AVIATION DIVISION
ISLAMIC REPUBLIC OF PAKISTAN

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR IMPROVEMENT OF THE METEOROLOGICAL RADAR NETWORK (PHASE- II)

IN

THE ISLAMIC REPUBLIC OF PAKISTAN

DECEMBER,1996

JAPAN INTERNATIONAL COOPERATION AGENCY
JAPAN WEATHER ASSOCIATION

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Project for Improvement of the Meteorological Radar Network (Phase-II) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team from August 10 to September 13,1996.

The team held discussions with the officials concerned of the Government of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss a draft report, and as this result, the present report was finalized.

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 Islamic Republic of Pakistan for their close cooperation extended to the teams.

December 1996

Kimiaki Fujita

President

Japan International Cooperation Agency

December, 1996

Mr. Kimiaki Fujita

President

Japan International Cooperation Agency

Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Improvement of the Meteorological Radar Network (Phase-II) in the Islamic Republic of Pakistan.

This study was conducted by Japan Weather Association, under a contract to JICA, during the period July 22, 1996 to January 13, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

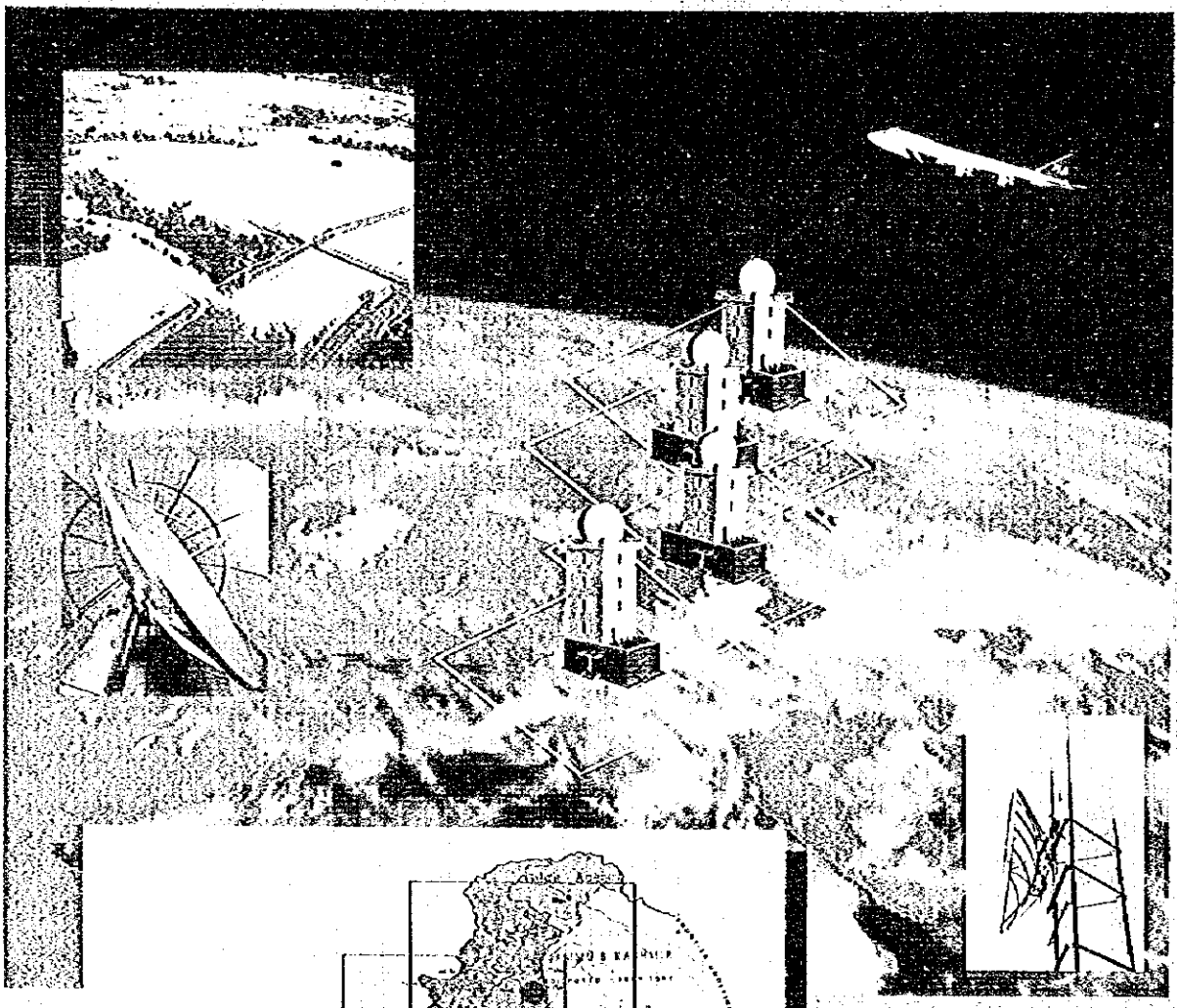
斎藤 隆

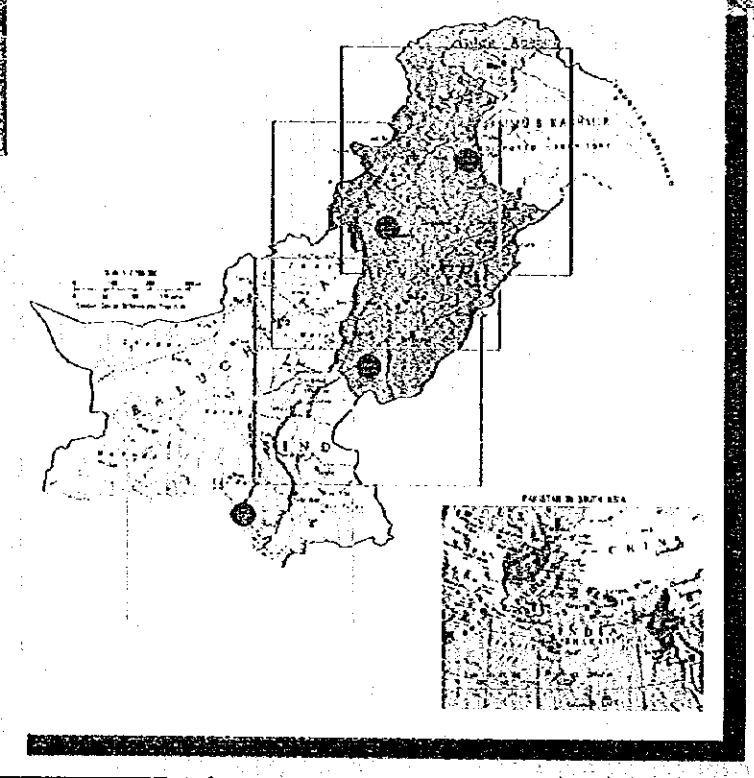
Takashi Saito

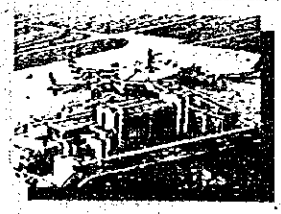
Project manager,

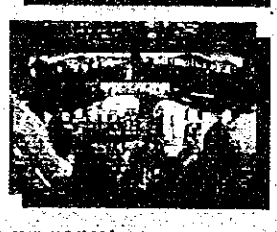
Basic design study team on the Project for Improvement of the Meteorological Radar Network (Phase-II)

