of the Kingdom of Nepal for the close cooperation and assistance extended to us during our study.

Finally, we hope that this report will be effectively used for the development of Tribhuvan International Airport.

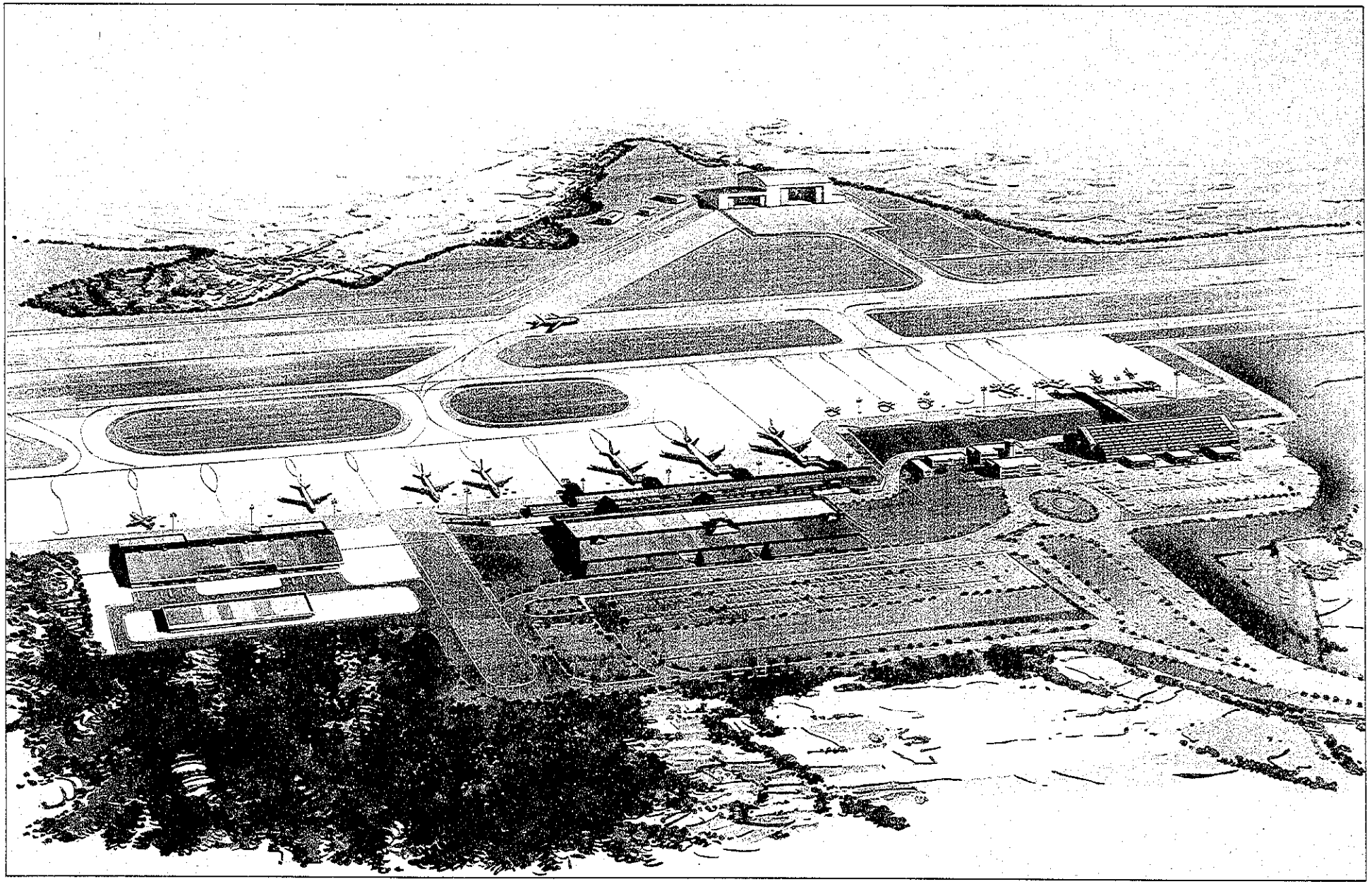
Very truly yours,



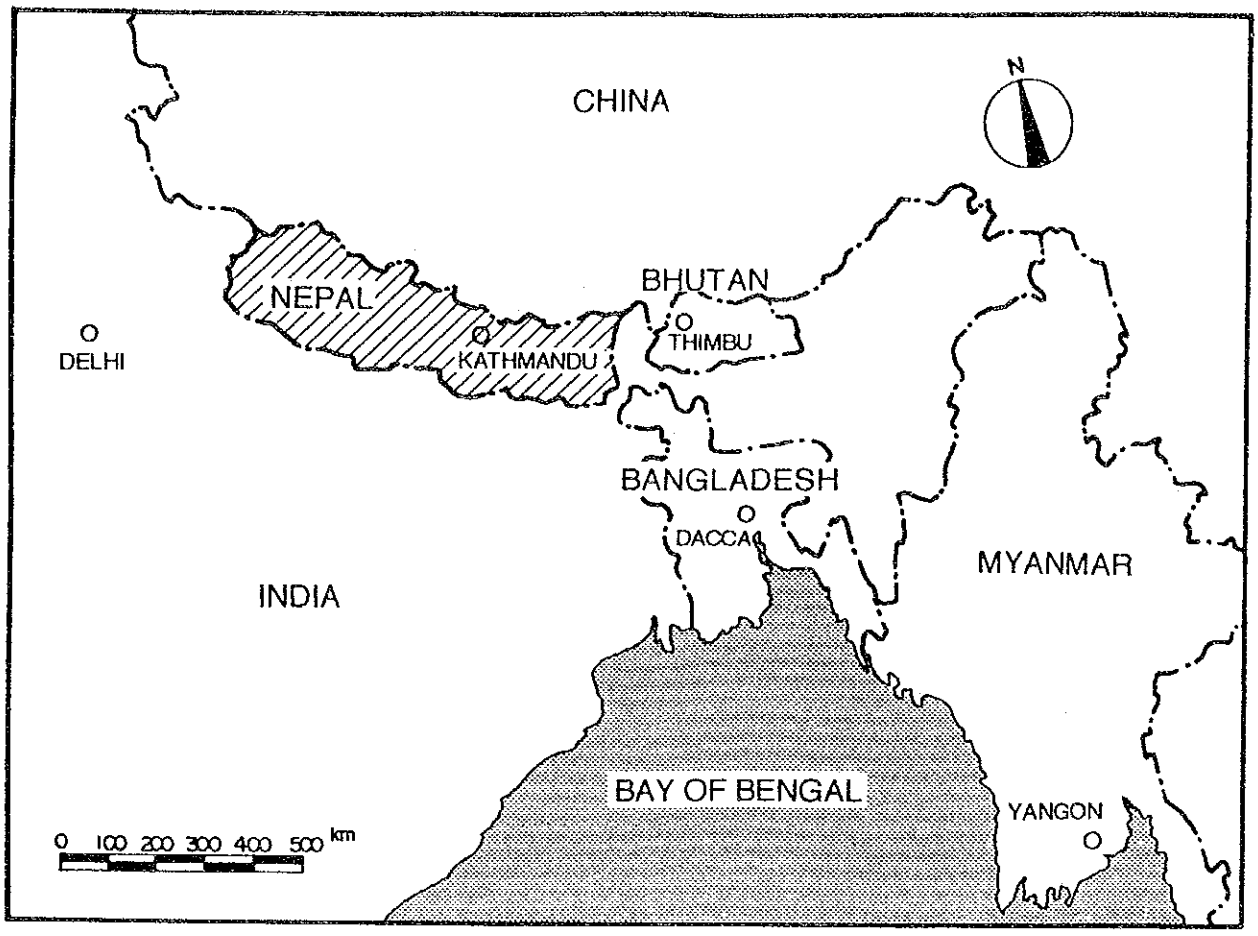
Shota Morita

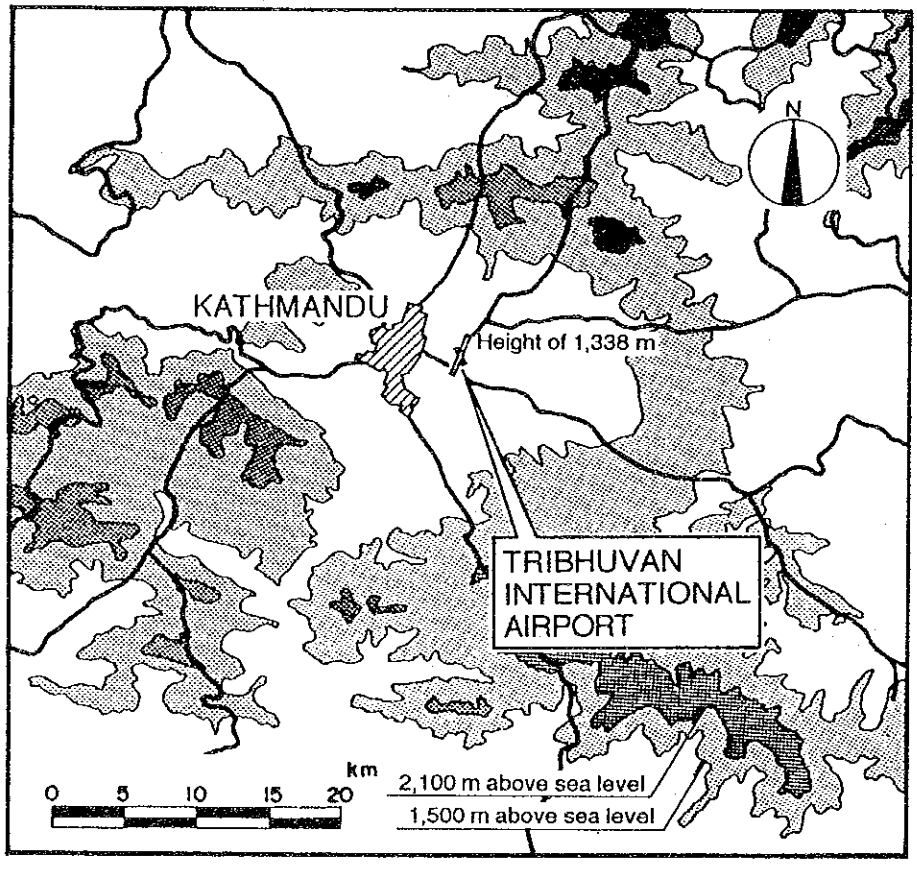
Team Leader
Study for Tribhuvan International
Airport Modernization Plan

Pacific Consultants International



TRIBHUVAN INTERNATIONAL AIRPORT
SHORT-TERM MODERNIZATION PLAN





LOCATION MAP

THE STUDY
OF
TRIBHUVAN INTERNATIONAL AIRPORT
MODERNIZATION PLAN
IN
NEPAL

SYNOPSIS

1 Background and Objectives of the Study

a. Nepal is an inland and mountainous country which possesses the highest peaks of the world. Due to its mountainous terrain and landlocked geographical features, the road system is still underdeveloped.

Thus air transport has a vital role in the national transportation system not only for passengers, but also for freight, both internationally and domestically.

The Tribhuvan International Airport (hereinafter referred to as TIA), which is sited at Kathmandu, the capital of Nepal, is the only international gateway of Nepal and also the central hub of domestic air transport in Nepal. The airport has a 3,050 meter-long runway, and is at an altitude of 1,300 meters.

In recent years, the demand for air transport in Nepal has been increasing steadily. TIA handled 780 and 292 thousand passengers for international and domestic flights respectively in 1992. This implies the urgent necessity of improvements to the airport capacity because of the age and narrowness of the airport facilities.

As mentioned above, TIA is located in the severe Himalayan natural features. This condition gives restraints to aircraft operations and also hinders the regular performance of navigation aids.

Thus the current TIA is not fully equipped with the airport facilities which are expected to be installed in modern international airports, particularly with respect to aeronautical navigation systems.

Under this situation, two air crashes occurred on the peripheral mountains of the Kathmandu valley in 1992.

b. The objectives of the Study are summarized as follows:

- formulation of a master plan for the modernization of air safety improvement and ground facilities improvement of TIA for the target year 2010
- conduct of a feasibility study for the short-term modernization plan of ground facilities improvement for the year 2003
- conduct of a technical study for an urgent project of air safety improvement

2 Airport Modernization Plan

The Airport Modernization Plan, which is the airport master plan of TIA for the target year 2010, consists of the Ground Facilities Improvement Plan and the Air Safety Improvement Plan.

2.1 Ground Facilities Improvement Plan

(1) Short-term Modernization Plan

- Construction of a new apron for B747 class aircraft
- Construction of a maintenance hangar with a maintenance apron
- Construction of an isolated aircraft parking position
- Construction of a perimeter road, security fence, terminal road and carpark
- Construction of a new international terminal building
- Construction of a new cargo terminal building
- Renovation of the existing international terminal building for domestic use

(2) Long-term Modernization Plan

- Expansion of the passenger terminal apron
- Expansion of the international terminal building
- Expansion of the cargo terminal building
- Expansion of the maintenance hangars

(3) Ultimate Modernization Plan

- Expansion of the runway strip width
- Construction of a parallel taxiway with a minimum separation distance with the runway
- Expansion of the apron and the terminal buildings

2.2 Air Safety Improvement Plan

(1) Urgent Plan

- Installation of ASR/SSR at TIA
- Installation of an additional SSR to complement the coverage of ASR/SSR
- Improvement of the communication system for radar operations
- Installation of Localizer type Directional Aids (LDA) with DME
- Improvement of CATC
- Establishment of skill evaluation, rating and a licensing institution for air traffic controllers
- Establishment of technical skill evaluation for maintenance staff

(2) Short-term Modernization Plan

- Installation of Circling guidance lights (CGL)
- Extension of ATIS coverage
- Replacement and rearrangement of the current meteorological observation equipment with an automatic system
- Replacement of the current Semi-automatic Message Switching System (MSS) with an Automatic Message Switching System
- Others

(3) Long-term Modernization Plan

- Runway lead-in lighting system
- Replacement of the existing system, such as HF, VHF transmitter/receivers, ATS console and VOR/DME due to their age
- Provision for en-route air traffic control due to air route re-structuring at the time of increased traffic volume

- Provision for a Microwave Landing System (MLS)
- Provision for an Aeronautical Mobile Satellite Service (AMSS), Automatic Dependent Surveillance (ADS) and Global Positioning System (GPS)

(4) Human Resources Development Plan

In order to cope with operation and maintenance of modern airport facilities and systems, the human resources should be developed well.

The human resources development plan for newly introduced equipment (Radar and LLZ/DME) consists of four phases to meet the sequence from preparation till operation.

2.3 Overall Airport Modernization Plan

The Overall Airport Modernization Plan was established based on the Ground Facilities Improvement Plan and the Air Safety Improvement Plan.

2.3.1 Overall Airport Modernization Plan

The airport modernization plan was established as a master plan for current improvements and future development so as to satisfy traffic demands and technical requirements and to be compatible with the environmental condition for the year 2010 and beyond.