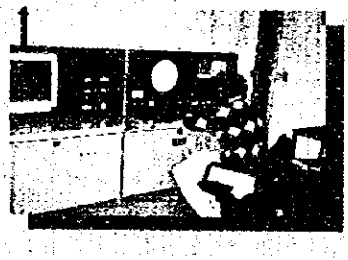
Japan Weather Association

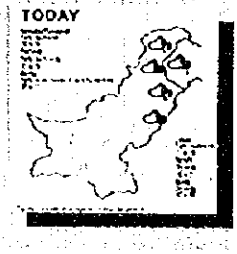








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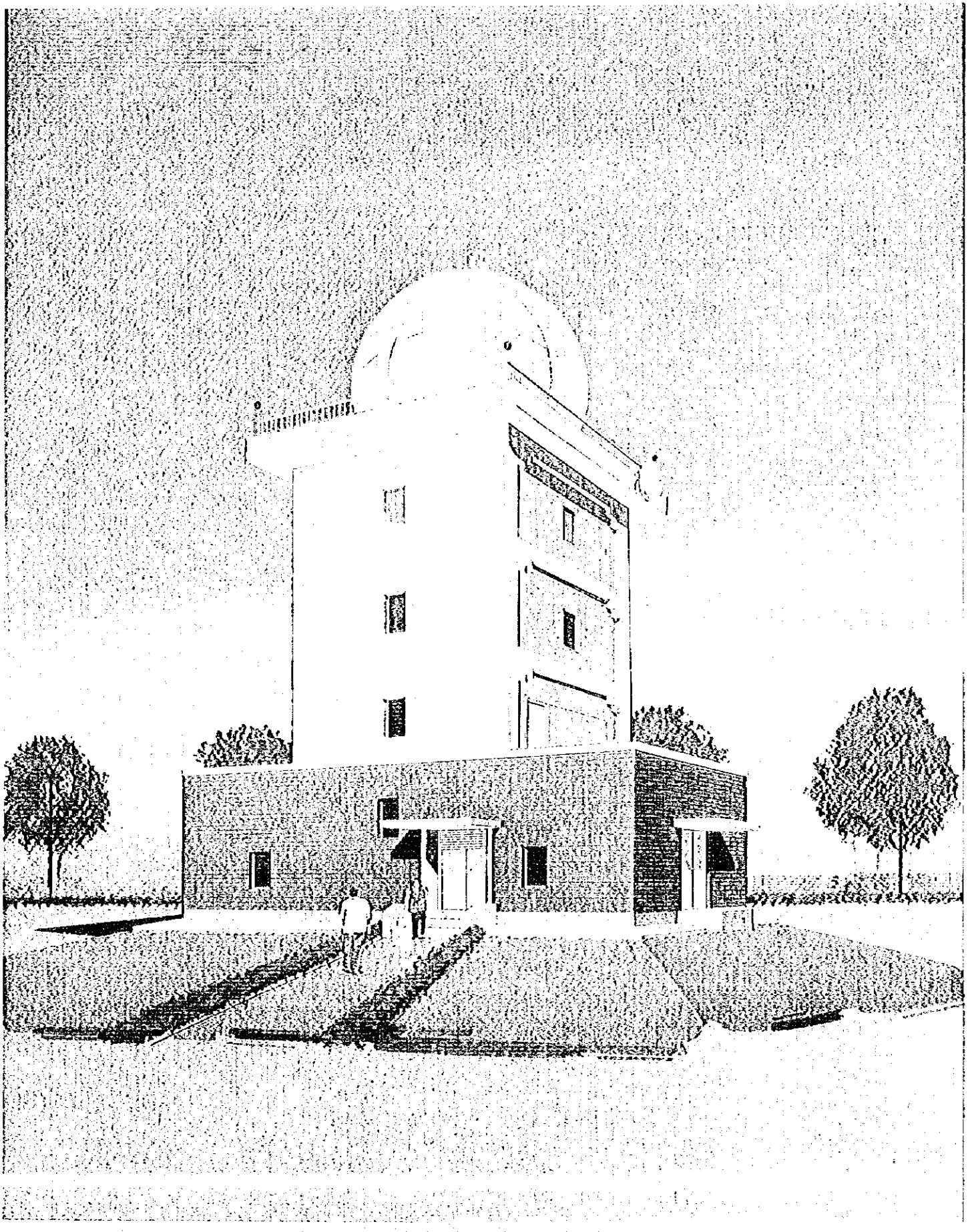
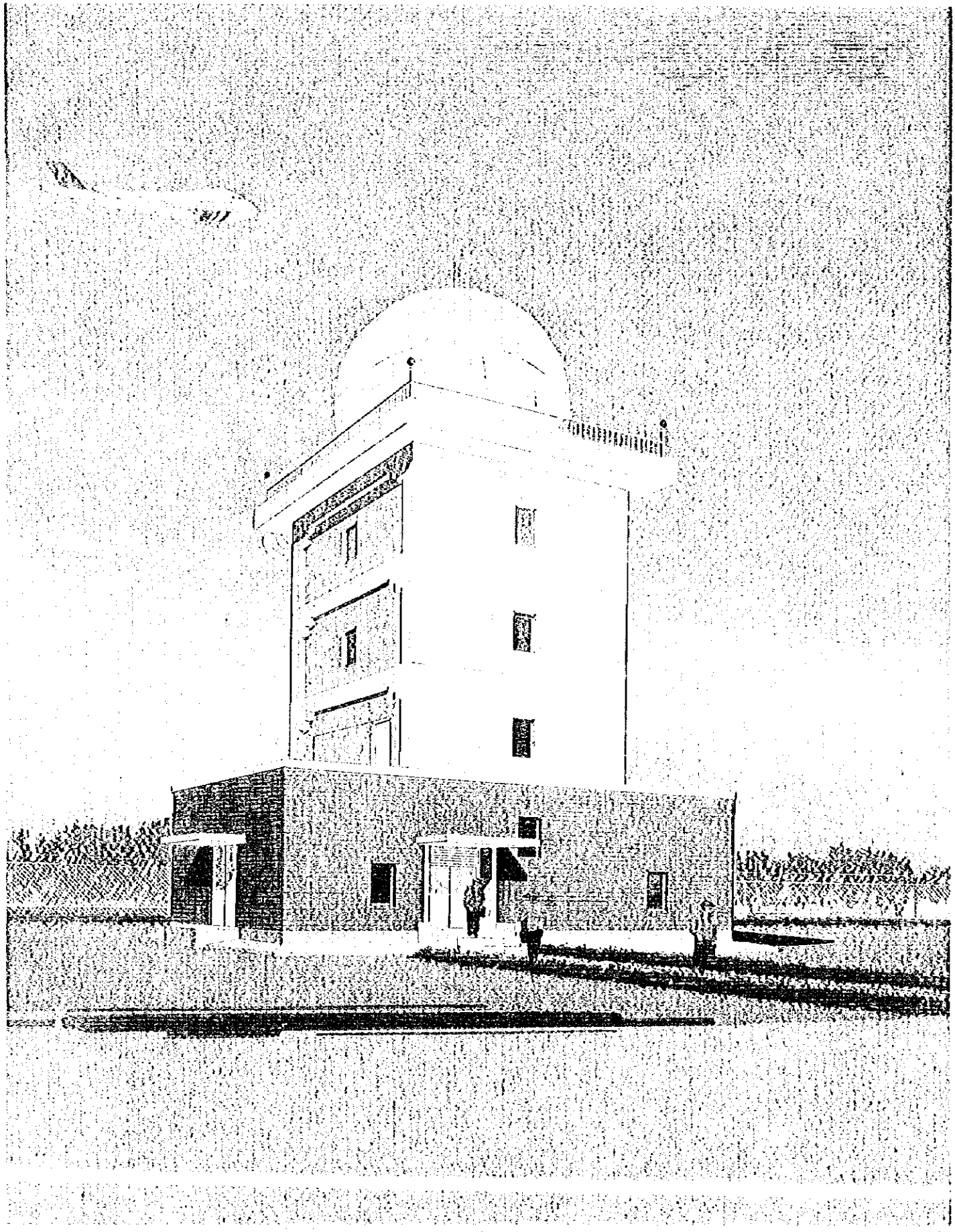
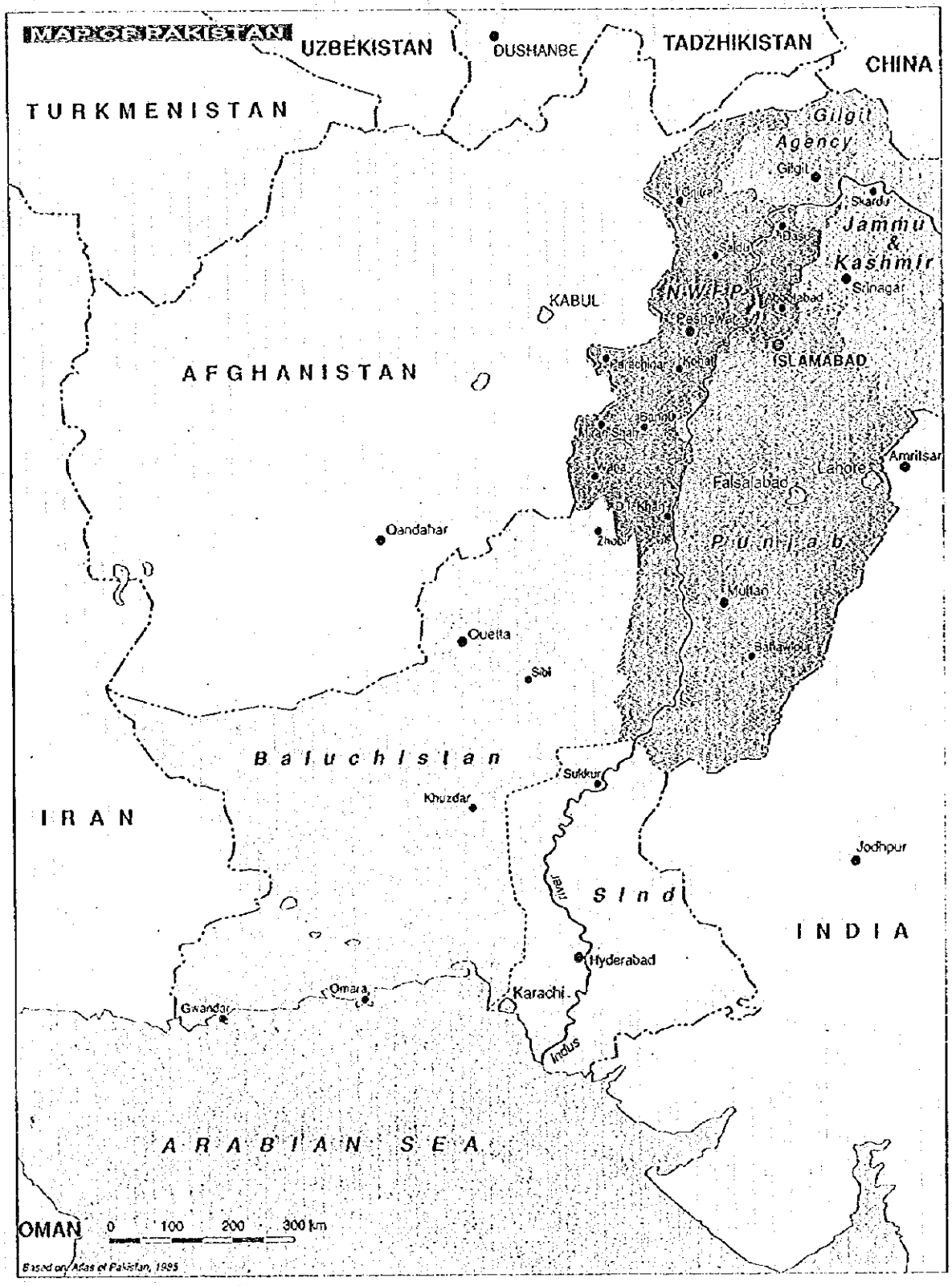


DERA ISMAIL KHAN RADAR TOWER



RAHIMYAR KHAN RADAR TOWER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UZBEKISTAN
DUSHANBE
TADZHIKISTAN
CHINA
TURKMENISTAN
Gilgit Agency
Gilgit
Skardu
Jammu & Kashmir
Srinagar
KABUL
N.W.F.P.
Peshawar
ISLAMABAD
AFGHANISTAN
Kohat
Bannu
Wana
Amritsar
Lahore
Faisalabad
D.I.Khan
Zhob
Qandahar
Punjab
Multan
Quetta
Sibi
Bahawalpur
Baluchistan
Sukkur
Khuzdar
IRAN
Jodhpur
Sind
INDIA
Hyderabad
Omara
Karachi
Gwandar
Indus
ARABIAN SEA
OMAN
0 100 200 300 km
Based on Atlas of Pakistan, 1995

PAKISTAN

Abbreviations

1. General

AC	Alternating Current
ADB	Asian Development Bank
AFTN	Aeronautical Fixed Telecommunication Network
BER	Bit Error Rate
BHN	Basic Human Needs
CAA	Civil Aviation Authority
CBR	Central Board of Revenue
CH	Channel
CIF	Cost, Insurance, and Freight
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CTI	Carrier Telephone Industries Ltd.
FL	Floor Level
G-III	Group - III
GDP	Gross Domestic Product
GL	Ground Level
GMT	Greenwich Mean Time
GTS	Global Telecommunications System
ISA	Industry Standard Architecture
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union-Radio
JICA	Japan International Cooperation Agency
MOC	Ministry of Commerce
MOF	Ministry of Finance
MOI	Ministry of Industry
NOC	Non-Objection Certificate

NTC	National Telecommunication Corporation
OJT	On the Job Training
PC-1	Planning Commission - 1
PCI	Peripheral Component Interconnect
PMD	Pakistan Meteorological Department
PSK	Phase Shift Keying
PTA	Pakistan Telecommunication Authority
PTCL	Pakistan Telecommunication Corporation Ltd.
SAP	Social Action Program
SCSI	Small Computer System Interface
SCSI-IF	Small Computer System Interface-Interface
SSB	Single Side Band
UHF	Ultrahigh Frequency
UNDP	United Nations Development Program
WD	Wheel Drive
WMO	World Meteorological Organization

2. Unit

A	Ampere
AH	Ampere Hour
dB	Decibel
dBm	Decibel Milliwatt
GHz	Gigahertz
hPa	Hecto Pascal
Kbps	Kilo Bit Per Second
Km	Kilometer
kVA	Kilovolt Ampere
kW	Kilowatt
Lx	Lux
m	Meter
m/s	Meter Per Second
MHz	Megahertz
rpm	Revolution Per Minute
Rs	Rupee
V	Volt
W	Watt

Contents

Appendices

Chapter 1
Background of the Project

Chapter 1 Background of the Project

Pakistan is affected seriously by the natural disasters which carry the highest potential for loss of life and property. In particular, the plain areas of Pakistan are buffeted by the flood, occurring almost every year, from heavy, concentrated rainstorms brought by cumulonimbi developing in the Intertropical Convergence Zone (hereinafter referred to as "ITCZ") during the monsoon season. Regrettably, the extensive damage from floods is the determining factor for significant set-back of national economy and development activities of Pakistan. Pakistan by now suffered a great financial loss in its history. The heavy rains carried by cumulonimbi not only wreak havoc on agricultural activities in the fertile plain areas but also give rise to flood and other disasters even in urban areas. In addition, these disasters also seriously obstruct air traffic operations, which in recent years has been increasing at a rapid clip.

As regards meteorological services, Pakistan is still at its early stage of development, and hence Pakistan Meteorological Department (hereinafter referred to as "PMD") is expected to continuously play the leading role in providing more authentic warning for the reduction of natural disasters in the county. PMD is mainly responsible for recording meteorological observation round the clock and providing weather information necessary for mitigation and prevention of meteorological disasters and development of socio-economic activities. PMD also provides meteorological information for aviation and shipping as scheduled, and daily weather forecasts to the general public. Concerning impending flood disasters caused by heavy rains in the area, PMD provides warnings and advisories to as many as all administrative divisions, concerned agencies and mass media, and is now striving for the improvement of its capabilities for meteorological disaster warning service in order to meet the increasing national and regional demand for prevention of flood disaster caused by heavy rains.

Pakistan is basically an agricultural country and about 75% of its population lives in villages. Flooding of the vast areas of Pakistan both rural and urban is a regular feature of the annual hydrological cycle. This results in loss of life, damages to property and disruption of communication network which adversely affects the economy of the country. The cause of flooding on such a large scale is the rainfall pattern and other climatological factors prevailing in this part of the world. About 50~70% of the annual precipitation with very high intensities occurs in the period July-September. Heavy downpours on sparsely vegetated hilly catchment

generate flash-flood waves which travel downstream resulting in heavy damages to valuable property, crops and human lives.

The list of the main meteorological disasters in Pakistan since 1970.

- Over the period 1973 ~ 1986, Punjab Province, which lies in the major granary area in Pakistan, was hit by floods almost every year, leaving many fatalities in their wake.

- In 1973, flood occurred in both Punjab and Sind Provinces, resulting in 500 recorded deaths and inundating 12 million acres in the two provinces combined. Total damage was assessed at Rs 2.5 billion.

- In 1976, floods struck Punjab, Sind, and Northwest Frontier Provinces, causing more than 300 fatalities.

- In 1987, heavy rains left wheat and other crops under water, causing damages of US $ 1,000,000.

- In 1988, heavy rains fell in the upper reaches of the Sutlej River, leaving 250 dead in Punjab Province, inundating 3,460,000 acres of land, and damaging 550,000 homes.

In order to prevent such meteorological disasters, the Pakistan government had established 5 weather radar systems to monitor meteorological phenomena, which is considered the most effective means of conducting meteorological observations over a wide area. Most of these five installations, however, had been in continuous use for over 20 years and so exhibited a noticeable decline in operating efficiency. These antiquated systems, therefore, had been impeding the preparation of accurate forecasts and warnings, making it imperative that the meteorological observation structure in Pakistan be upgraded, with primary emphasis on improved weather radar systems that would be capable of monitoring the distribution of heavy precipitation areas.

Under these circumstances, the government of Pakistan prepared a "the Project for Establishment of Meteorological Radar Network in the Islamic Republic of Pakistan" (hereinafter referred to as "the previous Project") and requested to the government of Japan for realization and it commenced by the Japan's Grant Aid Assistance in 1989. The purpose

of the previous Project was to replace the existing weather surveillance radar at Karachi and to newly install a weather surveillance radar at Islamabad with a view to upgrading activities of PMD, in particular observing a heavy rain and enabling PMD to detect movements of low depressions and cumulonimbus clusters in the ITCZ and monitoring the Karachi and Islamabad areas, constituting the nation's political and economic centre, which are of strategic logistical importance in terms of air transport as well .

The components of the previous Project were as follows.

1) Supply of the equipment

a. Weather surveillance radar systems

In order to accurately observe the precipitation carried by cumulonumbus groups [clusters], C-band radar systems (wave lengths : 5 cm) were installed at Karachi and Islamabad, with transmitting power of 250 kW and a detecting range of about 400 Km.

b. Data processing equipment

Data processing equipment were installed in the observation rooms at both radar sites to permit the calculation of hourly accumulated precipitation.

c. Radar imagery displays

To enable forecasters to directly monitor radar imagery for real time weather forecasting, remote displays were installed in the forecasting rooms at Karachi and Islamabad. In addition, telecommunication link was established between Karachi radar site and the Karachi International Airport for transmitting radar imagery from the site and a radar imagery display was installed at the Airport.

d. Automatic voltage regulators and standby generators

Automatic voltage regulators for protection of the radar equipment from voltage fluctuations in the commercial power source and standby generators for continuing radar observations during power failure were installed at each radar site.

2) Constarction of radar tower buildings at Karachi and Islamabad

In 1991, the previous Project was completed, and after the completion, more than five years has already been passed, and also the previous Project has been contributing in a major way to higher accuracy levels in weather forecasts and raising awareness within Pakistan of meteorological activities in general and the role of the PMD in particular.
Fortunately, under appropriate maintenance by PMD engineers for the weather surveillance radar systems supplied under Japan's Grant Aid Assistance, they are still working well and very instrumental in meteorological observation without any serious problems up to now. These meteorological radars are individually monitoring a precipitation of northern part and southern part of Pakistan.

In order to monitor meteorological phenomena in real time over the entire area of Pakistan, a networking of meteorological radars is indispensable to more accurately and speedily make flood forecasts and warnings. For aiming at reduction of flood disasters around Indus river basin in Pakistan, meteorological radar network will be able to ensure continuous supply of rainfall distribution, intensity and movement, cloud echoes and other necessary information.
However, at the time of completion of the previous Project, improvement of infrastructure in Pakistan including the telecommunication facilities was seriously behind schedule and it was very difficult to establish a meteorological radar network by using the existing telecommunication facilities.
The government of Pakistan has, therefore, been obliged to request additional assistance from Japan for provision of 3 weather surveillance radars to be installed at Dera Ismail Khan (hereinafter referred to as "D.I.Khan") in Northwest Frontier Province, Sukkur in Sind Province and Pasni in Baluchistan Province, which would then permit nationwide radar surveillance.

These locations were selected by the following reasons :

- D.I. Khan
  This location was intended to monitor and forecast precipitation areas in Northwest Frontier Province, containing such important cities as Peshawar and Sargodha, and the middle-to-upper portions of the Indus River basin.

- Sukkur
  This location would cover the middle-to-lower sections of the Indus basin, monitoring the low-pressure monsoons moving up from India and forecasting movements of major

precipitation areas associated with these monsoons.

- Pasni

  This location was intended to cover the southwestern part of the country along with the Arabian Sea, monitoring and forecasting movements of large rain masses accompanying the southwestern monsoons and of cyclones moving in from the Arabian Sea.

In response to the above request from the Government of the Islamic Republic of Pakistan, the Government of Japan conducted a basic design study for realization during the period July 22, 1996 to January 13, 1997, focusing on the following two points, and in conducting the study, the feasibility and rationale of the project with due consideration to the present situation of Pakistan have been examined.

1) Improvement of observing activities and facilities for issuance of accurate flood forecasts and warnings for the Indus River basin.

2) Appropriate utilization of the existing telecommunication links in Pakistan for transmitting radar imageries and meteorological information.

For formulating the most appropriate basic design for the Project, based on the results of field survey in Pakistan, three proposed locations of radar systems were examined and finally the Project sites were determined as follows.

1) Pasni was intended to cover the southwestern area and the Arabian Sea, primarily to monitor the movement of cyclones, therefore, Pasni was eliminated from the Project.

2) D.I. Khan was confirmed to be the optimum location for monitoring the middle-to-upper sections of the Indus River basin as well as the confluence points for its various tributary rivers. In addition, D.I. Khan site had already been secured because it is owned by PMD.

3) While Sukkur was intended to cover the middle-to-eastern portion of the middle-to-lower Indus basin, it was found to be unsuitable for monitoring the middle-to-northern section of this basin together with the points of confluence for the various Indus tributaries, where floods were most likely to develop from severe local rainfall. It was, therefore,

decided to consider an alternate location northeast of Sukkur.

During the field survey, sites at Khanpur and Rahimyar Khan were surveyed as an aiternate Sukkur. Khanpur is a meteorological observatory registrated by WMO, however, Khanpur site was unsuitable for establish a weather radar system due to a delay of infrastructure development (power and water supply, telecommunication, etc.) as well as the undeveloped condition and remoteness of the existing facilities.
The site at Rahimyar Khan, on the other hand, which was located within the Rahimyar Khan Airport premises, was suitable from the standpoint of infrastructure, security, and ease of access, being served by daily flights from several other cites.
Since the above reasons, a project site was, accordingly, changed from Sukkur to Rahimyar Khan. And, considering the fact that the new weather radar system would also improve operational safety at the local airport following project completion, the desirability of this site was further enhanced in terms of the additional benefits to be derived from the Project.

Since the original request was prepared, more than five years have already elapsed. In the interim, improvement of the telecommunications facilities and other infrastructures have been proceeding at a rapid pace with Pakistan's socio-economic development, while more accurate and advanced meteorological information has been required in accordance with the public demand.

Since the result of the study, the objective of the Project has been clarified to establish the meteorological observation network in Pakistan for reduction of flood disasters. For establishing an appropriate and efficient meteorological radar network, it is necessary to install 2 more radar systems at D. I. Khan and Rahimyar Khan. At the same time, together with the existing radar systems at Karachi and Islamabad, new radar systems at D. I. Khan and Rahimyar Khan and a meteorological telecommunication network to be established under the Project for radar imagery transmission will be able to cover and observe approximately 80% of the whole land of Pakistan and also the whole area of Indus river basin, which is highly vulnerable to frequent flooding from heavy rains.

Chapter 2
Contents of the Project

Chapter 2 Contents of the Project

2-1 Objectives of the Project

The objectives of this Project are to improve the observing activities and facilities of PMD for reduction of natural disasters and protection of people's life and property.