The outline of the plan is as follows;

a. annual passengers	2.49 million	(1.94 (Int'l) 0.55 (Dom))
b. annual cargo	54,000 ton	(52,000 (Int'l) 2,000 (Dom))
c. annual aircraft movement	29,000	(12,000 (Int'l) 17,000 (Dom))
d. target aircraft operated	B747 class	
e. major works		
taxiway	construction of exit taxiways	
apron	construction of 11 stands for international aircraft with: 2 for B747 classes 6 stands for domestic aircraft 3 stands for helicopters 6 parking stands for HS748 class	
passenger terminal building	construction (floor area: 33,000 sq.m for international passengers)	
	renovation (floor area: 10,750 sq.m for domestic passengers, converted from the current Int'l PTB)	
cargo terminal building	construction (floor area: 10,700 sq.m)	
air navigation systems	installation of ASR/SSR, additional SSR, LDA/DME, CGL, etc.	

As for the ultimate airport modernization plan beyond the year 2010, widening of the runway strip from 150 m to 300 m and shifting of the parallel taxiway are planned to meet with technical requirements.

2.3.2 Short-term Modernization Plan

The short-term plan consists of the higher necessity and urgent programs. The scope of the short-term modernization plan for the target year 2003 is summarized as shown below;

a.	annual passengers	1.85 million	(1.43 (Int'l) 0.42 (Dom))
b.	annual cargo	38,000 ton	(36,000 (Int'l) 2,000 (Dom))
c.	annual aircraft movement	28,000	(11,000 (Int'l) 17,000 (Dom))
d.	target aircraft operated	MD11 class	
e.	major works		

international terminal building	new construction with 25,000 sq.m floor area
domestic terminal building	renovation of the current international PTB with 10,750 sq.m floor area
cargo terminal building	new construction with 7,500 sq.m floor area
taxiway	construction of exit taxiways
aprons	expansion of international and domestic aprons
	construction of maintenance apron and isolated parking apron
roadways and car parks	expansion and construction for 1,020 lots with a circulation road
other civil words	construction of security fence and service roads

3 Feasibility Study of the Short-term Modernization Plan

3.1 Implementation Schedule and Project Cost

a. The implementation schedule is summarized as follows;

financial arrangement	:	1995
engineering services for detailed design/tendering	:	1996 - 1997
construction	:	1998 - 2000

b. The project cost is as follows;

item	cost (million US $)		
	local portion	foreign portion	total
civil works	6.1	21.4	27.5
architectural works	10.2	80.7	90.9
airport utilities	0.6	3.8	4.4
others	0.1	1.8	1.9
physical contingency	1.7	10.8	12.5
engineering services	1.4	12.3	13.7
total	20.1	130.8	150.9

3.2 Evaluation

From the technical point of view, the short-term plan is selected and planned to meet with the required technical standards and the level of services.

The environmental considerations reveal there will not be any serious impact from the plan on the surrounding area of the airport. However attention will be paid to aircraft noise in the future so as to keep in harmony with the local communities.

The economic and financial studies show the total viability by the following indexes;

EIRR	17.1 %
NPV	Rs. 2,400 million
B/C	1.47
FIRR	- 6.2 % (base case)

The results of the economic analysis are favorable. On the other hand, the results of the financial analysis (for the base case) are not optimistic.

Although a separate study should be considered for the increase of the revenue by making changes in the airport charges, this Project (the airport facility as an important transport infrastructure) gives benefits to the national economy for the increase of foreign income and the conveniences for the air travel of the Nepalese; when evaluated from an overall viewpoint its implementation can be considered to be adequate from the economic and financial stand.

4 Technical Study of the Urgent Project

4.1 The purpose of the Urgent Improvement Plan is to establish the system to prevent the recurrence of an aircraft accident. The work items to be implemented urgently was selected as the Urgent Project due to the longer time required for manufacturing and installation than other items. As the result, the following items were selected as the Urgent Project among the Urgent Improvement Plan:

- Installation of a radar
- Construction of a radar operation building
- Construction of a training center and installation of training equipment

Basic Design was carried out for system design and facility planning prior to the detailed design of manufacturing of the equipment and construction.

4.2 The project cost is as follows;

- ASR/SSR and training facility:	26,000 thousand US dollar
- Construction of radar operation building and other buildings:	5,000
- Others:	3,000

4.3 The human resources development plan for the operation and maintenance of the Project was established, as the radar system will be introduced at first in Nepal, and the healthy operation will rely on the staffs in charge.

5 Conclusions and Recommendations

5.1 Conclusions

Through the Study, it is confirmed that the Short-term Modernization Plan is feasible from the technical, environmental and economic/financial viewpoints. Furthermore, it is confirmed that the Urgent Project is technically feasible through the technical evaluation.

As a whole, the Short-term Modernization Plan and the Urgent Project will also contribute to enhance and improve the following performances in the national and regional fields, even though these values are intangible in the analysis.

a. improvement of air safety
b. enhancement of comfort of airport users by solving congestion and improving services
c. promotion of exports and imports
d. enhancement of domestic air transport and improvement of domestic air transport safety
e. modernization of Nepalese air transport

5.2 Recommendations

a. For implementation of the project, the following are recommended.

   - national and regional consensus
   - preparatory and coordination works between the parties concerned
   - financial arrangements

b. The Urgent Improvement Plan of TIA aims particularly at easing the work load of a pilot who is seriously kept busy in maintaining the aircraft position during approaching, and at giving precise information of an aircraft position to an air traffic controller for more secured control. Thus the plan is very important to be achieved, because of recovering the air safety of TIA and showing the quick effect of air safety.

   Therefore it is quite necessary to achieve the plan as soon as possible.

   The Urgent Project has been implemented as the first stage of the plan, since the diplomatic note on the detailed design of the radar system and other facilities was exchanged between Nepal and Japan on January 1994.

   The Project was selected in the urgent improvement plan taking into account the rather long period of the production of radar system and the construction of the concerned buildings, which is estimated to govern the overall project period. Therefore ASR/SSR and the training facility are expected to be completed as the first stage. And the succeeding installation of the additional SSR and LDA/DME and also the improvement of CATC as the second stage of the plan will fully complete the object.

c. Human resources development

   In accordance with the airport's modernization, new and modern systems and equipment are planned to be introduced. This implies the necessity of higher handling capabilities so as to support these modernized systems in airport operations and management. Therefore human resources development is strongly requested.

   To develop the necessary human resources by themselves in Nepal is a primary policy. However it will be expected to utilize international technical assistance at the beginning of the development so as to accelerate the process.

As CATC is the core institute of human resources development, it is strongly expected that they improve and strengthen their conditions.

d. Radar approach control

As a radar system will be introduced for the first time to Nepal, the radar service is planned to start by monitoring aircraft and then to change to full scale radar control with confirmation of the requisite conditions of (a) getting fully familiar with the operations and techniques by the Nepalese staff, (b) sufficient and adequate training for the staff and (c) satisfactory radar coverage.

The transition should be affirmatively and steadily done by spending sufficient time for familiarization and by utilizing international technical assistance fully.

e. Operation and maintenance of radar

It is clearly required for the radar system to be kept in a good condition by regular maintenance. To ensure this, it is strongly recommended that to secure the number of staff required, to train them well and to provide an adequate budget to sustain these.

TABLE OF CONTENTS

1. BACKGROUND AND OBJECTIVES OF THE STUDY

(1) Nepal is an inland country bordered by China and India, and is also a mountainous country which possesses the highest peaks of the world. The total land area is 147,000 km^2 and the population of 19 million (in 1992) is widely spread over the land.

Due to its mountainous terrain and landlocked geographical features, the road system, which needs high construction costs, is still underdeveloped. Thus air transport has a vital role in the national transportation system not only for passengers but also for freight, both domestically and internationally.

The industrial structure also indicates that the country is still in the initial stage of economic transition with agricultural shares of 60% in production and 90% in the number of workers. His Majesty's Government of Nepal recognizes that the diversification of the country's industrial structure, particularly towards an outward foreign exchange earning economy, is essential for sustainable growth, and emphasizes that tourism development is to be pursued in its Eighth Plan (1992~1997).

The tourism industry has been growing fast and has now become the highest foreign exchange earner. Two air crashes in the peripheral mountains of the Kathmandu Valley in 1992 will likely impact tourism adversely unless immediate measures are taken to create a positive image of TIA.

(2) The Tribhuvan International Airport (hereinafter referred to as "TIA"), which is sited at Kathmandu, the capital of Nepal, is the only international gateway of Nepal and also the central hub of air transport in Nepal. In recent years, the demand for air transport in Nepal has been increasing steadily. TIA handled 780 and 292 thousand passengers on international and domestic flights respectively in 1992. Particularly it shows the high growth in international transport, such as 25% and 10% increases in the annual number of passengers and cargo respectively between 1987 and 1992. This shows the urgent necessity of improvements to the airport capacity because of the age and narrowness of the airport facilities.

As mentioned above, TIA is located in severe Himalayan natural features. This condition limits aircraft operations and also hinders the regular performance of navigation aids. Thus TIA does not have the kind of airport facilities which are expected to be installed in modern international airports, particularly in respect to aeronautical navigation aids.

(3) Because of the above reasons, the modernization of the Tribhuvan International Airport, and particularly the improvement of the air navigation and air traffic control systems, is a matter of urgency and necessity. For this purpose, a comprehensive study needs to be carried out as the accelerating step towards the project implementation.

(4) The objectives of the study are summarized as follows:

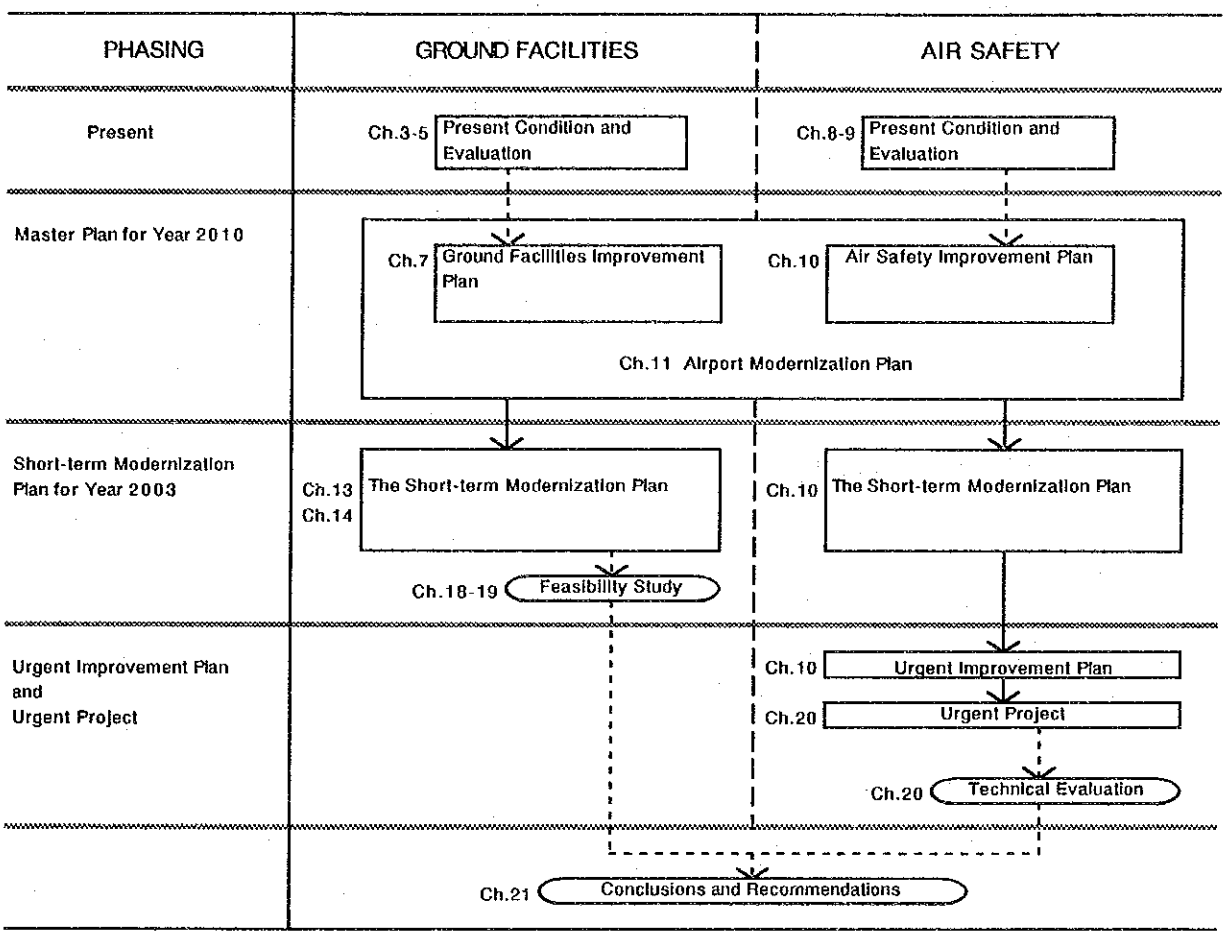
1) Formulation of a Master Plan for the modernization of air safety improvement and ground facilities improvement of TIA for the target year 2010

2) Conduct of a feasibility study for the Short-term Modernization Plan targeting year 2003

3) Conduct of a technical study for an Urgent Project of air safety improvement.

4) Conduct of technology transfers in and through the course of the Study.

(5) Figure 1.1 shows the work flow of the Study. Major work items are indicated with the related chapter in the Main Report.



Ch. : Chapter in the Main Report

Figure 1.1 Phasing of Airport Modernization Plan and Work Flow of the Study

2. AIRPORT MODERNIZATION PLAN

The Airport Modernization Plan, which is the airport master plan of TIA for the target year 2010, consists of the Ground Facilities Improvement Plan and the Air Safety Improvement Plan.

2.1 Ground Facilities Improvement Plan

2.1.1 Outline of the Existing Tribhuvan International Airport

The major facilities of the airport are summarized as follows:

Runway :	3,050 m x 45 m
Runway Strip :	3,140 m x 150 m
Taxiways :	Partial parallel taxiway
Apron :	International apron (6 aircraft stands), Domestic apron (5,640 sq.m), Maintenance apron, and VVIP apron
Buildings :	International passenger terminal building Domestic passenger terminal building Cargo terminal building Operation/airlines building
Air navigation systems :	DVOR/DME, NDB (Locator), Fan marker beacon, ALS, PAPI, Sequence flash light system, Runway threshold lights, Runway edge lights, Taxiway edge lights, Apron flood lights, Aerodrome beacon, ATS direct speech, HF, VHF, Semi automatic message switching system, Illuminated wind direction indicator, etc.

The air traffic at TIA in 1992 is listed below:

International passengers :	780,297
Domestic passengers :	292,137
International freight :	15,833 ton
Domestic freight :	680 ton
International aircraft movements :	7,597
Domestic aircraft movements :	16,991

A layout plan of the existing airport is shown in Figure 2.1.1.