In Pakistan, the most major natural disaster is flood caused by heavy rainfall. For aiming at reduction of flood disasters around Indus River basin in Pakistan, a networking of weather radars is indispensable to more accurately and speedily make flood forecasts and warnings.
For detecting and monitoring natural calamities at frequent intervals to forecast their intensity and land-fall more accurately, meteorological radar network will be able to ensure continuous supply of rainfall distribution, intensity and movement, cloud echoes and other necessary information to PMD and other organizations related to weather and flood forecasting for use in their day to day issuance of forecasts and warnings.
Weather radars can detect the occurrence, movement and intensity of rainfall within a radius of 400km from the radar site. A weather radar is the only equipment to be able to observe rainfall distribution, intensity and movement and also to provide precipitation information for large geographic areas on real time.

2-2 Basic Concept of the Project

At the present, there are two existing weather radars in quite good condition at Karachi and Islamabad established in 1991 under Japan's Grant Aid Assistance. These weather radars are individually monitoring a precipitation of northern part and southern part of Pakistan.

In the original request of the Pakistan government, 3 weather radars were planned to be installed at D.I.Khan in Northwest Frontier Province, Sukkur in Sind Province and Pasni in Baluchistan Province, which would then permit nationwide radar surveillance.
However, at the time of the request submitted to the government of Japan, improvement of infrastructure in Pakistan including the communication facilities was seriously behind schedule and it was very difficult to establish a meteorological radar network by using the existing telecommunication facilities.
Since the original request was prepared, more than five years have already elapsed. In the interim, improvement of the telecommunications facilities and other infrastructures have been

proceeding at a rapid pace with Pakistan's socio-economic development, while more accurate and advanced meteorological information has been required in accordance with the public demand.

After taking into account the changes in meteorological services as well as the present state of communication development, the Project will provide 2 weather radar systems including communication system to transmit observed radar imageries for establishing a meteorological radar network in Pakistan to cover and monitor the entire Indus River basin that was affected by frequent flooding from heavy rains.

Figure 2-1 shows the Pakistan Radar Network.

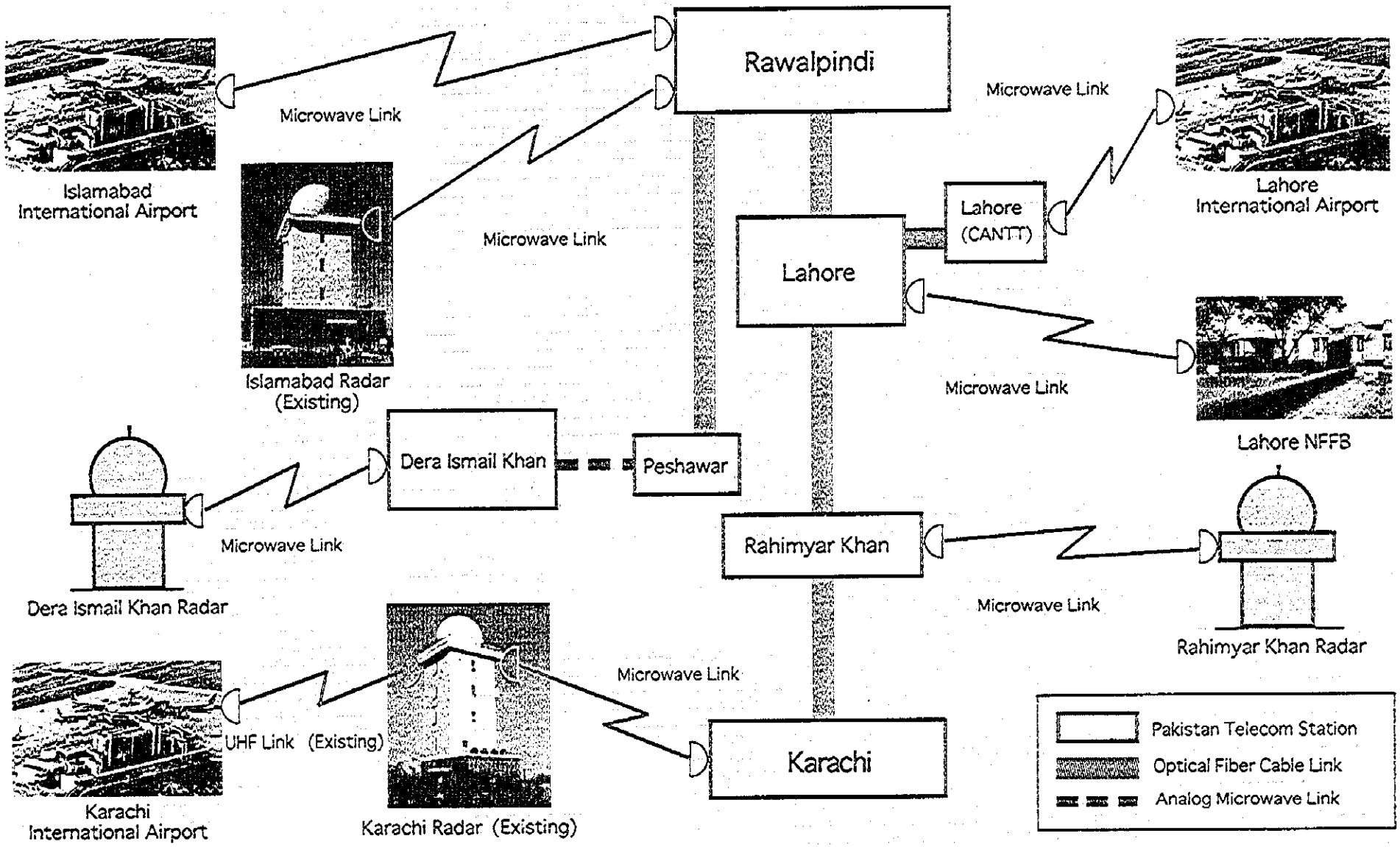

Fig. 2-1 Pakistan Meteorological Radar Network

1. Radar Sites

Previously, it had been planned to install a weather radar facility at D. I. Khan and Khanpur. However, due to the result of the basic design study in Pakistan that the site at Khanpur has been changed to the airport premises at Rahimyan Khan (approximately 60km to the southwest form Khanpur) in the same province.

In case of a weather radar system was installed at Khanpur, it would be possible to observe and monitor both the central portion of the Indus River basin in the area of confluence of the Sutlej and Chenab rivers and the granary area in the plains along this river. However, any observational problems from shifting the site from Khanpur to Rahimyan Khan can not be expected. Thus, considering the fact that the infrastructure at Rahimyar Khan is much better developed than that at Khanpur, that the meteorological information which are so vital to aviation could be provided directly to traffic control personnel and that the radar system could be linked to the existing optical fiber cable system running to the Rahimyar Khan telephone exchange, it is sure that Rahimyar Khan would be more suitable as the radar site and so have decided to install the weather radar at the Rahimyar Khan airport.
In due consideration of a future expansion of meteorological services, a maximum site area of 3,500 m^2 will be required incorporating both the radar tower and the observation field.

2. Meteorological Radar Network

The existing weather radars at Karachi and Islamabad, which cover the main population clusters around the country's first and second cities, respectively, have been most effective in preventing natural disasters. Nevertheless, with only one radar facility at each location, the observation range and information volume are necessarily limited, which has caused failures in tracking movements of precipitation areas.

Natural disasters originate not only within the observation ranges of the two radars but also in other parts of the country. Accordingly, it is necessary to eliminate such observation shadow by expanding the tracking range of the system through the addition of new weather radars. In order to reduce damage from such meteorological disasters as well, it is essential that a meteorological radar network be built to cover the entire country.

In the Project, weather radar systems are to be installed at D. I. Khan and at Rahimyar Khan so as to monitor precipitation throughout the Indus River basin, thereby bringing the entire

Indus basin within observation range. D. I. Khan is located in northwest Pakistan, which will make it possible to monitor precipitation areas in the mid-to-upper reaches of the main Indus basin. Thus, the new weather radar system at this site will permit the tracking of low-pressure areas accompanying cold fronts moving in from the West.

Rahimyar Khan, on the other hand, is located in the east-central section of the country, enabling the new radar station at that site to monitor rain areas in the lower-to-middle reaches of the Indus basin, thereby making it possible to observe large low-pressure areas moving up from India during the monsoon season.

The meteorological radar network, which will incorporate the two new radar systems as well as the two existing radar systems, will permit monitoring of the entire Indus basin via radar imagery composites, making it possible to track precipitation phenomena causing heavy rainfall to this basin. By monitoring the movements and transformations of rain area over the entire basin, the new system will contribute in a major way to improving the accuracy of the very short-range forecasts that are so critical to precipitation forecasts in the basin.

3. Radar Imagery Composites

At the present, the existing radar system at Karachi and Islamabad for continuous monitoring of echo data observed by weather radar system via monitoring displays in observation and forecasting rooms. However, owing to the lack of communication links between Karachi and Islamabad, radar images can be displayed only separately at each site. But, with the improvement of telecommunication facilities in Pakistan, it is possible to display composite radar images drawn from four radar systems.

Under the Project, radar image composition will be performed at both Karachi and Islamabad from the following reasons.

1) System Reliability

In case of radar imagery composition to be concentrated at only the Karachi, a system breakdown would interrupt transmission of composite and other radar imagery. However, radar imagery composition is performed at both Karachi and Islamabad, the probability of simultaneous breakdowns at the 2 locations would be extremely low; even if one location to fails, imagery transmission could be sustained from the other site. Thus, system reliability

would be greatly enhanced by decentralizing composite processing between the two locations, as opposed to doing this work at only a single location.

2) Recurrent Costs

The rate structure for leased lines is a function of transmission speed and distance. Thus, when transmission speed is constant, the cost will vary according to the distance between destinations.

Approximate distance between each radar site and Karachi or Islamabad is as follows.

- between D. I. Khan and Karachi : 2,100 km
- between D. I. Khan and Islamabad : 500 km
- between Rahimyar Khan and Karachi : 650 km

With a view to minimizing the recurrent costs of leased lines, composite imagery processing systems should be installed at two locations, Karachi and Islamabad.

3) *Improvement in real time monitoring and very short range forecasts for heavy rains*

By using composite imagery of 4 weather radar systems, it will be possible to monitor precipitation conditions in virtually all parts of the country.

PMD issues general weather forecasts at two stations, its main Karachi station and Islamabad. Karachi prepares and issues the national forecast along with that for the southern area and also Islamabad prepares and issues the national forecast as well as that for the northern region. Radar imageries and meteorological data are highly effective in compiling these forecasts, particularly the very short range forecasts, permitting the capture of ever-changing meteorological phenomena when anticipating floods or other natural disasters. At both Karachi and Islamabad, radar imageries, with a view to monitoring precipitation in their respective observation range, are obtained on real time, and the radar imagery composed for the north and south will result in more accurate forecasts. There is, accordingly, a need for composite processing systems at both Karachi and Islamabad.