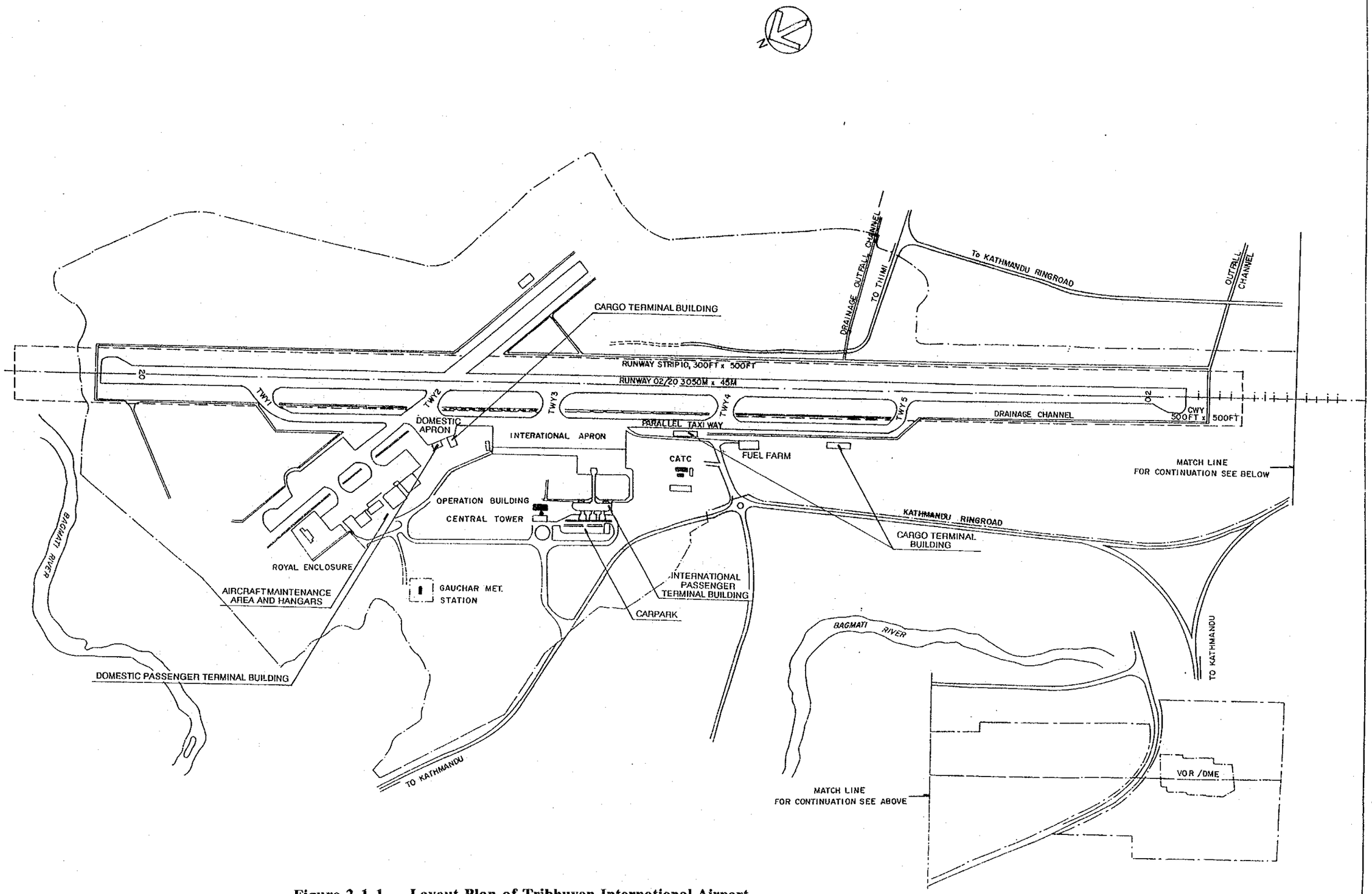


Figure 2.1.1 Layout Plan of Tribhuvan International Airport

2.1.2 Air Traffic Demand Forecast

For the annual air traffic demand forecasts at Tribhuvan International Airport, the forecast years are 1995, 2000, 2003, 2005 and 2010 covering the following categories:

- International passengers
- Domestic passengers
- International cargo
- Domestic cargo
- Aircraft movements

The forecast method is the regression analysis using the economic indices of GDPs in the related countries/areas as explanatory values.

The future international air passenger traffic demand is shown in Fig. 2.1.2.

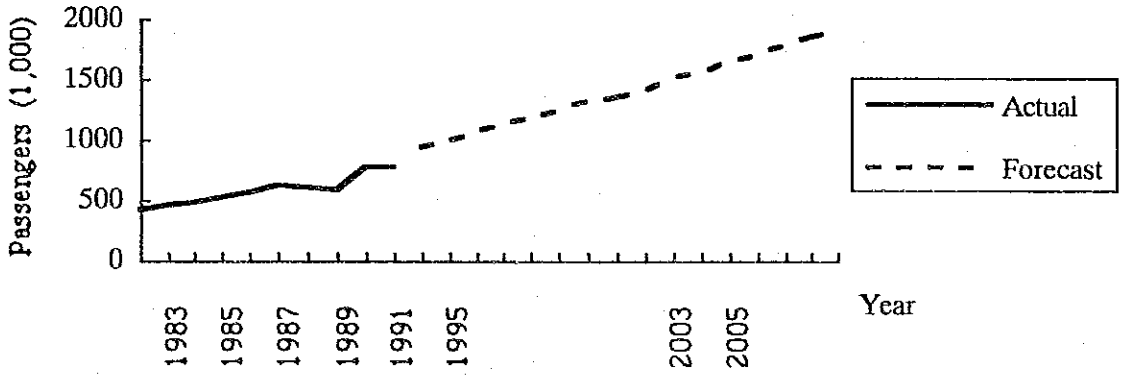


Fig. 2.1.2 International Passenger Traffic Forecast

The future domestic air passenger traffic demand is shown in Fig. 2.1.3.

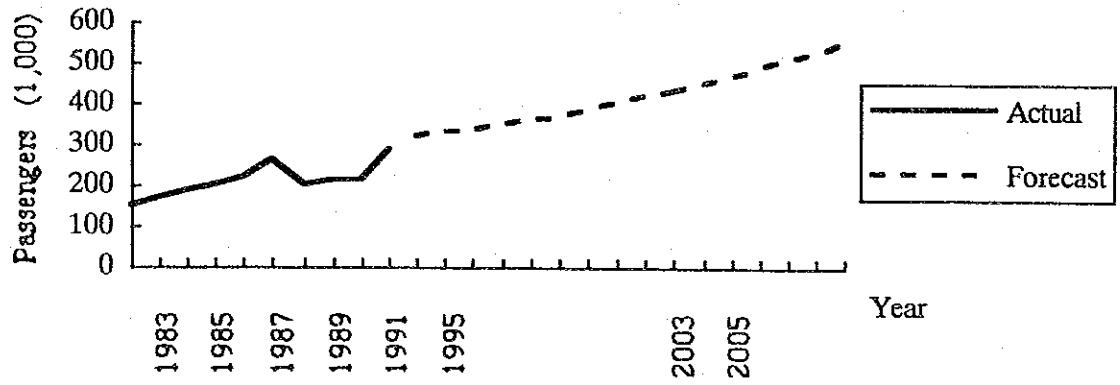


Fig. 2.1.3 Domestic Passenger Traffic Forecast

The future international air cargo traffic demand is shown in Fig. 2.1.4.

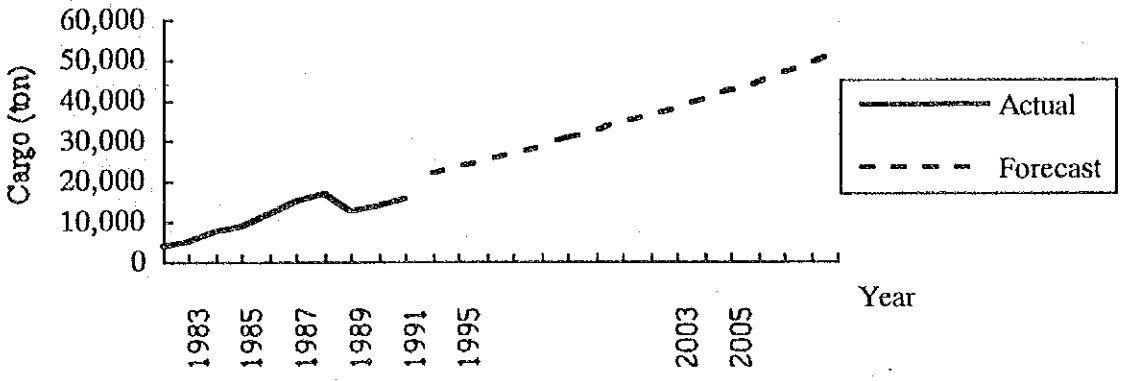


Fig. 2.1.4 International Cargo Traffic Forecast

The future domestic air cargo traffic demand is shown in Fig. 2.1.5.

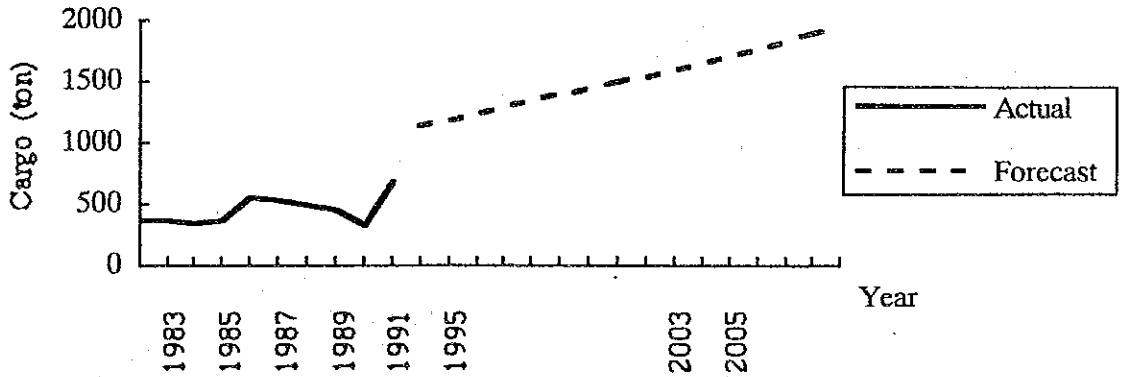


Fig. 2.1.5 Domestic Cargo Traffic Forecast

Table 2.1.1 shows the summary of air traffic demand forecasts on an annual basis. The breakdown of the annual traffic demand into a design basis is made. Table 2.1.2 shows the summary of future aircraft movements by planning year.

Table 2.1.1 Summary of Forecast Results

Year	International Passengers (1,000)	Domestic Passengers (1,000)	International Cargo (ton)	Domestic Cargo (ton)
1995	940	320	21,850	1,130
2000	1,250	370	31,050	1,380
2003	1,430	420	36,410	1,530
2005	1,570	450	40,350	1,630
2010	1,940	550	51,600	1,940
(Annual Average Growth Rates)				
1995-2000	5.9%	2.9%	7.3%	4.1%
2000-2005	4.7%	4.1%	5.4%	3.5%
2005-2010	4.3%	4.1%	5.0%	3.5%

Table 2.1.2 Summary of Aircraft Movements

INTERNATIONAL

YEAR	PASSENGER	AIRCRAFT MOVEMENTS					
		J	L	M	N	S	TOTAL
ANNUAL							
2010	1,940,000	1,180	1,770	1,770	3,540	3,540	11,800
2005	1,570,000	520	1,560	1,300	2,860	4,160	10,400
2003	1,430,000	0	1,710	1,426	3,136	5,130	11,400
2000	1,250,000	0	1,530	1,020	2,550	5,100	10,200
1995	940,000	0	1,062	638	1,912	4,888	8,500
PEAK DAY							
2010	6,690	4	6	6	12	12	40
2005	5,410	2	4	4	8	14	32
2003	4,930	0	6	4	10	16	36
2000	4,310	0	4	4	8	16	32
1995	3,240	0	4	2	6	16	28
PEAK HOUR							
2010	1,320	0.8	1.2	1.2	2.4	2.4	8
2005	1,100	0.4	0.8	0.8	1.6	2.9	6.5
2003	990	0	1.2	0.8	2	3.2	7.2
2000	880	0	0.8	0.8	1.6	3.3	6.5
1995	680	0	0.8	0.4	1.3	3.3	5.8

DOMESTIC

YEAR	PASSENGER	AIRCRAFT MOVEMENTS			
		B757	HS748	DHC6	TOTAL
ANNUAL					
2010	550,000	880	7,880	8,750	17,500
2005	450,000	510	5,920	10,480	16,900
2003	420,000	340	5,540	10,920	16,800
2000	370,000	170	4,100	12,830	17,100
1995	320,000	160	2,960	12,480	15,600
PEAK DAY					
2010	2,390	4	32	36	72
2005	1,960	2	24	42	68
2003	1,830	2	22	44	68
2000	1,610	0	16	52	68
1995	1,390	0	12	50	62
PEAK HOUR					
2010	390	0.7	5.2	5.9	11.8
2005	320	0.3	4	6.9	11.2
2003	300	0.3	3.6	7.3	11.2
2000	270	0	2.6	8.6	11.2
1995	230	0	2	8.4	10.4

Note:
J : B747-400
L : DC10, MD11,A330, B777
M : B767, A300, A310
N : B757, A320
S : B737, B727

2.1.3 Airport Facility Requirements

The facility requirements for Tribhuvan International Airport were established for the year of 1995, 2000, 2003, 2005 and 2010, and the results are summarized in Table 2.1.3. The facility requirements are estimated basically in compliance with the relevant standards and recommended practices of the International Civil Aviation Organization (ICAO). Those of the Federal Aviation Administration (FAA) of the United States, Japan Civil Aviation Bureau (JCAB) and International Air Transport Association (IATA) are also referred to in areas where the ICAO does not cover or where more practical planning is possible by using these standards.

2.1.4 Evaluation of the Existing Airport

Compared to the present conditions and the surrounding environment of TIA, the requirements for the facilities were analyzed and evaluated for planning.

Table 2.1.4 summarizes the comparison of the characteristics of the existing facilities and the ICAO recommendations. Table 2.1.5 shows the capacity of the existing airport facilities and future demands.