The composite images, of Rahimyar Khan and Karachi radar stations, composed at Karachi will be called "southern composite images", those of D. I. Khan and Islamabad stations,

composed at Islamabad be called "northern composite images", and those compiled from all 4 stations "national composite images". The northern composites are shown in Figure 2-2, the southern in Figure 2-3, and the national in Figure 2-4.

Composite processing systems will, therefore, be installed at both Karachi and Islamabad.

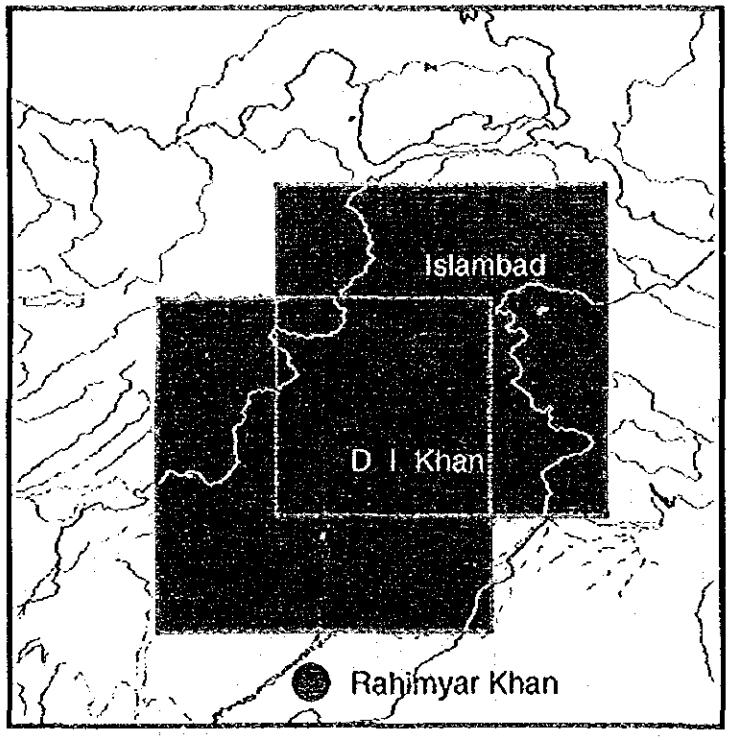

Fig. 2-2 Northern Composite Image

C O M P O S I T E

15 : 30

23 JUN 96

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Islamabad	OPR	+0.0	OFF
D.I.Khan	NO OPR	+11.5	OFF

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	2 <=R< 5mm/h
	5 <=R< 10mm/h
	10 <=R< 20mm/h
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	100 <=R< 150mm/h
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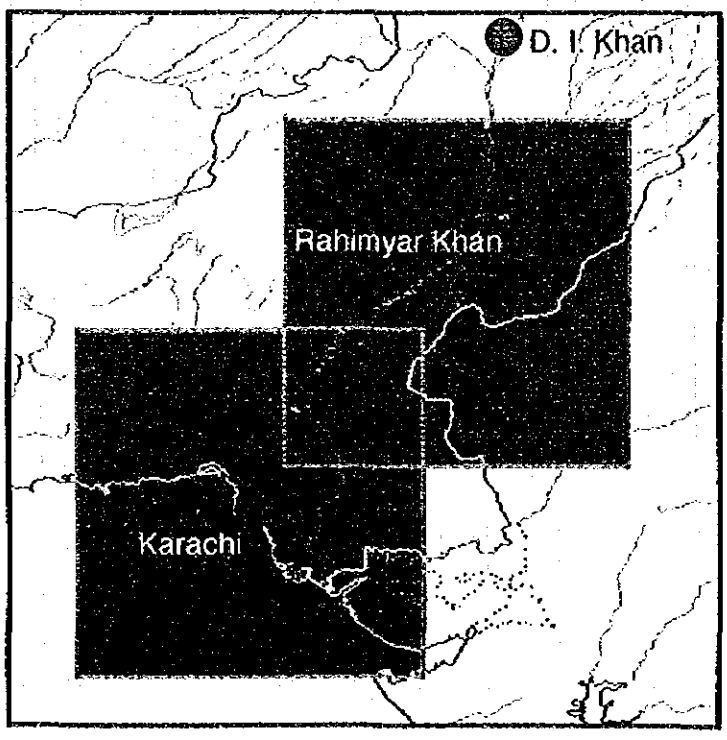

Fig. 2-3 Southern Composite Image

C O M P O S I T E

15 : 30

23 JUN 96

< Site >	< Status >	< EL >	< MTI >
Rahimyar Khan	OPR	+0.0	OFF
Karachi	NO OPR	+11.5	OFF

	OUT OF COVERAGE
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	1 <=R< 2mm/h
	2 <=R< 5mm/h
	5 <=R< 10mm/h
	10 <=R< 20mm/h
	20 <=R< 40mm/h
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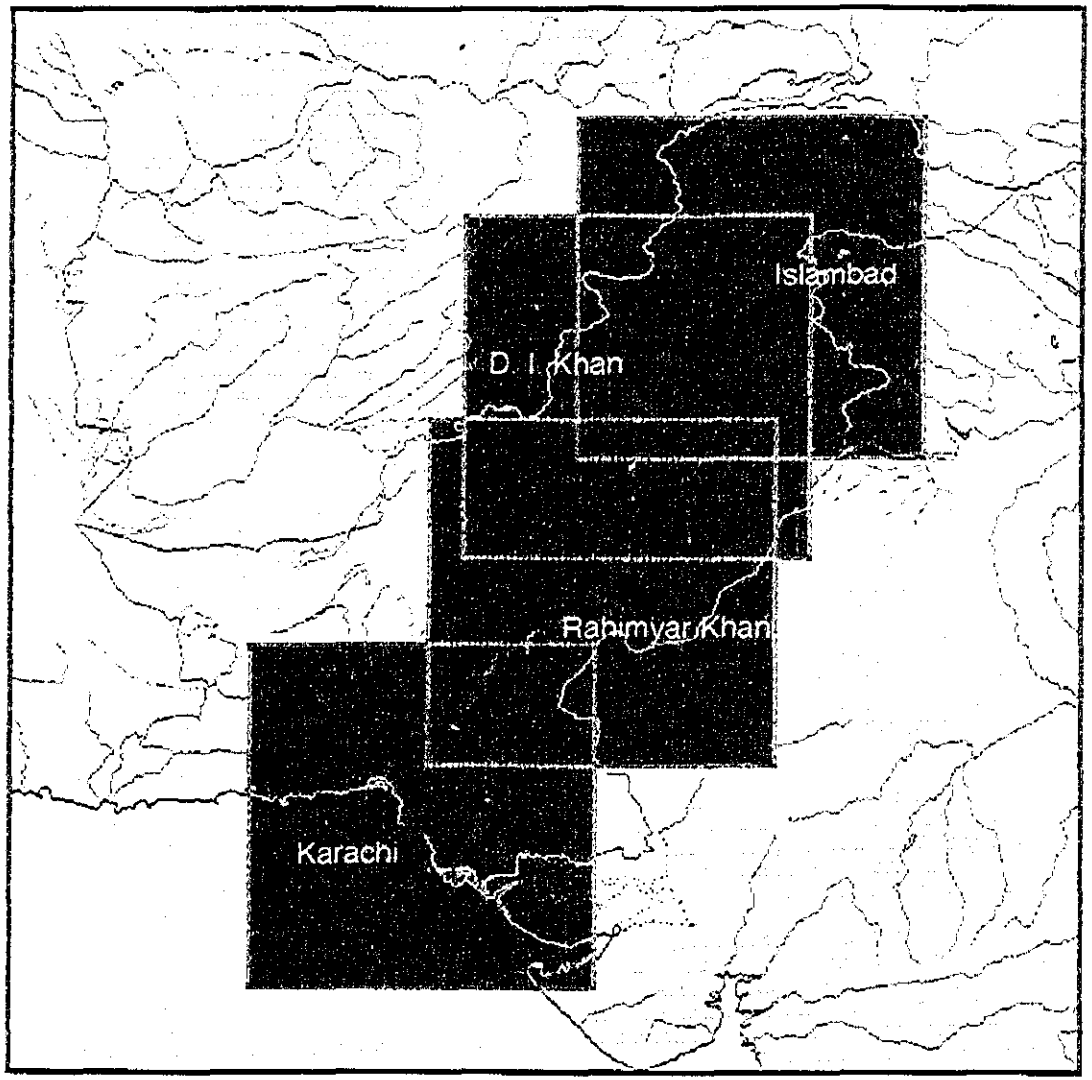
	100 <=R< 150mm/h
	150 <=R< mm/h



COMPOSITE

15 : 30

10 NOV 96

< Site >	< Status >	< EL >	< MTI >
Islamabad	OPR	+0.0	OFF
D.I.Khan	NO OPR	+11.5	OFF
Rahimyar Khan	OPR	+0.0	OFF
Karachi	NO OPR	+11.5	OFF

	OUT OF COVERAGE
	RC< 1mm/h
	1 <=R< 2mm/h
	2 <=R< 5mm/h
	5 <=R< 10mm/h
	10 <=R< 20mm/h
	20 <=R< 40mm/h
	40 <=R< 70mm/h
	70 <=R< 100mm/h
	100 <=R< 150mm/h
	150 <=R< mm/h

Fig. 2-4 National Composite Image

4. Transmission and Display of Radar Imagery

1) Karachi and Islamabad

At Karachi and Islamabad, in order to display the composite imagery on the existing display monitors in the forecasting rooms, their hardware and software will both have to be extensively upgraded. Considering upgrading costs and equipment durability, new display monitors are to be installed in each forecasting room for the display of composite imagery. The existing monitors will continue to display images received from the each radar station.

2) D.I. Khan and Rahimyar Khan

At D.I. Khan and Rahimyar Khan, display monitors will be installed in the forecasting rooms in the radar tower building at each site, but displays will be shown only on the individual radar screens.

3) Briefing rooms at the aeronautical meteorological offices at Karachi, Islamabad and Lahore International Airports and the National Flood Forecasting Bureau (hereinafter referred to as "NFFB") at Lahore

Composite processing of 4 radar imageries will be finally performed at Karachi and Islamabad, using the existing telecommunication link. The composite images will be also shown on the display monitors at the following stations.

- Briefing room at the aeronautical meteorological offices in Karachi, Islamabad and Lahore International Airport
- NFFB at Lahore

At Karachi, composite imageries are transmitted to the aeronautical meteorological office in Karachi International Airport through the existing telecommunication line. At Islamabad, composite imageries are transmitted to a newly established the aeronautical meteorological office in Islamabad International Airport and to the Lahore NFFB for viewing on display monitors. The NFFB, in turn, transmits the composite imageries received from Islamabad to the aeronautical meteorological office in Lahore International Airport.