Table 2.1.3 Summary of the Airport Facility Requirements

Item	Unit	Year						Remarks
		Present	Future Demand					
		1992	1995	2000	2003	2005	2010	
1 Annual Passengers								
International		780,000	940,000	1,250,000	1,430,000	1,570,000	1,940,000	
Domestic		292,000	320,000	370,000	420,000	450,000	550,000	
Total		1,072,000	1,260,000	1,620,000	1,850,000	2,020,000	2,490,000	
2 Annual Cargo								
International	ton	15,833	21,850	31,050	36,410	40,350	51,600	
Domestic	ton	680	1,130	1,380	1,530	1,630	1,940	
Total	ton	16,513	22,980	32,430	37,940	41,980	53,540	
3 Annual Aircraft Movements								
International		7,597	8,500	10,200	11,400	10,400	11,800	
Domestic		16,991	15,600	17,100	16,800	16,900	17,500	
Total		24,588	24,100	27,300	28,200	27,300	29,300	
4 Maximum Aircraft Operated		DC10class	MD11 class	MD11 class	MD11 class	B747	B747	
5 Peak Day Passengers								
International		2,700	3,240	4,310	4,930	2,005	6,690	
Domestic		1,300	1,390	1,610	1,830	1,960	2,390	
Total		4,000	4,630	5,920	6,760	3,965	9,080	
6 Peak Day Aircraft Movements								
International		24	28	32	36	32	40	
Domestic		68	62	68	68	68	72	
Total		92	90	100	104	100	112	
7 Peak Hour Passengers								
International		580	680	880	990	1,100	1,320	
Domestic		210	230	270	300	320	390	
Total		790	910	1,150	1,290	1,420	1,710	
8 Peak Hour Aircraft Movements								
International		5	5.8	6.5	7.2	6.5	8.0	
Domestic		11	10.4	11.2	11.2	11.2	11.8	
Total		18	16.2	17.7	18.4	17.7	19.8	

Item	Unit	Year						
		Present	Future Requirement					
		1992	1995	2000	2003	2005	2010	beyond 2010
1 ICAO Aerodrome Reference Code		4D	4D	4D	4D	4E	4E	4E
2 Runway								
Length	m	3,050	3,050	3,050	3,050	3,050	3,050	3,050
Width	m	45	45	45	45	45	45	45
3 Runway Strip								
Length	m	3,140	3,140	3,140	3,140	3,140	3,140	3,170
Width	m	150	150	150	150	150	150	300
4 Parallel Taxiway								
System		Partial	Partial	Partial	Partial	Partial	Partial	Full
Width	m	23	23	23	23	23	23	23
Separation Distance with Runway	m	109	176	176	176	182.5	182.5	182.5
5 Apron (Number of Stands)								
International								
B747-400 class	no.	-	-	-	-	2	2	
MD11 class	no.	1	2	2	3	1	2	
B767/A300 class	no.	2	1	1	1	1	2	
B757/B737 class	no.	3	5	5	5	5	5	
Total	no.	6	8	8	9	9	11	
Domestic								
HS748 class	no.		2	2	3	3	3	
DHC6 class	no.	3	3	3	3	3	3	
Total	no.	3	5	5	6	6	6	
6 Passenger Terminal Building(Floor Area)								
International	sq.m	10,750	17,000	22,000	25,000	28,000	33,000	
Domestic	sq.m	700	4,200	5,000	5,400	5,800	7,100	
Total	sq.m	11,450	21,200	27,000	30,400	33,800	40,100	
7 Cargo Terminal Building								
International	sq.m	-	4,400	6,200	7,200	8,100	10,300	
Domestic	sq.m	-	250	300	300	350	400	
Total	sq.m	3,500	4,650	6,500	7,500	8,450	10,700	
8 Car Parking								
International	sq.m	17,000	9,500	15,400	17,500	19,300	27,700	
Domestic	sq.m	0	3,200	4,900	5,300	5,600	8,100	
Total	sq.m	17,000	12,700	20,300	22,800	24,900	35,800	
9 Rescue and Fire-Fighting Facilities								
Level of Protection		5	7	7	7	8	8	
Number of Vehicles (RIV)	no.	0	1	1	1	1	1	
(Major vehicles)	no.	4	2	2	2	3	3	
10 Airport Utilities								
Electricity	KVA	650	1,700	2,100	2,300	2,500	3,000	
Water Supply	t/day	130	330	410	460	500	600	
Sewage Disposal	t/day	130	330	410	460	500	600	
Solid Waste Disposal	kg/day	-	1,800	2,200	2,400	2,500	3,000	
11 Aviation Fuel supply								
Tank Capacity	KL	2,100	1,600	1,900	2,000	2,000	2,400	
Fuel Depot Area	sq.m		7,000	7,000	7,000	7,000	8,500	

Table 2.1.4 Comparison of the Existing Facility Characteristics with the ICAO Recommendations

ITEM	Unit	PRESENT CONDITION	ICAO RECOMMENDATION		CONFORMITY WITH ICAO RECOMMENDATIONS		
					Present	2003	2010
Aerodrome Code		4D	4D	4E			
			Non-Precision Approach				
Runway							
Width	m	46	45	45	Y	Y	Y
Max. Slope(Longitudinal)							
(a quarter of runway length at each end)	%	1.25	0.8	0.8	N	N	N
(remaining section)	%	1.35	1.25	1.25	N	N	N
Max. Slope (Transverse)	%	N.A.	1.5	1.5			
Shoulder Width	m	2	7.5	7.5	N *1	N *1	N *1
Max. Shoulder Slope	%	2.5	2.5	2.5	N	N	N
Runway Strip							
Length	m	3,140	*2 3,170	*2 3,170	N	N	N
Width	m	150	300	300	N	N	N
Max. Slope(Longitudinal)	%	1.35	1.75	1.5	Y	Y	Y
Max. Slope (Transverse)	%	1.5	2.5	2.5	Y	Y	Y
Parallel Taxiway							
Width	m	23	23	23	Y	Y	Y
Max. Slope(Longitudinal)	%	1.312	1.5	1.5	Y	Y	Y
Max. Slope (Transverse)	%	1.5	1.5	1.5	Y	Y	Y
Overall Width incl.Shoulder	m	27	38	44	N	N	N
Separation Distance with;							
Runway Center Line	m	109	176	182.5	N	N	N
Object	m	30	40.5	47.5	N	N	N

Y : conforms with ICAO recommendation
N : does not conform with ICAO recommendation

*1 : This recommendation will be satisfied by the on-going project.
*2 : 3,050 m + 60 m x 2

Table 2.1.5 Capacity and Demand of the Existing Facilities

Facility	Capacity	Demand		Serviceable Period
		2003	2010	93 95 2000 03 05 10
Runway		*	*	
Length	3050	(3050)	(3050)	
Capacity				
Movement / Hour	19 (IFR)	18.4	19.8	
Pavement		**	**	
PCN / ACN	54	53	52	
	PCN	ACN	ACN	
Apron				
International Apron				
Number of Aircraft Stands				X
B747-400 class	-	-	2	
MD11 class	1	3	2	
A300 class	2	1	2	
B757 class	-	5	5	
B727 class	3	-	-	
Total	6	9	11	
Area (sq.m)	35,547			
Pavement				
PCN	53	53	52	
Domestic Apron				
Number of Aircraft Stands				X
B757 class		*** (1)	*** (1)	
HS748 class		3	3	
DHC6 class	3	3	3	
Total	3	6	6	
Area (sq.m)	5,640			
Passenger Terminal Building	****			
Floor Area (sq.m) (Int'l)	10,750	25,000	33,000	X
(Dom)	700	5,400	7,100	X
Cargo Terminal Building				
Floor Area (sq.m)	3,500	7,500	10,700	
Car Park				
Number of lots	141	650	1,020	X
Rescue and Fire				
Category	5	7	8	X

Note: X indicates that the facility has reached its capacity.

* : Weight restriction is required.
** : ACN of Maximum aircraft operated.
*** : Common use with international stands.
**** : Unit floor area per a peak hour passenger for the int'l terminal building
Existing building : 13sq.m
New building : 25sq.m

PCN : Pavement Classification Number
ACN : Aircraft Classification Number
IFR : Instrument Flight Rules

2.1.5 Ground Facilities Improvement Plan

(1) General

This section describes the airport master plan for ground facilities of Tribhuvan International Airport by studying the development policy for the future through the comparison study.

For establishment of the improvement plan for TIA, the following basic policies are taken into consideration:

- Maximum utilization of the terrace where the existing airport is situated in order to avoid a large amount of earth works for the expansion
- Staged implementation of the improvement so as to utilize the newly-built facilities as much as possible
- Maximum utilization of the existing facilities and setting up of a priority for each improvement works, considering financial constraints

Each facility improvement will be classified into the following stages.

Short-term Modernization Plan aiming at the year 2003
Long-term Modernization Plan aiming at the year 2010
Ultimate Modernization Plan for continuous development beyond the year 2010

(2) Terminal Area Development

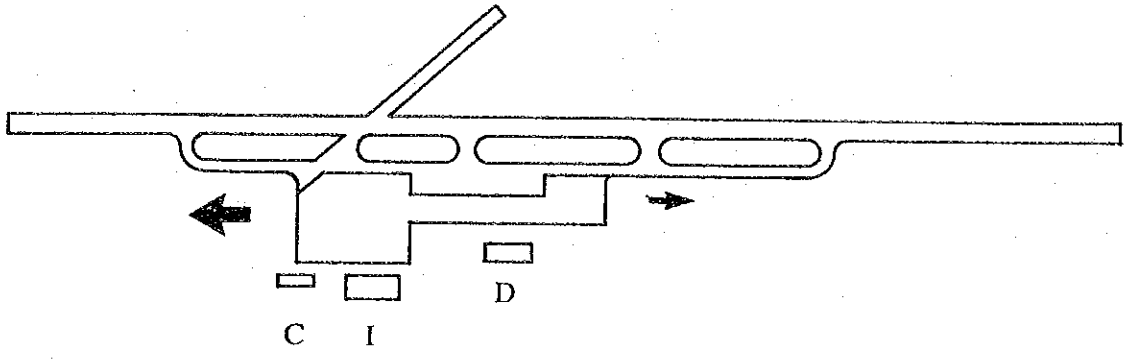
As the first step of the airport master planning for TIA, the location of the future terminal area development is studied. As alternative locations, the following three cases are established.

Case 1: Developing the present terminal mainly to the north in order to accommodate large type of aircraft. The international terminal will be located at the northern part with the domestic terminal at the southern part.

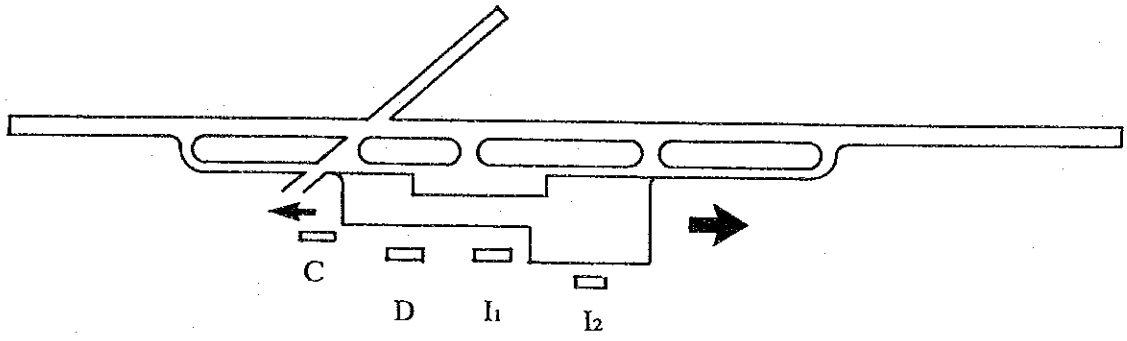
Case 2: Developing the present terminal mainly to the south. The international terminal will be located at the southern part and domestic terminal at the northern part.

Case 3: Expanding the present international terminal for international use, and constructing a new remote terminal for domestic use.

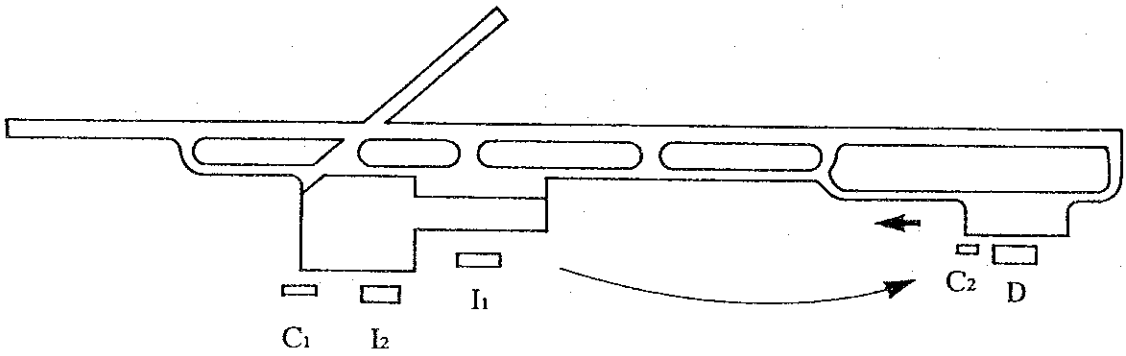
The pros and cons are compared in Table 2.1.6. As a result of the comparison, the development to the north (Case-1) is selected as the best alternative.



Case 1 Northern Development



Case 2 Southern Development



Case 3 Remote Terminal

I : International Passenger Terminal
D : Domestic Passenger Terminal
C : Cargo Terminal

Figure 2.1.6 Alternatives for Terminal Area Developments

Table 2.1.6 Comparison of Terminal Area Developments

Evaluation item \ Alternative case	Case 1 Northern Development of Present Terminal		Case 2 Southern Development of Present Terminal		Case 3 Present Terminal + New Remote Terminal (Dom PTB or CTB)	
A. Convenience for Airport Users						
1. Passenger & Cargo						
1) Transfer between Int'l and Dom	-	Good	-	Good	X	Poor
2) Easy identification of PTB	-	Good	-	Easy	X	Not easy
3) Vehicle circulation on landside	-	Simple	X	Not simple	-	Simple
2. Airport Operation						
1) Vehicle circulation on airside	-	Good	-	Good	X	Poor
2) Flexibility of spot assignment	-	Good & Easy	-	Good & Easy	X	Poor & Complicated
3) Cargo handling & conveying	-	Easy	-	Easy	X	Not easy
4) Airport administration & security	-	Easy	-	Easy	X	Not easy
B. Expandability of terminal	-	Easy and Compact	X	Not difficult but more land aquisition needed	X	Easy but inconvenience not improved
C. Cost consideration	-	Small volume of earth work	X	Medium volume of earth work	X	Large volume of earth work
Total Evaluation	0	1	3	2	8	3

(3) Terminal Area Layout Planning

Based on the selected case of the terminal area development to the north, the basic configuration of aprons is defined as follows:

- The northern portion of the aprons will be for international use because of the long depth
- The southern apron will be the domestic use

There are three alternative terminal layout plans as shown in Figure 2.1.7 taking into account the full usage of the existing international terminal building.

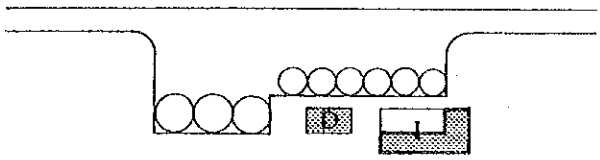
CASE-A : In this case the present international terminal building will be expanded to accommodate the needs in the design year, with the domestic terminal building sited north of the international terminal building. Therefore the use of international terminal buildings and the international and domestic aprons will cross each other. Work for land fill will be necessary to construct a flat area for the expansion.

CASE-B : In this case the present international terminal building will be converted to a domestic terminal building. A new international passenger terminal building will be constructed north of the domestic terminal building.

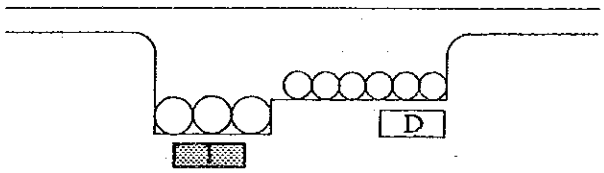
CASE-C : In this case a second international terminal building will be constructed to accommodate the excess demand which the present international terminal building cannot handle. Therefore the domestic terminal building will be sited between the two international terminal buildings.

Features of each alternative above are compared in Table 2.1.7. As the result of the comparison, CASE-B is selected as the best concept of the layout plan.