During the basic design study period, PMD has requested to include that radar imageries also be transmitted to the briefing room at the aeronautical meteorological office in Lahore International Airport. In this connection, the request of PMD was studied regarding social importance of this airport in Pakistan, terms of the number of flight arrivals and departures, the number of passengers using the airport and the volume of cargo handled. The result of study, as shown in Tables 2-1 ~ 2-6, demonstrate that, in each of these categories, Lahore is the third most important airport in Pakistan, after Karachi and Islamabad, and that meteorological information are indispensable to air traffic safety at this airport. Accordingly, it is been decided that radar images will also be transmitted to the briefing room of the Lahore International airport.

Table 2-1 Total Aircraft Movements By Airport In Pakistan During 1989-90

(Number)

Airport / Aerodrome	DOMESTIC			INTERNATIONAL			TOTAL COMMERCIAL			General Aviation (D+I)	Local	Grand Total
	Scheduled	Non-Scheduled	Total	Scheduled	Non-Scheduled	Total	Scheduled	Non-Scheduled	Total			
1	2	3	4	5	6	7	8	9	10	11	12	13
Karachi	20381	36	20417	21613	3570	25183	41994	3606	45600	3705	8793	58098
Islamabad	15654	135	15789	2444	179	2623	18098	314	18412	2481	12148	33041
Lahore	14096	307	14403	1852	211	2063	15948	518	16466	1616	10138	28220
Peshawar	6907	3	6910	642	46	688	7549	49	7598	261	1499	9358
Gwadar	1949	12	1961	313	10	323	2262	22	2284	36	66	2386
Quetta	2652	6	2658	-	-	-	2652	6	2658	-	334	2992
Bannu	816	-	816	-	-	-	816	-	816	62	2	880
Bahawalpur	918	-	918	-	-	-	918	-	918	36	10	964
Chitral	1100	2	1102	-	-	-	1100	2	1102	300	4	1406
Dalbandin	-	-	-	-	-	-	-	-	-	40	1	41
D.I.Khan	1832	-	1832	-	-	-	1832	-	1832	48	1	1881
Faisalabad	2442	-	2442	-	-	-	2442	-	2442	570	-	3012
Gilgit	1202	12	1214	-	-	-	1202	12	1214	508	118	1840
Hyderabad	1280	18	1298	-	-	-	1280	18	1298	81	2	1381
Jacobabad	314	-	314	-	-	-	314	-	314	2	-	316
Jiwani	276	2	278	-	-	-	276	2	278	-	2	280
Khuzdar	494	-	494	-	-	-	494	-	494	6	-	500
Kohat	204	-	204	-	-	-	204	-	204	-	32	236
Mianwali	148	4	152	-	-	-	148	4	152	-	-	152
Mirpur Khas	444	8	452	-	-	-	444	8	452	4	-	456
Moenjodaro	1772	22	1794	-	-	-	1772	22	1794	23	1	1818
Multan	3477	41	3518	-	-	-	3477	41	3518	677	22113	26308
Muzaffarabad	748	8	756	-	-	-	748	8	756	37	-	793
Nawabshah	1212	20	1232	-	-	-	1212	20	1232	219	854	2305
Ormara	12	2	14	-	-	-	12	2	14	2	-	16
Panjgur	2282	-	2282	-	-	-	2282	-	2282	-	-	2282
Pasni	1332	20	1352	-	-	-	1332	20	1352	45	499	1896
Rawalakot	674	-	674	-	-	-	674	-	674	38	-	712
R.Y.Khan	152	-	152	-	-	-	152	-	152	32	-	184
Saidu Sharif	1188	-	1188	-	-	-	1188	-	1188	156	-	1344
Skardu	604	18	622	-	-	-	604	18	622	18	51	691
Sui	230	-	230	-	-	-	230	-	230	95	-	325
Sukkur	3005	37	3042	-	-	-	3005	37	3042	440	64	3546
Turbat	3118	-	3118	-	-	-	3118	-	3118	12	26	3156
Zhob	1332	-	1332	-	-	-	1332	-	1332	10	-	1342
TOTAL	94247	713	94960	26864	4016	30880	121111	4729	125840	11560	56758	194158

(D+I) refer to Domestic & International.

Table 2-2 Percentage Share Of Various Airports In Aircraft Movements During 1989-90

S.No.	Airport	Domestic	International	Transit	Total
1	2	3	4	5	6
	INTERNATIONAL				
1.	Karachi	21.50	81.55	18.29	29.92
2.	Islamabad	16.63	8.49	21.41	17.02
3.	Lahore	15.17	6.68	17.20	14.53
4.	Peshawar	7.28	2.23	2.58	4.82
5.	Gwadar	2.07	1.05	0.15	1.23
6.	Quetta	2.80	0.00	0.49	1.54
	DOMESTIC				
7.	Bannu	0.86	0.00	0.09	0.45
8.	Bahawalpur	0.97	0.00	0.07	0.50
9.	Chitral	1.16	0.00	0.44	0.72
10.	Dalbandin	0.00	0.00	0.06	0.02
11.	D.I.Khan	1.93	0.00	0.07	0.97
12.	Faisalabad	2.57	0.00	0.83	1.55
13.	Gilgit	1.28	0.00	0.92	0.95
14.	Hyderabad	1.37	0.00	0.12	0.71
15.	Jacobabad	0.33	0.00	0.00	0.16
16.	Jiwani	0.29	0.00	0.00	0.14
17.	Khuzdar	0.52	0.00	0.01	0.26
18.	Kohat	0.21	0.00	0.05	0.12
19.	Mianwali	0.16	0.00	0.00	0.08
20.	Mirpur Khas	0.48	0.00	0.01	0.23
21.	Moenjodaro	1.89	0.00	0.04	0.94
22.	Multan	3.70	0.00	33.36	13.55
23.	Muzaffarabad	0.80	0.00	0.05	0.41
24.	Nawabshah	1.30	0.00	1.57	1.19
25.	Ormara	0.01	0.00	0.00	0.01
26.	Panjgur	2.40	0.00	0.00	1.18
27.	Pasni	1.42	0.00	0.80	0.98
28.	R.Y.Khan	0.71	0.00	0.06	0.37
29.	Rawalakot	0.16	0.00	0.05	0.09
30.	Saidu Sharif	1.25	0.00	0.23	0.69
31.	Skardu	0.66	0.00	0.10	0.36
32.	Sui	0.24	0.00	0.14	0.17
33.	Sukkur	3.20	0.00	0.74	1.63
34.	Turbat	3.28	0.00	0.06	1.63
35.	Zhob	1.40	0.00	0.01	0.69
	Total:-	100.00	100.00	100.00	100.00

Table 2-3 Total Passengers Handled By Airport In Pakistan During 1989-90

(Number)

Airport/ Aerodrome	Scheduled			Non - Scheduled			Scheduled + Non-Scheduled			Transit	Grand Total
	Embarked	Dis-Embarked	Total	Embarked	Dis-Embarked	Total	Embarked	Dis-Embarked	Total		
1	2	3	4	5	6	7	8	9	10	11	12
Karachi	2492058	2412290	4904348	55749	54392	110141	2547807	2466682	5014489	310667	5325156
Islamabad	889168	860435	1749603	30657	30626	61283	919825	891061	1810886	16925	1827811
Lahore	800962	806377	1607339	33145	14173	47318	834107	820550	1654657	138353	1793010
Peshawar	209727	204036	413763	464	995	1459	210191	205031	415222	6442	421664
Gwadar	31035	28429	59464	3674	3825	7499	34709	32254	66963	1750	68713
Quetta	103352	105066	208418	402	243	645	103754	105309	209063	2929	211992
Bannu	9275	5143	14418	-	-	-	9275	5143	14418	75	14493
Bahawalpur	12672	11289	23961	-	-	-	12672	11289	23961	-	23961
Chitral	21660	21086	42746	-	-	-	21660	21086	42746	-	42746
D.I.Khan	18552	14687	33239	12	44	56	18564	14731	33295	8440	41735
Faisalabad	76799	78550	155349	70	186	256	76869	78736	155605	-	155605
Gilgit	20459	22495	42954	432	496	928	20891	22991	43882	11	43893
Hyderabad	4078	4142	8220	-	-	-	4078	4142	8220	7080	15300
Jacobabad	2057	1824	3881	-	-	-	2057	1824	3881	8	3889
Jiwani	2904	2101	5005	-	-	-	2904	2101	5005	22	5027
Khuzdar	2634	2038	4672	-	-	-	2634	2038	4672	702	5374
Kohat	236	236	472	-	-	-	236	236	472	112	584
Mianwali	219	284	503	-	-	-	219	284	503	111	614
Mirpur Khas	1245	993	2238	-	-	-	1245	993	2238	3200	5438
Moenjodaro	15340	15053	30393	208	142	350	15548	15195	30743	4172	34915
Multan	127639	128774	256413	-	-	-	127639	128774	256413	16300	272713
Muzaffarabad	5163	3815	8978	-	-	-	5163	3815	8978	264	9242
Nawabshah	4406	3863	8269	-	5	5	4406	3868	8274	8674	16948
Ormara	142	77	219	44	27	71	186	104	290	9	299
Panjgur	18308	16740	35048	5	42	47	18313	16782	35095	11611	46706
Pasni	12058	16974	29032	361	430	791	12419	17404	29823	8577	38400
Rawalakot	3968	3531	7499	-	-	-	3968	3531	7499	-	7499
R.Y.Khan	2311	1856	4167	-	-	-	2311	1856	4167	78	4245
Saidu Sharif	12424	8750	21174	-	-	-	12424	8750	21174	2390	23564
Skardu	28949	29142	58091	562	744	1306	29511	29886	59397	116	59513
Sui	3610	3208	6818	-	-	-	3610	3208	6818	5	6823
Sukkur	44384	40157	84541	198	129	327	44582	40286	84868	18123	102991
Turbat	41085	35217	76302	421	264	685	41506	35481	76987	5507	82494
Zhob	9600	9217	18817	-	-	-	9600	9217	18817	7967	26784
TOTAL	5028479	4897875	9926354	126404	106763	233167	5154883	5004638	10159521	580620	10740141

Table 2-4 Percentage Share of Various Airports In Passenger Traffic During 1989 - 90