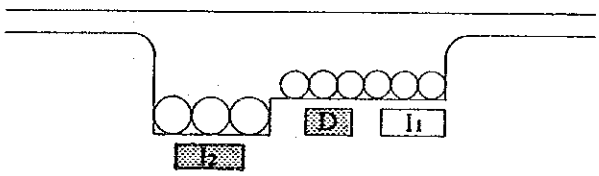
Case - A



Case - B



Case - C



Legend

I : International PTB

D : Domestic PTB

: Existing Portion

: New and/or Extended Portion

Figure 2.1.7 Alternatives of Terminal Area Layout

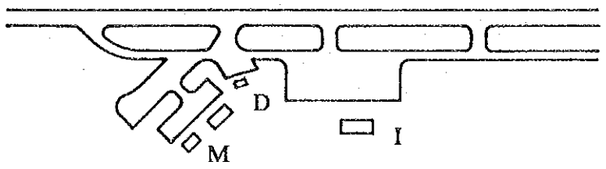
Table 2.1.7 Comparison of Terminal Area Layout Alternatives

Alternative	CASE A		CASE B		CASE C	
A. Convenience for Airport Users						
1 Passengers						
1) Transfer between Int'l and Dom	-	Good	-	Good	X	Poor
2) Easy Identification of PTB	-	Good	-	Easy	X	Not easy
3) Vehicle Traffic Flow in Land side	-	Simple	-	Simple	X	Complicated
4) Possibility of Installing Boarding Bridge to Int PTB	X	Difficult	-	Possible	-	Partly Possible
2 Airport Operation						
1) Spot Assignment and PTB siting	X	Poor	-	Good	X	Poor & Complicated
2) Flexibility of Spot Assignment	-	Good & Easy	-	Good & Easy	X	Poor & Complicated
3) Vehicle Traffic Flow in Air side	X	Complicated	-	Simple	X	Complicated
4) CIQ Staff and Facilities	-	Good	-	Good	X	Duplicate
5) Ground Support Equipment & Staff	-	Good	-	Good	X	Duplicate
B. Expandability of Terminal						
1) Pax Terminal Buildings	-	Possible, but increasing inconvenience of terminal operations due to the opposite direction of Int'l apron	-	Good	X	Difficult for Dom PTB
C. Cost Consideration						
1) Construction Cost	X	1.1 times of CASE-C	X	1.1 times of CASE-C	-	(1.0)
2) Operating cost	-	Low	-	Low	-	High
Total Evaluation	5	2	1	1	10	3

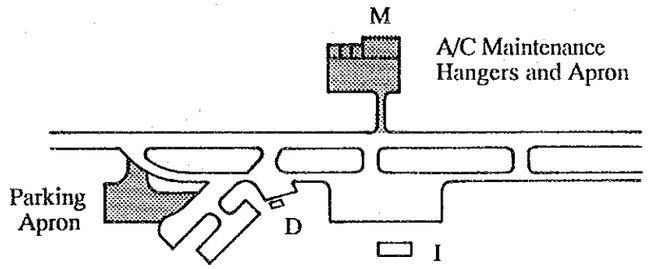
(4) Phased Development Planning

The development will be carried out step by step, following the continuous stages as shown in Figure 2.1.8.

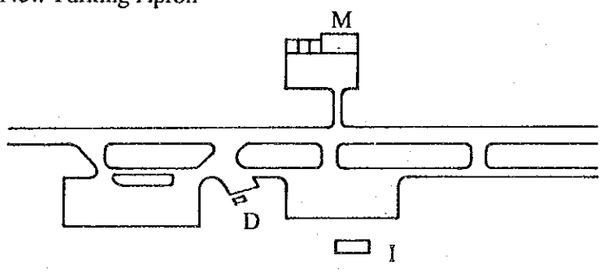
Stage 1. Present Condition



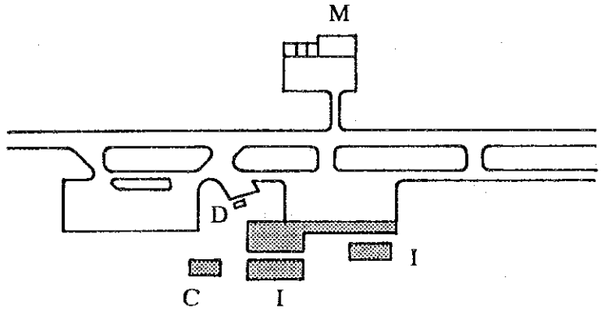
Stage 2. Construction of New Aircraft Maintenance Hangers and Apron, and New Parking Apron



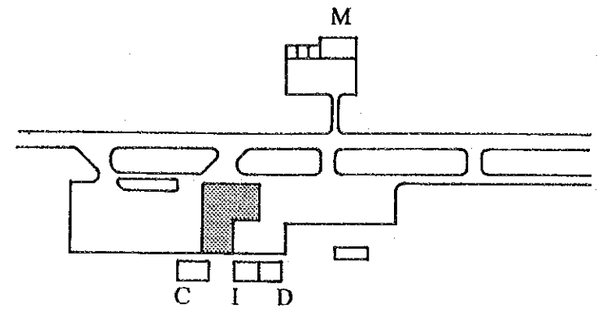
Stage 3. Demolition of Existing Aircraft Maintenance Area and Hangers, Expansion of New Parking Apron



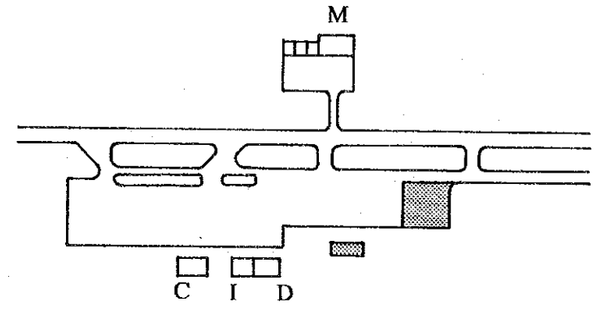
Stage 4. Construction of New Int'l PTB and New CTB, Expansion of Int'l Apron



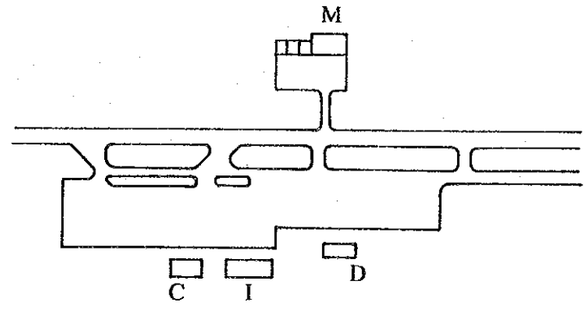
Stage 5. Demolition of Existing Dom PTB, Expansion of Int'l Apron



Stage 6. Conversion of Existing Int'l PTB to Dom PTB, Expansion of Dom Loading Apron



Stage 7. Completion of the Development



Note:

D : Domestic Passenger Terminal Building
I : International Passenger Terminal Building
C : Cargo Terminal Building
M : Aircraft Maintenance Hangers

Figure 2.1.8 Process of the Terminal Development

(5) Ground Facilities Improvement Plan

The Ground Facilities Improvement Plan is summarized in Table 2.1.8 with a comparison between the existing facilities and the requirements for the year 2010.

Table 2.1.8 Ground Facilities Improvement Plan of Tribhuvan International Airport

A. Traffic Demand

Item	Unit	1992	2010
Annual Passengers			
International		780,000	1,940,000
Domestic		292,000	550,000
Total		1,072,000	2,490,000
Annual Cargo			
International	ton	15,833	51,600
Domestic	ton	680	1,940
Total	ton	16,513	53,540
Annual Aircraft Movements			
International		7,597	11,800
Domestic		16,991	17,500
Total		24,588	29,300
Peak Hour Passengers			
International		580	1,320
Domestic		210	390
Total		790	1,710
Peak Hour Aircraft Movements			
International		5	8.0
Domestic		11	11.8
Total		18	19.8

B. Facilities

Item	Unit	1993	2010 (Requirement)	2010 (Plan)
Aerodrome Reference Code		4D	4E	4E
Runway Classification		Non-precision approach	Non-precision approach	Non-precision approach
Runway				
Length	m	3,050	3,050	3,050
Width	m	45	45	45
Runway Strip				
Length	m	3,140	3,140	3,140
Width	m	150	150	150
Parallel Taxiway				
Length	m	1,945	1,945	1,945
Overall Width	m	23	23	23
Separation Distance				
Between runway center line	m	109	109* (partially 182.5)	109* (partially 182.5)
to objects	m	30	47.5	47.5

Table 2.1.8 (Cont'd)

Item	Unit	1993	2010 (Requirement)	2010 (Plan)
Apron (Number of aircraft stands)				
Passenger Terminal Apron				
International				
B747-400 class		-	2	2
MD11 class		1	2	2
B767/A300 class		2	2	2
B757/B737 class		3	5	5
Sub Total		6	11	11
Domestic				
HS748 class		2	3	3
DHC6 class		3	3	3
Sub Total		5	6	6
Helicopter		-	3	3
Aircraft Parking Apron				
HS748 class		5	3	3
Passenger Terminal Building				
International Floor Area	m^2	10,750	33,000	33,000
Domestic Floor Area	m^2	700	7,100	10,750 (Conversion of existing Int'l terminal building
Cargo Terminal Building				
International Floor Area	m^2	Int'l+Dom=	10,300	10,300
Domestic Floor Area	m^2	3,500	400	400
Car Park				
International	m^2	-	27,700	27,700
Domestic	m^2	-	8,100	8,100
Total	m^2	17,000	35,800	35,800
	lot	141	1,020	1,020
Rescue & Fire Fighting				
Category		5	8	8
Vehicles		4	4	4
Capacity	L		18,200	18,200
Aircraft Maintenance Hangars		2	2	2

2.2 Air Safety Improvement Plan

2.2.1 Present Condition of Air Safety

(1) Air Navigation System

a) Air Traffic Control System

Air traffic control facilities at TIA are specified into two major functions, ACC and Control Tower.

The ACC has the responsibility to provide an air traffic control and information service within the KTM FIR. The service area of ACC is divided into two sub sectors, East and West. The ATC tower is in charge of approach control, aerodrome control and surface movement control at TIA.

b) Radio Navigation System

Major radio navigation aids currently installed at TIA are DVOR/DME, NDB, locators, fan marker beacons, etc. They are provided at preferable sites complying with the instrument approach procedures and the standard instrument departure procedures of the airport.

The replacement of DVOR/DME, which has been providing the major navigation service at TIA, is in progress by the Navigation Aids Project offered by the Australian Government.

c) Aeronautical Telecommunication Systems

Aeronautical Telecommunication Systems are specified into two categories by system function as an aeronautical fixed communication service and a mobile service.

a Aeronautical Fixed Communication Service

A point to point aeronautical telecommunication network and circuit are established at TIA by means of radio links, land lines and HF radio.

i) International Teletype Network (AFTN) and domestic teletype network

A semiautomatic teletype message switching system (MSS), processing with a 70 MB memory capacity, has been operated at the message switching center. A total of 16 lines, which are capable of handling messages from/to 13 input /output terminals and 3 receiving only terminals, are provided at ATS sections, the meteorological office, the briefing room, the airlines office and CAL.

Domestic teletype messages are provided by one of the MSS terminals which are installed at the Domestic Communication Center. This will be mentioned later.

ii) ATS Direct Speech

Since 1990, the Kathmandu/Calcutta and Kathmandu/Varanasi ATS voice communication circuits have been upgraded from HF voice communication to leased common carrier lines. However, the reliability of the line is low due to the poor local line quality. Some of the problems will be improved after the establishing of a UHF radio link between TIA and the Nepal Telecommunication Corporation (NTC) station which is being coordinated by the Australian Project.

iii) Domestic Radio Telecommunication

An HF radio telephone communication network is established between the Kathmandu Communication Center and thirty-two domestic airports. Two domestic HF communication centers controlling the eastern and western networks are located in the operation building. All domestic aeronautical information is handled here and relayed to the centers. Information is converted to teletype messages for the MSS at the center.

b Aeronautical Mobile Service

i) International HF Mobile Service

SEA-1 (1A) and MID-2 flight information services are provided. However, communication difficulties at night time are reported due to no optimum frequency assignment.

ii) HF Domestic Aeronautical Mobile Service

A flight information service is provided to domestic en-route flights with two HF frequencies. Communication difficulties at night and at twilight are reported due to in-adequate frequency assignment.

iii) VHF Aeronautical Mobile Service

A radio relay station is located on the top of Phulchauki mountain so as to establish satisfactory coverage for the VHF communications required for the ACC and RCC.

d) Aeronautical Ground Light Systems

a Types of lighting systems installed

The following aeronautical ground lighting systems are installed and operated at the airport.

a. Precision Approach Light System (CAT -I) (RWY - 02)
b. PAPI (RWY - 02 and 20)
c. Sequenced Flash Light System (RWY - 02)
d. Runway Edge Light System (RWY -02 and 20)
e. Runway Threshold Light System (RWY - 02 and 20)
f. Runway End Light System (RWY -02 and 20)
g. Runway End Identification Light System (RWY - 20)
h. Taxiway Edge Light System
i. Taxiway Guidance Light System
j. Illuminated Wind Direction Indicator
k. Apron Flood Light System
l. Aerodrome Beacon

b Power supply

There are three substations for the lighting systems. The first one is located in the main substation named P0. The second one, located at the south end of the runway, is named P1 and the third, P2 is at the north end of the runway.

The two main transformers are specified as 380V/ 5.5 KV, 3-phase, 250 KVA and are installed in the substation P0. The power supply to each substation is distributed by a 5,500V link distribution system.

c Control system

All aeronautical lighting systems are remotely controlled by a control console installed in the control tower. Remote control relay panels are installed in each substation and connected to the console by control cables.

(2) Human Resource Development

a) Outline of current training courses

The following training is provided at the Civil Aviation Training Center (CATC):

Courses	Training Period
Work shop seminar	3 to 4 days
Aviation security for junior police	16 days
Aviation security for senior officers	4 weeks
Air Traffic Control officer refresher course	7 weeks
Technical officer refresher course	6 weeks
Conversion from communication officer to ATC officer	23 weeks
Basic ATC officer	16 months

2.2.2 Evaluation of Air Safety

(1) Air Navigation System

a) Air Traffic Control System

The necessary improvements to the air traffic control system are as follows:

a. Introduction of an approach radar control service at Kathmandu TMA

Since an aircraft flying by instrument flight rules (IFR) in the Kathmandu control air space is controlled based on a procedural method, the flying position of the aircraft can be verified only by the controller's vision or position reports from the aircraft by means of radio communication.

In order to ensure safe operations even in poor weather conditions, visual verification of the aircraft's position for controllers by use of radar would be beneficial. A terminal radar system, therefore, should be introduced as soon as possible.

b. Expansion of radio service coverage

A transmitter should be provided for the exclusive use of ATIS at a suitable site such as the Mt. Phulchauki relay station.

b) Radio Navigation System

The following facilities should be improved in order to enhance the reliability of the system:

a. Only a VOR/DME is installed at TIA as guidance for an instrument approach. However, the accuracy of the system is not sufficient for final approach guidance to the runway.

Therefore, it would be desirable to install ILS at TIA which is the most accurate and easily-handled equipment at present. Although a glide path may not be applicable to TIA, because of the mountains intruding upon the glide slope angle, a localizer is established to be helpful to enhance the safety of approach aircraft to TIA.

Therefore, both guidance systems, not only LLZ/DME but also the current VOR/DME, are recommended so as to improve safety.

b. Locators, East and South, are still operational, but they have already reached the end of their useful lifetime.

c) Aeronautical Telecommunication Systems

The following systems should be improved to provide sufficient services and ensure the reliability of an aeronautical fixed communication service:

a. HF communication should be replaced with another communication system due to the poor reliability of the system. The existing HF system will be retained only as a back-up system for aeronautical communications.

b. The Message Switching System (MSS) does not have enough capacity in the system memory, and the function of the system is limited due to its semi-automatic nature. The implementation of an improved system is required to meet the completion of the fixed communication system development.

c. A multiple network is required to ensure communication reliability.

d) Aeronautical Ground Light Systems

All lighting systems operated at TIA follow the recommendations of ICAO Annex 14. However, guidance lighting systems for approach and departure to and from Runway 20 are not installed, which would be important and useful systems to ensure a circling approach course set up close to the mountains.

(2) Air Traffic Control Service

The one-way route system has been introduced to the ATS routes structure in the vicinity of TIA. However, due to the recent increase of aircraft operations to and from TIA, problems have arisen with this ATS route system especially on the inbound routes. In the Third ASIA/PACIFIC Regional Air Navigation Meeting of ICAO, recommendations for the revision of the one-way route system in the vicinity of major aerodromes, and the establishment of arrival and departure routes instead of the one-way routes system were accepted.

Therefore, to ensure the safe and expeditious air traffic flow, the existing one-way route system in the vicinity of TIA should be urgently modified to a two-way routes system.

(3) Human Resource Development

The following points on the Human Resource Development are recommended.

CATC should be strengthened in terms of structure and equipment so as to develop the necessary training of DCA personnel. Improvement of the training environment should be promoted by relocation and construction of a training building with the necessary modern training facilities.

Instructors with the required technical levels should be maintained in sufficient numbers for CATC courses.

Personal records of OJT should be maintained so as to be utilized for their rating and technical ability evaluation.

2.2.3 Air Safety Improvement Study

(1) Study of ILS and LLZ Approach Procedures to RWY 02

a) ILS Approach Procedure

Installation of ILS for Runway 02 is not suitable since the GP angle 6°22'54" is too steep and not practicable for safe aircraft operations. An ILS approach with offset for Runway 02 was also studied. However, 7,500 feet AMSL class mountains still remain in the intermediate and final approach segments.

b) LLZ Approach Procedure

Since there is no suitable site for the installation of onset LLZ antenna for Runway 02, installation of an offset LLZ antenna is unavoidable; LLZ Approach Procedure were studied and a draft made. However, the slope of the final approach phase of this procedure is still steep due to obstacles located to the south of the airport.

(2) Study of IGS Approach Procedure to RWY 20

It is considered that the establishment of a practical IGS approach procedure for Runway 20 is very difficult due to the many obstacles in the final approach area.

(3) Study of Approach Procedure Alternatives to the IGS Approach to RWY 20

The possibility to establish approach procedures for Runway 20 over the ravine were studied, and it is considered that the plans basically have the possibility to make safe aircraft operations provided that a new VOR/DME is installed at the point at approximately R-328/7.4 nm of KTM VOR/DME for the construction of a missed approach course.

(4) Study of Radar System

A terminal radar system consisting of an ASR/SSR is the most important element in the air safety improvement plan. At first, a radar system will be operated for the monitoring of approaching aircraft, and after the familiarization period, it will transfer to the full-scale control of the Kathmandu terminal control airspace.

a) Objectives of the radar approach control service

The objective of the radar approach control service in Kathmandu TMA is to provide a radar advisory service for approaching and/or departing aircraft at the starting stage.

b) Approach routes in Kathmandu TMA

The existing Sierra instrument approach procedure should be maintained even after the commission of the radar operation, because this is most familiar to the international airlines pilots and is the almost sole approach path to TIA.

Beside of the current approach route, new routes has been studied by the Nepalese authority to solve the concentration and the congestion of the traffic around Simara at present and in future, which is described in 2.2.2, by introducing the bi-directional routes and developing new approach routes between Sierra and Romeo fixes.

c) Required coverage for the terminal radar

The terminal radar must cover the approaching and arriving routes. On the basis of the above requirement, the Kathmandu terminal radar should cover the Sierra Approach Route. In addition to this, it is required to cover the east and the west approach routes which are planned to restructure the airspace use.

d) Radar system

i) site of radar

Because of severe topographical condition of the Kathmandu Valley, there was no fully satisfactory site to cover the requirement of the radar performance. The airport site is most desirable for final approach control, but the radar is estimated to cover only within the valley. On the other hand, a radar on the top of a mountain can perform well above the altitude of the radar site but this cannot cover inside the valley, where TIA lies, due to the characteristics of the radio.

As the result of this study, the following both sites are necessary to satisfy the required radar coverage for terminal radar control.

- ASR/SSR at TIA
- an additional radar on the top of a mountain (such as Mt. Phulchouki)

ii) radar configuration

a. To monitor and control all of arriving aircraft to an airport, it is necessary to install ASR/SSR at an airport, because of thicker traffic and handling aircraft without an equipped transponder .

b. As for an additional radar at a mountain top, there are two kind of systems; ASR/SSR or SSR.

Due to the current PANS-RAC (1985) of ICAO, SSR information without primary radar information shall not normally be used for the provision of separation to aircraft except as specified by Regional Air Navigation Agreements. Nevertheless, ICAO is on the way to revise the status of radar control by SSR to be more positive, based on the technology development and the advanced reliability of SSR equipment.

Mt. Phulchouki was selected as the best site when compared with other mountain sites. However, the area is quite limited for the construction of a structure, so that it would be difficult to construct both an ASR and SSR on this site. And at the altitude of SSR coverage (more than 9,000 ft), there will be less altitude change of approaching aircraft than at the lower altitude. And at this kind of altitude, as most of bigger aircraft are equipped with a Transponder, it is thought that it will be able to provide the separation by SSR, with the regular check of the SSR wave accuracy in the case of terminal radar control.

c. Considering these conditions totally, SSR is planned for an additional radar on a mountain top of Mt. Phulchouki.

e) Required procedure of SSR operation

According to the current PANS-RAC, it is required that this terminal radar system should be specified by Regional Air Navigation Agreements, after the authorization of the Nepal government and establishing the operation criteria.

2.2.4 Air Safety Improvement Plan

(1) Phased Improvement

The Air Safety Improvement Plan has three phases as shown below:

a) Urgent Improvement Plan with the top priority to improve the current condition of TIA
b) Short-term Improvement Plan aiming at the year 2003
c) Long-term Improvement Plan aiming at the year 2010

(2) Air Safety Improvement Plan

The Plan consists of the following programs;

a) Urgent Improvement Plan

- Installation and operation of an Airport Surveillance Radar (ASR) supported by a Secondary Surveillance Radar (SSR) at TIA for approach monitoring and approach control
- Installation of an additional SSR to complement the ASR/SSR coverage at TIA for aircraft surveillance

- Improvement of the communication system for radar operations
- Installation of Localizer type Directional Aids (LDA) with collocated Distance Measuring Equipment (DME)
- Improvement of CATC, including buildings and equipment for practical training
- Establishment of a skill evaluation, rating and licensing institution for air traffic controllers to conform to the ICAO recommendations
- Establishment of technical skill evaluations for maintenance staff

b) Short-term Improvement Plan

- Extension of ATIS coverage
- Replacement and rearrangement of the current meteorological observation equipment with an automatic system
- Replacement of the current Semi-automatic Message Switching System (MSS) with an Automatic Message Switching System
- Communications network improvement for both the domestic teletype network and international AFTN simultaneously.
- Packet switching with an open system interconnection (OSI) model
- Optimum frequency allocation for HF fixed and mobile services and replacement of antenna with a suitable antenna system
- Replacement of East and South Locators
- Establishment of an ATS direct speech circuit between Kathmandu and domestic major airports / international airports by means of a communication satellite microwave radio link
- Establishment of a domestic teletype network by means of a satellite microwave radio link instead of the existing HF point to point communications
- Replacement of the Locators of NDB
- Establishment of maintenance management planning and spare parts control

c) Long-term Improvement Plan

- Replacement of the existing system, such as HF, VHF transmitter/receiver, ATS console and VOR/DME due to their age
- Provision for en-route air traffic control due to air route re-structuring at the time of increased traffic volumes
- Provision for a Microwave Landing System (MLS)
- Provision for an Aeronautical Mobile Satellite Service (AMSS), Automatic Dependent Surveillance (ADS) and Global Positioning System (GPS)

(3) Human Resources Development Plan

In order to cope with operation and maintenance of modern airport facilities and systems, human resources should be developed sufficiently.

The human resources development plan for the newly introduced equipment (Radar and LDA/DME) consists of the following four phases to meet the sequence from preparation full operation.:

I. Preparation Phase (up to facility accomplishment)

- Airspace adjustment and approach procedures
- Approach radar control training
- Training required for the introduction of LLZ/DME
- Training for instructors
- Basic theoretical training
- Vendor training
- Maintenance training

II. Hand-over phase (from facility accomplishment to hand-over)

- Facility hand-over field training

III. Familiarization Phase (from hand-over to commencement of operation)

- Simulator training
- Laboratory training
- Practical training
- Familiarization training

IV. Operation phase (from operation to localization)

- Simulator and OJT training
- Training for backup personnel
- Management training

(4) Cost Estimate

(1) Urgent improvement plan

	(thousand dollar)
- ASR/SSR and training facility	27,000
- LDA or LLZ/DME	3,000
- Additional SSR	3,500
- Improvement of CATC	10,100

(2) Short-term development plan

- CGL	60
- MSS	3,200
- AMOS	1,100
- ATIS	70
- CSAT	3,000
- Locators	700

(3) Long-term development plan

- SSR (en-route)	5,000

2.3 Overall Airport Modernization Plan

2.3.1 Airport Modernization Plan

Based on the Ground Facilities Improvement Plan and the Air Safety Improvement Plan, the Airport Modernization Plan for Tribhuvan International Airport for the target year 2010 is established as shown in Figure 2.3.1. Figure 2.3.1 shows the Airport Modernization Master Plan for Tribhuvan International Airport for the target year 2010. Major work items to be included in the Airport Modernization Plan are summarized as follows:

(1) Urgent Plan

a) Air Safety Improvement Plan

- Installation of ASR/SSR at TIA
- Installation of an additional SSR on the top of Mt. Phulchauki
- Improvement of the communication system for radar operations
- Installation of LDA collocated with DME
- Improvement of CATC
- Establishment of skill evaluation, rating and a licensing institution for air traffic controllers
- Establishment of technical skill evaluation for maintenance staff

(2) Short-term Modernization Plan

a) Air Safety Improvement Plan

- Installation of Circling guidance lights (CGL)
- Extension of ATIS coverage
- Replacement and rearrangement of the current meteorological observation equipment with an automatic system
- Replacement of the current Semi-automatic Message Switching System (MSS) with an Automatic Message Switching System
- Others

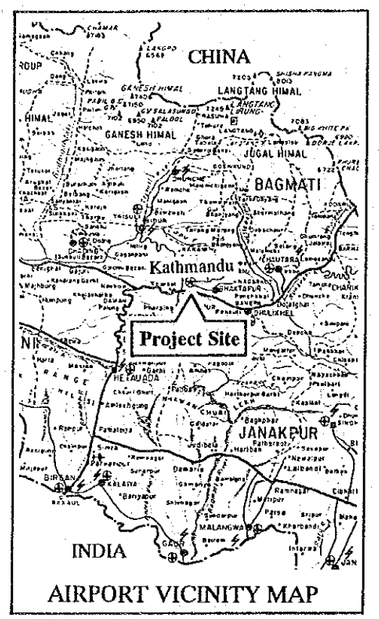
b) Ground Facilities Improvement Plan

- Construction of a new apron for B747 class aircraft
- Construction of a maintenance hangar with a maintenance apron
- Construction of an isolated aircraft parking position
- Construction of a perimeter road, security fence, terminal road and carpark
- Construction of a new international terminal building
- Construction of a new cargo terminal building
- Renovation of the existing international terminal building for domestic use

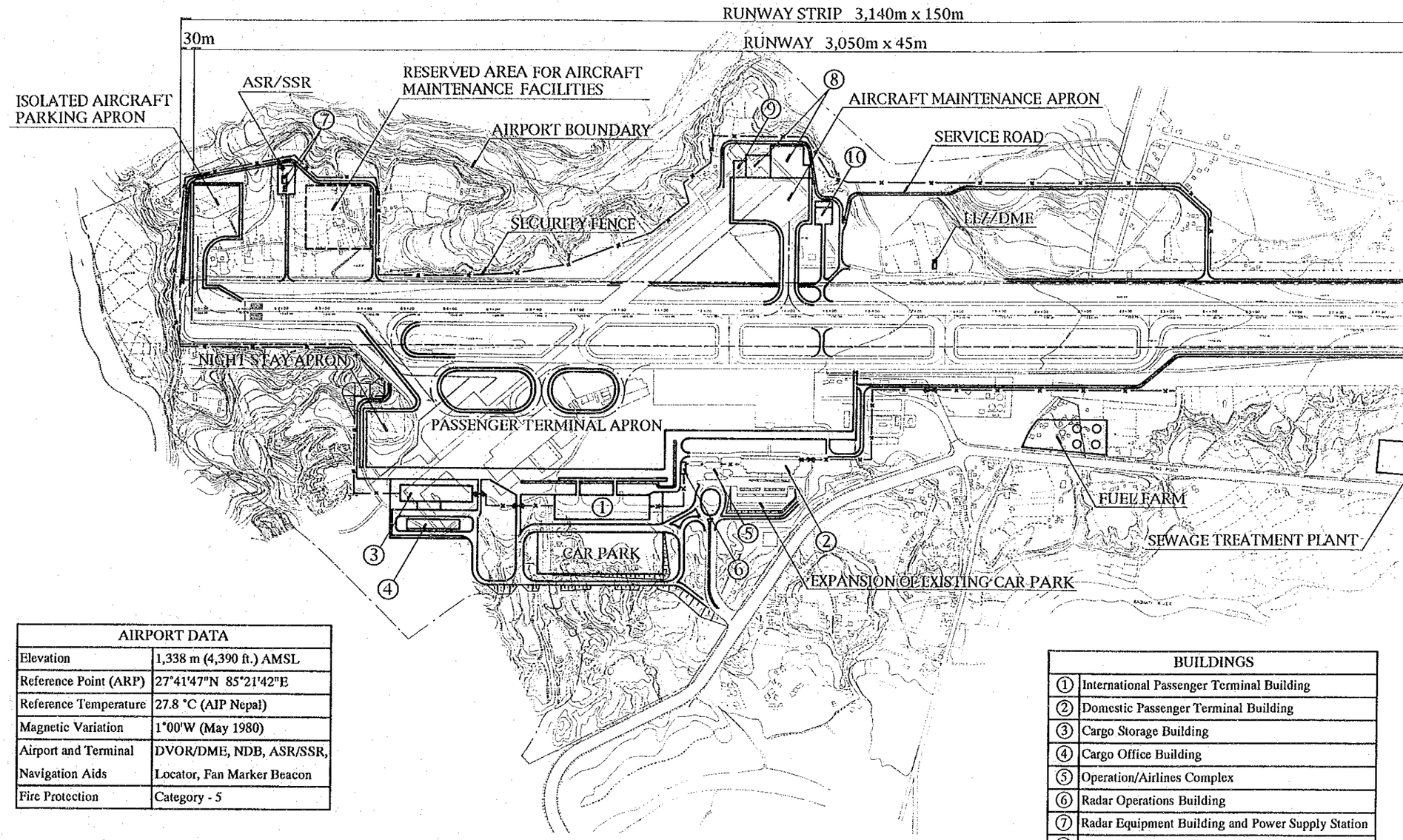
(3) Long-term Modernization Plan

a) Air Safety Improvement Plan

- Runway lead-in lighting system
- Replacement of the existing system, such as HF, VHF transmitter/receivers, ATS console and VOR/DME due to their age
- Provision for en-route air traffic control due to air route re-structuring at the time of increased traffic volume
- Provision for a Microwave Landing System (MLS)
- Provision for an Aeronautical Mobile Satellite Service (AMSS), Automatic Dependent Surveillance (ADS) and Global Positioning System (GPS)