S.No.	Airport	Domestic	International	Transit	Total
1	2	3	4	5	6
	INTERNATIONAL				
1.	Karachi	32.60	78.62	53.51	49.58
2.	Islamabad	19.45	12.86	2.91	17.02
3.	Lahore	22.58	6.64	23.83	16.69
4.	Peshawar	5.27	1.64	1.11	3.93
5.	Gwadar	0.87	0.25	0.30	0.64
6.	Quetta	3.13	-	0.50	1.97
	DOMESTIC				
7.	Bannu	0.21	-	0.01	0.13
8.	Bahawalpur	0.35	-	-	0.22
9.	Chitral	0.53	-	-	0.40
10.	D.I.Khan	0.62	-	1.45	0.39
11.	Faisalabad	2.30	-	-	1.45
12.	Gilgit	0.65	-	0.01	0.41
13.	Hyderabad	0.23	-	1.22	0.14
14.	Jacobabad	0.06	-	0.01	0.04
15.	Jiwani	0.07	-	0.01	0.05
16.	Khuzdar	0.08	-	0.12	0.05
17.	Kohat	0.01	-	0.02	0.01
18.	Mianwali	0.01	-	0.02	0.01
19.	Mirpur Khas	0.08	-	0.55	0.05
20.	Moenjodaro	0.52	-	0.72	0.33
21.	Multan	4.02	-	2.81	2.54
22.	Muzaffarabad	0.14	-	0.05	0.09
23.	Nawabshah	0.25	-	1.48	0.16
24.	Ormara	0.00	-	0.01	0.01
25.	Panjgur	0.69	-	2.00	0.43
26.	Pasni	0.57	-	1.47	0.36
27.	Rawalakot	0.11	-	-	0.07
28.	R. Y. Khan	0.06	-	0.01	0.04
29.	Saidu Sharif	0.35	-	0.40	0.22
30.	Skardu	0.88	-	0.02	0.55
31.	Sui*	0.10	-	0.01	0.06
32.	Sukkur	1.52	-	3.12	0.96
33.	Turbat	1.22	-	0.93	0.76
34.	Zhob	0.40	-	1.38	0.25
	Total:-	100.00	100.00	100.00	100.00

Table 2-5 Total Cargo Handled By Airport In Pakistan During 1989-90

(Metric Tons)

Airport/ Aerodrome	Scheduled			Non - Scheduled			Scheduled + Non-Scheduled			Transit	Grand Total
	Loaded	Un-Loaded	Total	Loaded	Un-Loaded	Total	Loaded	Un-Loaded	Total		
1	2	3	4	5	6	7	8	9	10	11	12
Karachi	95258	49683	144941	840	462	1302	96098	50145	146243	5413	151656
Islamabad	11736	12055	23791	74	143	217	11810	12198	24008	-	24008
Lahore	14522	8053	22575	224	185	409	14746	8238	22984	-	22984
Peshawar	897	2444	3341	5	6	11	902	2450	3352	-	3352
Gwadar	45	87	132	1	5	6	46	92	138	-	138
Quetta	494	736	1230	1	-	1	495	736	1231	-	1231
Bannu	-	7	7	-	-	-	-	7	7	-	7
Bahawalpur	2	9	11	-	-	-	2	9	11	-	11
Chitral	-	53	53	-	-	-	-	53	53	-	53
D.I.Khan	14	74	88	-	-	-	14	74	88	-	88
Faisalabad	217	402	619	-	-	-	217	402	619	-	619
Gilgit	4	30	34	-	-	-	4	30	34	-	34
Hyderabad	3	8	11	-	-	-	3	8	11	-	11
Jacobabad	-	10	10	-	-	-	-	10	10	-	10
Jiwani	1	3	4	-	-	-	1	3	4	-	4
Khuzdar	4	5	9	-	-	-	4	5	9	-	9
Kohat	-	1	1	-	-	-	-	1	1	-	1
Mianwali	-	-	-	-	-	-	-	-	-	-	--
Mirpur Khas	-	-	-	-	-	-	-	-	-	-	--
Moenjodaro	2	72	74	-	-	-	2	72	74	-	74
Multan	297	448	745	-	-	-	297	448	745	-	745
Muzaffarabad	-	2	2	-	-	-	-	2	2	-	2
Nawabshah	1	7	8	1	-	1	2	7	9	-	9
Ormara	-	-	-	-	-	-	-	-	-	-	-
Panjgur	10	41	51	-	-	-	10	41	51	-	51
Pasni	8	32	40	-	-	-	8	32	40	-	40
Rawalakot	-	1	1	-	-	-	-	1	1	-	1
R.Y.Khan	-	1	1	-	-	-	-	1	1	-	1
Saidu Sharif	15	13	28	-	-	-	15	13	28	-	28
Skardu	11	81	92	-	1	1	11	82	93	-	93
Sui	1	5	6	-	-	-	1	5	6	-	6
Sukkur	12	215	227	-	1	1	12	216	228	-	228
Turbat	7	111	118	-	1	1	7	112	119	-	119
Zhob	2	12	14	-	-	-	2	12	14	-	14
Total	**123563**	**74701**	**198264**	**1146**	**804**	**1950**	**124709**	**75505**	**200214**	**5413**	**205627**

Table 2-6 Percentage Share Of Various Airports In Cargo Traffic During 1989-90

S.No	Airport	Domestic	International	Transit	Total
1	2	3	4	5	6
INTERNATIONAL					
1.	Karachi	47.61	87.30	100.00	73.75
2.	Islamabad	17.36	8.73	-	11.68
3.	Lahore	26.65	3.16	-	11.18
4.	Peshawar	3.51	0.65	-	1.63
5.	Gwadar	0.18	0.01	-	0.07
6.	Quetta	1.46	0.15	-	0.60
DOMESTIC					
7.	Bannu	0.01	-	-	0.01
8.	Bahawalpur	0.02	-	-	0.01
9.	Chitral	0.07	-	-	0.02
10.	D.I.Khan	0.12	-	-	0.02
11.	Faisalabad	0.86	-	-	0.27
12.	Gilgit	0.05	-	-	0.02
13.	Hyderabad	0.02	-	-	0.01
14.	Jacobabad	0.01	-	-	0.01
15.	Jiwani	0.01	-	-	0.01
16.	Khuzdar	0.01	-	-	0.01
17.	Kohat	0.01	-	-	0.01
18.	Mianwali	-	-	-	-
19.	Mirpur Khas	0.01	-	-	0.01
20.	Moenjodaro	0.11	-	-	0.04
21.	Multan	1.06	-	-	0.35
22.	Muzaffarabad	0.01	-	-	0.01
23.	Nawabshah	0.01	-	-	0.01
24.	Ormara	-	-	-	-
25.	Panjgur	0.07	-	-	0.02
26.	Pasni	0.06	-	-	0.02
27.	Rawalakot	0.01	-	-	0.01
28.	R.Y.Khan	0.01	-	-	0.01
29.	Saidu Sharif	0.04	-	-	0.01
30.	Skardu	0.13	-	-	0.05
31.	Sui	0.01	-	-	0.01
32.	Sukkur	0.32	-	-	0.10
33.	Turbat	0.16	-	-	0.05
34.	Zhob	0.02	-	-	0.01
	Total:-	100.00	100.00	100.00	100.00

5. Communication Links

1) Existing Trunk Line

The optical fiber trunk line has been established between 2 destinations, Karachi and Rawalpindi, and a low-capacity circuit has been opened between Rawalpindi and Islamabad. Another optical fiber trunk line has been opened between Rawalpindi and Peshawar and this line will provably be extended to D. I. Khan in 1997. After completion of the extension to D. I. Khan, it will subsequently be extended to Karachi, thereby providing an alternate routing to the present trunk line. On the other hand, it has become clear that the distance of the existing analog microwave line from the telephone exchange at D. I. Khan to the Peshawar exchange would be shorter and better condition than that of the routing to Multan exchange.

When transmitting radar imagery, it is essential that a high quality circuit be secured. In light of the above conditions, therefore, it has been decided to utilize the line between D.I. Khan and Peshawar.

It should be noted in this connection that we took measuring equipment to the Peshawar exchange and conducted checks on the quality of the microwave line between D.I. Khan and Peshawar. These tests have established that line quality over this link is sufficient to transmit radar imagery.

2) Radio frequency allocation for the new microwave line

During discussions with the Pakistan Telecommunication Authority (hereinafter referred to as "PTA"), in Pakistan, UHF band of 400 ~ 900 MHz is already allocated to public or mobile radio telecommunication and that no further allocations are available within this band. However, as we understand that allocations are feasible in the 2 GHz band, therefore, to avoid interference, it has been decided that the newly established microwave line will use 2 GHz band.

3) Transmission band for leased lines

The transmission capacity for leased lines using optical fiber cable, as provided by Pakistan Telecommunication Co., Ltd. (hereinafter referred to as "PTCL"), as a public network, is currently not less than 64 Kbps but, in a short time, digital cross-connection equipment will

be installed. With this digital cross-connection equipment, PTCL will be able to provide small transmission capacity such as 2.4, 4.8 and 9.6 Kbps to any users and so, in order to reduce PMD's recurrent costs, the 2.4 Kbps or the 4.8 Kbps line will be used for this Project as a radar imagery transmission route.

In tandem with the nationwide expansion of optical fiber cable, the PTCL has inaugurated a packet switching service. In consideration of the possibility of using this new service as a means of reducing recurrent costs, there are some drawbacks to this service. In this Project, therefore, we will employ leased lines.

In case of using packet switching system, a volume-based fee system is adopted based on a combination of connection time and data volume. Thus, the charges would vary with the volume of data needed to transmit the radar imageries.
This packet switching service is presently available only in Karachi, Islamabad, and other major cities, and it will be some time before the service area can be extended to such provincial cities as D. I. Khan and Rahimyar Khan.

4) Routing between radar sites and telephone exchanges

The following 7 telecommunication links will newly be established between the radar sites and the various telephone exchanges under the Project.

a. Radar site at D. I. Khan~ D. I . Khan telephone exchange
b. Radar site at Rahimyan Khan ~ Rahimyan Khan exchange
c. Karachi existing radar site ~ Karachi exchange (Airport station)
d. Islamabad existing radar site ~ Rawalpindi exchange
e. Aeronautical meteorological office at Islamabad International Airport ~ Rawalpindi exchange
f. NFFB at Lahore ~ Lahore exchange (Egerton road station)
g. Aeronautical meteorological office at Lahore International Airport ~ Lahore exchange (Cantonment station)

6. Radar Tower Buildings

Radar tower buildings will be built two sites at D.I. Khan and Rahimyan Khan.

The main rooms to be required for these tower buildings are as follows.

- Radar equipment room
- Radar observation room
- Forecasting room (at Rahimyan Khan, this room will be a Forecasting & briefing room)
- Data room
- Maintenance room
- Electricity / Pump room
- Generator room
- Storage room

7. Vehicles

For the following reasons, it is recommended to provide 2 vehicles for the radar sites at D. I. Khan and Rahimyar Khan to be established under the Project.
4WD pickup trucks, with cargo carrying capacity and rugged enough to be used even under flood conditions, would be most suitable.

- PMD staff at both D.I. Khan and Rahimyar Khan is to be increased by 17 persons at each station. Their duties will involve primarily radar observations, forecasting works, and information services. Since these employees will work on a 3-shift cycle around the clock, 365 days per year, it is essential that vehicles be provided for night shift rotations.

- The Indus River flows close to D. I. Khan and so, particularly during floods or during heavy rain when flooding is anticipated, the water level of the river will have to be monitored to correct and modify forecasts. Vehicles are clearly needed in connection with these observations.

- Public transportation (rail, bus) is lagging in Pakistan, leaving vehicles as the surest means of local transport, as between the radar sites and the Lahore Regional Meteorological Centre (hereinafter referred to as "RMC"). Since Lahore RMC has jurisdiction over both D. I. Khan and Rahimyar Khan, any maintenance operation that cannot be handled at the radar sites will have to be performed by the RMC, making vehicles absolutely essential for the transport of repair parts for the radar systems.

In light of the above considerations, the basic concept of the Project is to install weather radars and construct radar tower buildings at D. I. Khan and Rahimyar Khan to monitor the entire length of the Indus River basin, which is vulnerable to frequent flooding from severe local rainstorms; and to establish a telecommunication network for transmitting radar imageries, based on 4 radar systems linking the 2 new radar systems with the existing radar systems at Karachi and Islamabad. Imagery composition and display equipment will also be installed at Karachi and Islamabad, while radar display monitors will also be provided at 4 locations, International Airports at Karachi, Islamabad and Lahore, along with NFFB at Lahore.

2 - 3 Basic Design

2 -3 - 1 Design Concept

1. Design Concept of the Equipment

The basic design concept of weather radar systems, radar image transmission system, and communication system to be installed under the Project is as follows.

a. To design all equipment to conform operation and maintenance systems and technical capabilities of the PMD.

b. To attempt to make appropriate compatibility and suitability between the equipment to be supplied under this Project and the existing radar systems at Karachi and Islamabad.

c. To apply, whenever possible, digital communication system as the communication link for transmitting radar imagery to minimize a loss of radar image quality as much as possible for consideration of the existing communication environment in Pakistan.

d. To minimize recurrent costs of opertion and maintenance for the equipment at the PMD.

2. Design Concept of the Buildings

1) Building Plan : "Radar Tower Building"

Based on the future plans of the PMD, the design concept is to make building and facility plans for achieving duties as meteorological radar facilities which are to become operating bases for a weather radar network. The Plan is to construct meteorological radar tower buildings that will ensure appropriate and effective operations and accommodate the required systems, equipment, and manpower.

The basic concept is to design meteorological radar tower buildings incorporating with the following eight functions.

a. To be capable of properly and efficiently caring out the five principal components of a meteorological related activity : observation, telecommunication, data processing & analysis, forecasting, and dissemination.

b. To be capable of carrying out various meteorological services as the "Meteorological Radar Tower Building."

c. To provide an environment where services to be performed effectively and efficiently in accordance with the flow of the meteorological services.

d. To be capable of responding to the service curriculum, with forecasting and observation sections on 24 hour shifts.

e. To be furnished with suitable equipment (Uninterrupted Power Supply system and Auto Voltage Regulator, etc.) for performing the meteorological services of 24 hours a day, 365 days a year, never resting for even a single second.

f. Having the mission of supplying uninterrupted radar observation and weather forecast & warning even during heavy rain, flooding, etc., the radar tower building is to be sufficiently robust with adequate countermeasures taken against natural disasters.

g. To be capable of adapting to the meteorological radar system and other related equipment to be supplied under the Project.

h. To be capable of adapting to the meteorological duties and the staff numbers.

2) Structural Design

In order to withstanding natural disasters (especially heavy rain and flooding), the safe and economical structural design is to be applied, and local structural materials are selected wherever possible. For design and selection of the foundation structure, the results of accurate soil investigations at each project site will be applied.

3) Building Equipment Plan

Building equipment required for the round the clock operation throughout the year, and the executions of uninterrupted radar observation and forecasting & warning even during the

heavy raining and flooding, are to be planned. The equipment is to be selected from the viewpoint of easy operation and maintenance, taking safety and economy into consideration.

4) Construction Plan

By using the materials available in the local markets in Pakistan and applying local construction methods, an appropriate and economical construction plan is to be established.

5) Reductions of Operation, Maintenance and Administration Cost

The size and grade of the buildings are to be appropriately decided so as to avoid imposing any undue technical or financial burdens on the PMD with respect to ongoing operations and maintenance after completion of the building construction. Therefore, reliable and economical construction materials should be selected for the buildings and also easy local procurement of the materials should be considered for the future maintenance.

3. Design Concept for Implementation Schedule

For smooth implementation of the Project to be carried out by Japan's Grant Aid Assistance, the Client, PMD should be fully conversant with the required procedures. As the previous project was completed within a single fiscal year, therefore, only one Exchange of Notes was required.

However, this Project will consist of a detailed design stage and an implementation stage due to a fiscal year system of the government of Japan, by this reason, two Exchange of Notes will be required for a detailed design stage and an implementation stage of this Project. Thus, appropriate arrangements and coordination by the Pakistan side for receiving of will be indispensable and important for smooth implementation of the Project. Regarding the implementation schedule of the Project, actually, there is no sufficient time spare. Because the expiry date of the Exchange of Notes for an implementation stage will be by March, 1999 and the implementation period is supposed to be required for 17.5 months after signing of a contract between the Client , PMD, and a Japanese contractor. To avoid the Project delay and to keep the time schedule, the cooperation of both countries, accordingly, is essential to smooth project implementation and the Consultant should then coordinate closely in connection with advance procedures and preparations together with the Client, PMD.

4. Design Conditions

1) Meteorological Radar Network System

a. The 2 existing radars will positively be connected to the 2 new radars.

b. An allowance will be made for future expansion of this radar network through design provisions to accommodate the addition of future weather radars.

c. The radar network will include the newly installed microwave link as well as the existing optical fiber cable and analog microwave links operated by PTCL.

d. Composition of the meteorological radar network

The system, as outlined below, will be connected to the newly established telecommunication system as well as the existing public telecommunication links.

- D.I. Khan weather radar system
- Rahimyar Khan weather radar system
- The existing Karachi weather radar system
- The existing Islamabad weather radar system
- Radar imagery display system at Karachi International Airport
- Radar imagery display system at Islamabad International Airport
- Radar imagery display system at the Lahore NFFB
- Radar imagery display system at Lahore International Airport

2) Weather Radar System

a. In the interest of standardization between the meteorological observation and equipment operations, the weather radars that are to be established under this Project will be made fully compatible with the existing weather radars at Karachi and Islamabad.

b. The detecting capability of weather radar is determined by such factors as installed height, the angle of the antenna, the earth's curvature, and the height of the meteorological phenomena bearing precipitation. In this Project, The height of the Cb, which is the target of the observations, is set at 6 ~ 12 Km, and so the detection

range of the weather radar will be set at 400 Km to permit proper monitoring of the Cb clusters and other meteorological phenomena in this Project.

c. The observation items for the weather radar will be the intensity of the echo received from the rain particles as well as the hourly accumulated precipitation to raise the quantitative accuracy of precipitation.

d. For purposes of composite processing, the observation data must be made uniform. To accomplish this, we plan to use the same C-band as is used for the existing frequency band at Karachi and Islamabad.

e. In composite processing, the radar images are processed as simultaneously observed by the 4 weather radar stations. This requires that times be synchronized for each radar site so that signal processing may be synchronized with world standard time, which serves as the standard.

3) Radar Imagery Transmission System

a. The subject system must be able to transmit the radar imagry data observed by the 2 existing and 2 new radar stations.

b. The system must be capable of displaying the radar imageries on a display monitor.

c. The display range of the radar imageries will be set at 600 Km x 600 Km

d. The mesh of the echo intensity has been fixed at 2.5 Km x 2.5 Km, which is capable of establishing the precipitation conditions (rain area, intensity, etc.).

e. The system must be capable of composing radar imageries from either 2 or 4 stations and displaying these composite images on a display monitor.

f. The Project will allow for future expansion of meteorological observation activities, such as an increase in the number of weather radars, an increase in transmitted data, and expanded data processing requirements.

4) Telecommunication System

The newly installed digital radio equipment will conform to ITU recommendations and other international standards

a. Circuit quality

Circuit quality of the digital radio link will conform to ITU - R, 634 - 3, while Bit error rates (hereinafter referred to as "BER") will satisfy the following conditions :

- The number of duration when the BER exceeds 10^{-3} will not exceed 0.054% in any month.
- The number of duration when the BER exceeds 10^{-6} will not exceed 0.4 % in any month.
- The number of error duration in any month will not exceed 0.32%.

b. Radio frequency

The radio frequency will be in the 2 GHz band and will conform to ITU - R, 283 - 5.

c. Antenna

The height of the antenna, in so far as possible, have an effective earth radius coefficient of K= 4/3, while the clearance coefficient will satisfy at least 1.0.

d. Design specifications

The Basic Design will assume the following specifications.

Radio frequency	: 2GHz
Transmission capacity	: 2 Mbps
Modulation method	: 4 PSK
Transmitter output	: + 29 dBm
Minimum receiving input	: (10^{-3} BER) - 93.5 dBm
Antenna	: Diameter : 1.2 m or 1.8 m
Gain	: 25.3 dB or 28.5 dB

The antenna gain will show a standard value, as determined in accordance with the diameter

and radio frequency. Minimum receiving input will show an average value.

DC power supply is intended to furnish power from a storage battery to prevent interruptions in power supply to the newly installed digital radio equipment in case of commercial power failure. Accordingly, the storage battery will be capable of supplying the power in 4 hours.

5) Design Conditions for the Radar Tower Buildings

The following design conditions will be considered in connection with the facility and equipment plans.

a. Facility Plan (Required scale of the buildings)

In connection with the weather radar facility plan, sufficient space must be provided to allow PMD staff to function efficiently as a weather radar field monitoring team and to accommodate and effectively and appropriately utilize, the systems and equipment at both the new and existing facilities.

The appropriate size and scale of radar tower buildings have been determined on the basis of the staff, system, and equipment required to carry out the functions, role, and operations of a weather radar systems. The number of rooms and floor areas of the radar tower buildings have been designed on the basis of the administration structure, personnel requirements, systems, equipment, and operating space established under this Project, taking into account the present conditions at PMD (i.e., in terms of the existing systems, equipment, and operating space).

The power supply requirements for the buildings must be sufficient to support the systems and equipment needs established for the Project, along with general lighting, air-conditioning systems, and other equipment for the buildings. In assessing the scale of air-conditioning systems, the heating values of the personnel using the space, the newly established systems and equipment, lighting, and other heat-generating items and have thereby determined the methods, types, and capacities of air-conditioning systems.

With regard to the power supply systems, in order to carry out the mission of the buildings to operate around the clock throughout the year, conducting radar observations and issuing forecasts, warnings and bulletins even during natural disasters, power supply systems must include an uninterrupted power supply system and engine generator system to insure proper

operation of the systems and equipment.

The sites for the weather radar facilities to be constructed under this Project are located at D.I. Khan and Rahimyar Khan. No particular problems are expected at the former site, since it is located in the D.I. Khan observatory. The Rahimyar Khan site, on the other hand, is located inside the Rahimyar Khan Airport owned by the CAA, and so serious consideration must be given to achieving mutual accommodation between the Plan facilities, existing facilities, and those presently under construction, particularly as regards the airport facilities, control tower, intra-airport communication and radio facilities, underground lines, as well as aircraft landing, takeoff, and taxiing patterns.