AIRPORT VICINITY MAP

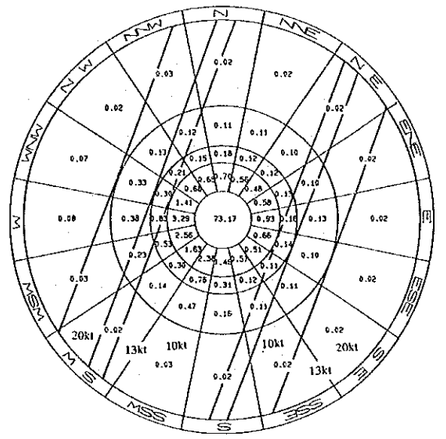


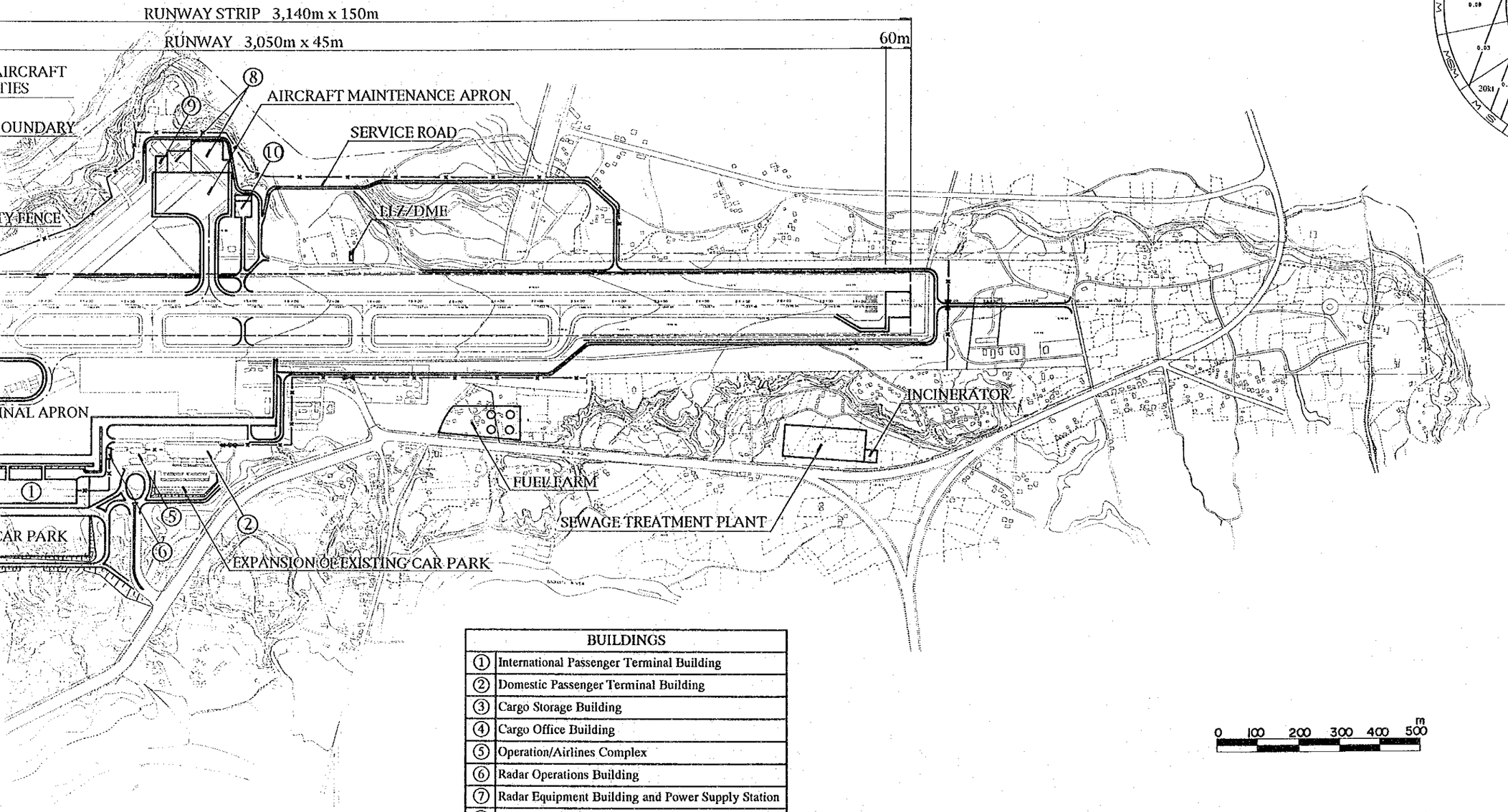
RUNWAY DATA		
Runway Orientating		02/20
Effective Gradient		0.77%
Wind Coverage (Cross Wind)		98.40% (13kt)
		99.73% (20 kt)
Instrument Runway		Yes (RWY 02, 20)
Pavement Strength		PCN 54/F/A/W/T
Approach Surface		1:50
Navigation Aids	RWY 02	DVOR/DME
	RWY 20	DVOR/DME
Visual Aids	RWY 02	SALS
	RWY 20	-

AIRPORT DATA	
Elevation	1,338 m (4,390 ft.) AMSL
Reference Point (ARP)	27°41'47"N 85°21'42"E
Reference Temperature	27.8 °C (AIP Nepal)
Magnetic Variation	1°00'W (May 1980)
Airport and Terminal Navigation Aids	DVOR/DME, NDB, ASR/SSR, Locator, Fan Marker Beacon
Fire Protection	Category - 5

BUILDINGS	
①	International Passenger Terminal Building
②	Domestic Passenger Terminal Building
③	Cargo Storage Building
④	Cargo Office Building
⑤	Operation/Airlines Complex
⑥	Radar Operations Building
⑦	Radar Equipment Building and Power Supply Station
⑧	Aircraft Maintenance Hangars
⑨	ATSC Hangar
⑩	Fire Station

ALL-WEATHER WIND COVERAGE		
Source	:	Department of Hydrology and Meteorology
Location	:	Tribhuvan International Airport
Period	:	January 1990 - December 1992





BUILDINGS	
①	International Passenger Terminal Building
②	Domestic Passenger Terminal Building
③	Cargo Storage Building
④	Cargo Office Building
⑤	Operation/Airlines Complex
⑥	Radar Operations Building
⑦	Radar Equipment Building and Power Supply Station
⑧	Aircraft Maintenance Hangars
⑨	ATSC Hangar
⑩	Fire Station

Figure 2.3.1 Airport Modernization Plan of Tribhuvan International Airport (Year 2010)

b) Ground Facilities Improvement Plan

- Expansion of the passenger terminal apron
- Expansion of the international terminal building
- Expansion of the cargo terminal building
- Expansion of the maintenance hangars

(4) Ultimate Modernization Plan

a) Ground Facilities Improvement Plan

- Expansion of the runway strip
- Construction of a parallel taxiway with a minimum separation distance with the runway
- Expansion of the apron and the terminal buildings

2.3.2 Initial Environmental Examination

(1) Contents of the Examination

As the initial environmental examination, the social and natural conditions and pollution in the area were studied. Through the scoping, aircraft noise was selected as the major environmental item for environmental impact assessment.

(2) Results of the Examination

1) Urgent Improvement Plan

The installation of the air safety facilities will contribute to the enhancement of safety at TIA, but there will be no change or impact on the environmental conditions.

2) Modernization Plan

Aircraft noise was selected through the Initial Environmental Examination for Environmental Impact Assessment.

There is aircraft noise around the airport already. This has not yet become a serious problem, but there is the possibility of aircraft noise becoming a social issue due to an increase of aircraft operations.

This will be studied by means of an aircraft noise forecast simulation.

2.3.3 Short-term Modernization Plan

The Short-term plan consists of modernization items which have a comparatively high urgency in the airport modernization master plan, from the viewpoint of airport safety and the level of services provided.

The work items of the Short-term modernization plan are shown in Table 2.3.1.

Table 2.3.1 Short-term Modernization Plan of Tribhuvan International Airport

I. Ground Facilities Improvement Plan

A. Civil Works

1. Passenger Terminal Apron

   Construction of a new apron for B747 class aircraft

2. Aircraft Maintenance Apron

   Construction of a new apron in front of the new aircraft maintenance hangar for B767 class aircraft

3. Isolated Aircraft Parking Position

   Construction of an isolated aircraft parking position for one (1) B747 class aircraft

4. Apron Service Road

5. Perimeter Road

6. Security Fence

7. Terminal Roadway and Car Parks

B. Architectural Works

1. International Passenger Terminal Building

   Floor area : 25,000 sq.m, three stories

2. Domestic Passenger Terminal Building

   Renovation of the existing passenger terminal building, Floor area : 10,750 sq.m

3. Cargo Terminal Building

   A cargo storage building and an office building, Total floor area : 7,500 sq.m

4. Aircraft Maintenance Hangar

   For one B767 class and one HS748 class aircraft, Floor area : 6,500 sq.m

C. Airport Utilities

1. Electrical Power Supply

   Installation of an emergency generator (500 KVA)

2. Water Supply

Installation of new elevated water tanks (400t x 2)

3. Sewage Disposal

Construction of a new sewage treatment plant (460 t)

4. Solid Waste Disposal

Installation of a new incinerator (2.4 t)

II. Air Safety Improvement Plan

A. Urgent Improvement Plan

1. ASR/SSR in TIA and SSR at Mt. Phulchauki
2. Additional SSR
3. LLZ/DME or LDA
4. Training Facilities

B. Short-term Modernization Plan

1. CGL (Circling Guidance Light)
2. MSS (Message Switching System)
3. CSAT (Satellite Communication System)
4. AMOS (Automatic Meteorological Observation System)
5. Locator

3. FEASIBILITY STUDY OF THE SHORT-TERM MODERNIZATION PLAN

As the navigational aids are included in a package of Air Safety Improvement Plan through the technical study, and also these are not generally applicable to economic analysis, the feasibility study handles ground facilities improvement.

3.1 Preliminary Design

3.1.1 General

The preliminary design of the facilities for the Ground Facilities Improvement Plan of the Short-term Modernization Plan is carried out on the selected work items in Section 2.3.3.

The objective of the preliminary design is to clarify the basic concept and design criteria, and to the outline specifications and dimensions of the facilities for the purpose of cost estimates. The airport layout plan and terminal area layout plan in the short-term modernization plan are shown in Figures 3.1.1 and 3.1.2 respectively.

3.1.2 Civil Works

(1) Passenger Terminal Apron

The passenger terminal apron will be expanded so as to have a sufficient number of aircraft stands for the year 2003. For the new apron in front of the new terminal building, the position of the aircraft nose is set at 359 m from the runway centerline, 110 m deeper than the existing one, so that B747-400 class parking aircraft will not infringe upon the transitional surface even when the runway strip is expanded to 300 m in future. The apron depth including the apron taxiway is to be 130 m so as to keep the minimum clearance between the apron taxiway center line and the parking aircraft, as stipulated in Annex 14 of ICAO, and to minimize the pavement area.

The existing apron will be used for the parking of HS748 and DHC6 class aircraft, so that no expansion work is planned in the Short-term Modernization Plan period.

(2) Aircraft Maintenance Apron and Hangar

The location of the hangar was decided so that the buildings may be constructed within the flat space on the terrace, and a B767 class aircraft which is parking on the maintenance apron will not infringe upon the transitional surface for the 300 m-wide runway strip in the future.

In the Short-term Modernization Plan, two maintenance hangars are planned; one is for B767 class aircraft and the other is for HS748 class aircraft. A maintenance apron will be in front of the hangar which has sufficient space for one B767 and one HS748 parking.

(3) Other Facilities

Development of the following civil facilities is planned in the Short-term Modernization Plan.

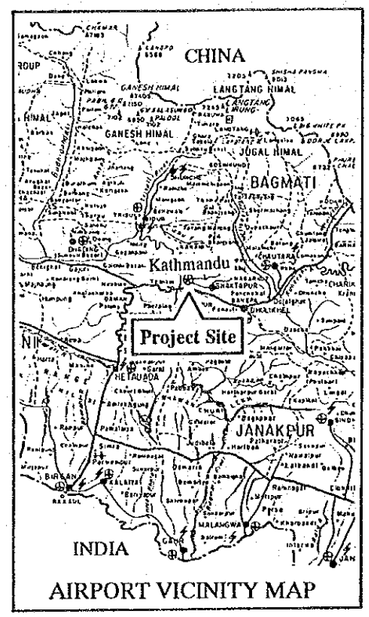
- Isolated aircraft parking position to accommodate one B747 with a self-maneuvering parking configuration

- Apron service road
- Perimeter road (new construction and paving of existing unpaved roads)
- Terminal Road and Car Parks

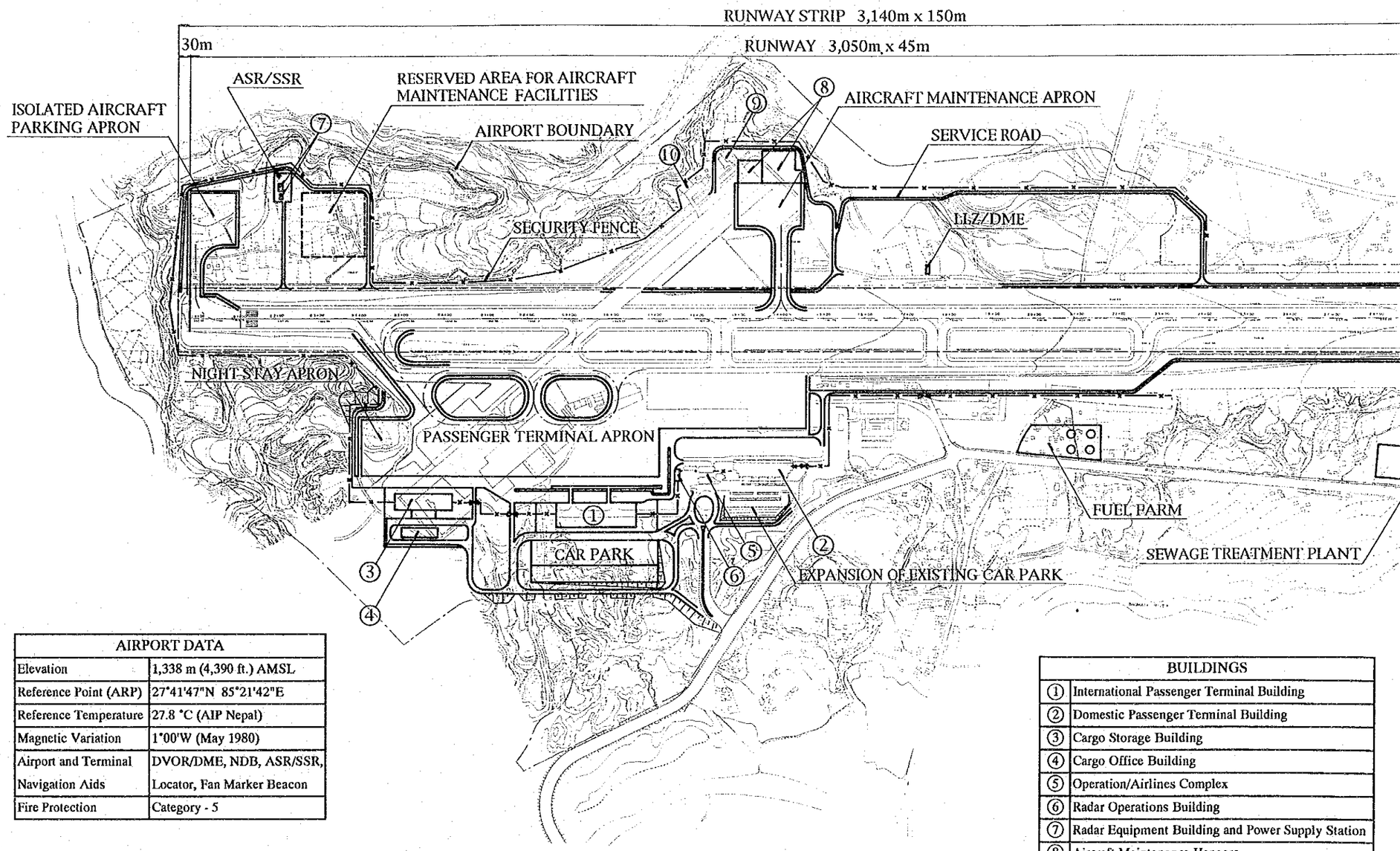
3.1.3 Architectural Works

(1) International Passenger Terminal Building

A new international passenger terminal building is designed in a linear frontal concept with one and a half processing levels taking into account the passenger demand and the provision of passenger boarding bridges. The international passenger terminal building will have a total floor area of about 25,000 sq.m with a 3-story reinforced concrete structure.



AIRPORT VICINITY MAP

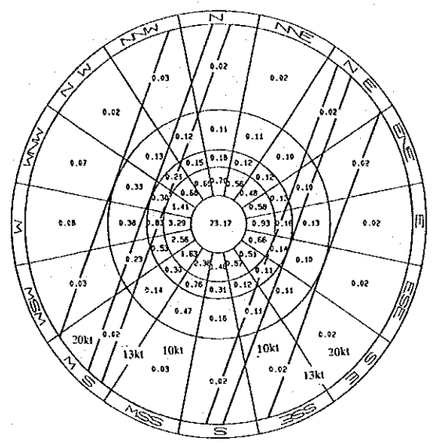


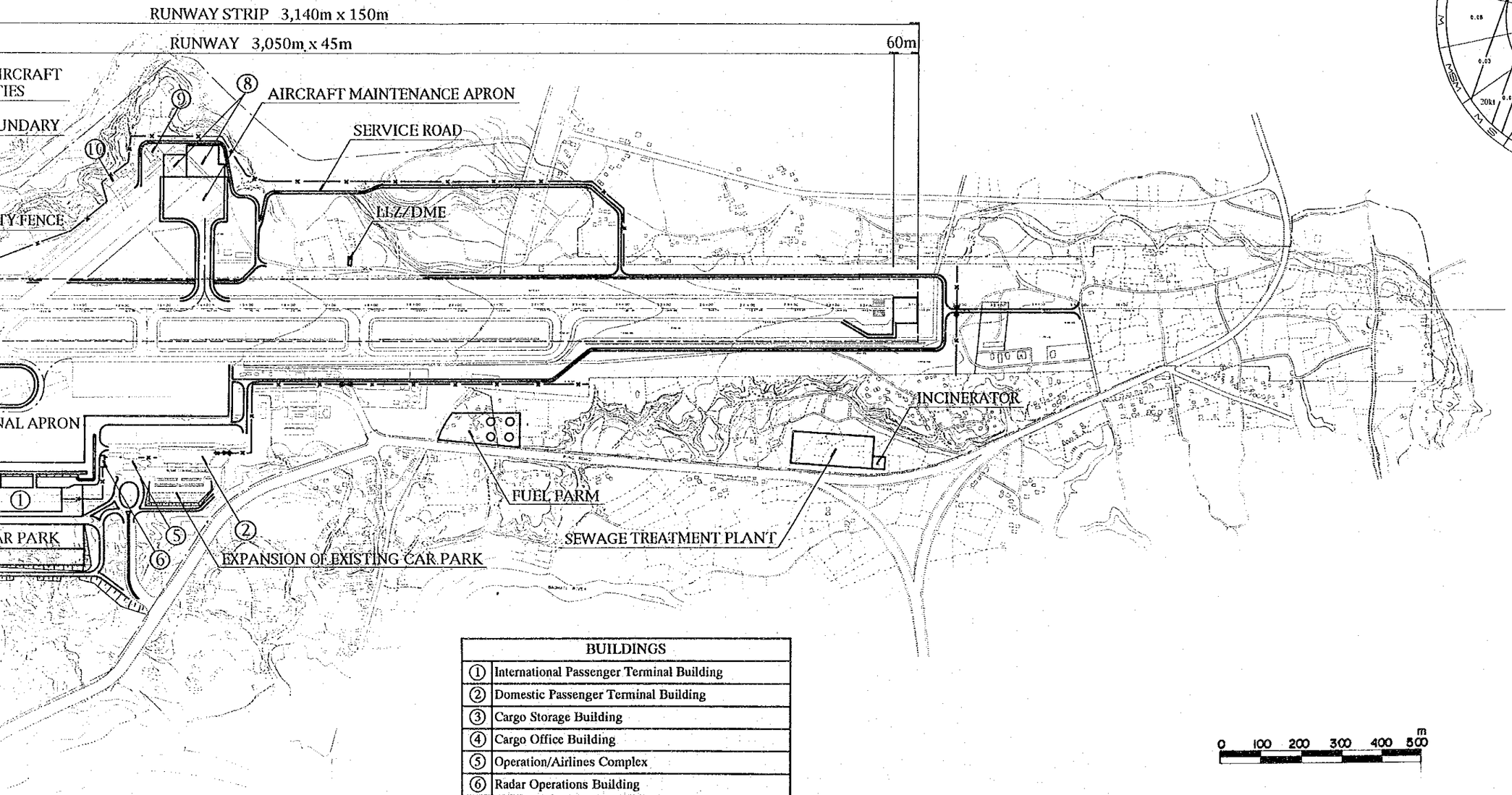
RUNWAY DATA		
Runway Orientating		02/20
Effective Gradient		0.77%
Wind Coverage (Cross Wind)		98.40% (13kt)
		99.73% (20 kt)
Instrument Runway		Yes (RWY 02, 20)
Pavement Strength		PCN 54/F/A/W/T
Approach Surface		1:50
Navigation Aids	RWY 02	DVOR/DME
	RWY 20	DVOR/DME
Visual Aids	RWY 02	SALS
	RWY 20	-

AIRPORT DATA	
Elevation	1,338 m (4,390 ft.) AMSL
Reference Point (ARP)	27°41'47"N 85°21'42"E
Reference Temperature	27.8 °C (AIP Nepal)
Magnetic Variation	1°00'W (May 1980)
Airport and Terminal Navigation Aids	DVOR/DME, NDB, ASR/SSR, Locator, Fan Marker Beacon
Fire Protection	Category - 5

BUILDINGS	
①	International Passenger Terminal Building
②	Domestic Passenger Terminal Building
③	Cargo Storage Building
④	Cargo Office Building
⑤	Operation/Airlines Complex
⑥	Radar Operations Building
⑦	Radar Equipment Building and Power Supply Station
⑧	Aircraft Maintenance Hangars
⑨	ATSC Hangar
⑩	Fire Station

ALL-WEATHER WIND COVERAGE		
Source	:	Department of Hydrology and Meteorology
Location	:	Tribhuvan International Airport
Period	:	January 1990 - December 1992





BUILDINGS	
①	International Passenger Terminal Building
②	Domestic Passenger Terminal Building
③	Cargo Storage Building
④	Cargo Office Building
⑤	Operation/Airlines Complex
⑥	Radar Operations Building
⑦	Radar Equipment Building and Power Supply Station
⑧	Aircraft Maintenance Hangars
⑨	ATSC Hangar
⑩	Fire Station

Figure 3.1.1 Airport Layout Plan of Short-term Modernization Plan (Year 2003)

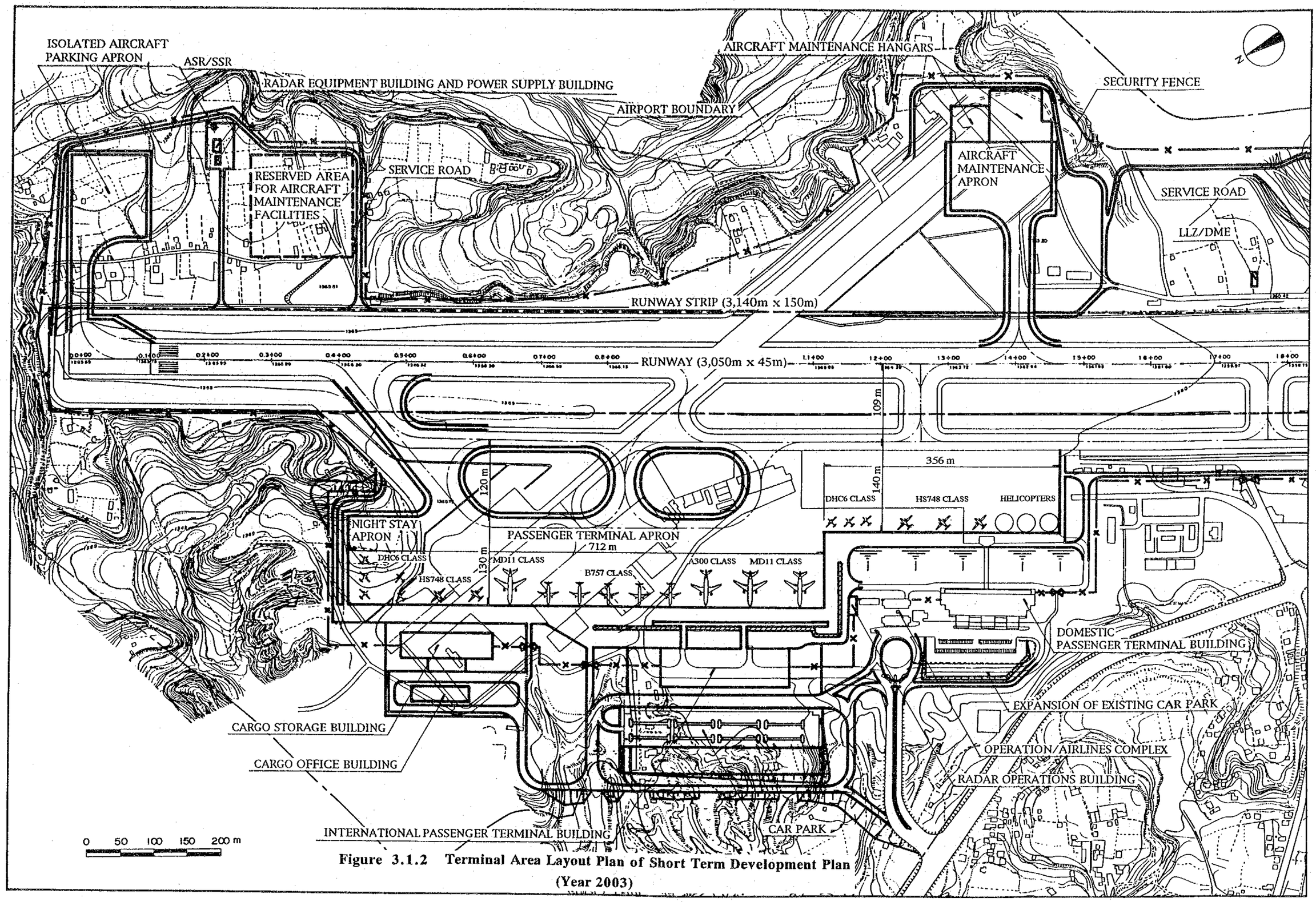


Figure 3.1.2 Terminal Area Layout Plan of Short Term Development Plan (Year 2003)

(2) Domestic Passenger Terminal Building

The terminal building has presently a total floor area of about 10,750 sq.m with a 3-story reinforced concrete structure. The architectural renovation floor plans were studied based on the architectural design considerations and passenger and baggage flows explained in the previous sections.

(3) Cargo Terminal Building

New cargo terminal buildings will be located to the north of the new international passenger terminal. The terminal buildings consist of a cargo storage building and an office building and will have a total floor area of about 7,500 sq.m for the short-term modernization (2003).

The cargo storage building will accommodate international and domestic services. The international and domestic cargo volumes in the year 2003 are expected to be 36,400 tons and 1,500 tons respectively.

Therefore, the cargo storage building will mainly accommodate international services.

The cargo storage building will be a single story building with a steel frame structure and will be about 5,400 sq.m in total floor area. The office building will accommodate airline offices, customs offices, AQ (animal quarantine) and PQ (plant quarantine) offices, agent offices etc., and will be a single story of a reinforced concrete structure with a total floor area of about 2,100 sq.m.

(4) Maintenance Hanger

A new maintenance hangar will be located to the east of the runway, almost in front of the terminal across the runway and will accommodate one B-767 and one HS748 aircraft for the short-term modernization (2003). The maintenance hangar will have a total floor area of about 6,500 sq.m and will be a steel frame structure.

3.1.4 Airport Utilities

(1) Electrical Power Supply

The supplying capacity and reliability of the existing transmission lines will be insufficient for the new power demand at each stage of the Short-term Modernization Plan. The NEA, therefore, will be required to construct new exclusive transmission lines as soon as possible during the period of the Short-term Modernization Plan.

(2) Water Supply

The capacity of city water supply system should be increased in accordance with the increase of water demand. For this purpose, and the capacity of the wells are to be studied at first, and then a request for increasing the capacity of the city water supply shall be made to the responsible authority.

(3) Sewage Disposal

A new sewage treatment plant will be constructed to treat all effluent and discharge to drainpipes connected to the river nearby the airport.