Department of Meteorology and Hydrology
The Republic of the Union of Myanmar

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM
IN
THE REPUBLIC OF THE UNION OF MYANMAR

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

JAPAN WEATHER ASSOCIATION
INTERNATIONAL METEOROLOGICAL CONSULTANT INC.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to consist of Japan Weather Association (JWA) and International Meteorological Consultant Inc. (IMC).

The survey team held a series of discussions with the officials concerned of the Government of the Republic of the Union of Myanmar, and conducted field investigations. As a result of further studies in Japan, 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.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Union of Myanmar for their close cooperation extended to the survey team.

March, 2013

Masami FUWA
Director General, Global Environment Department
Japan International Cooperation Agency

Summary

Summary

Myanmar is a country facing both the Bay of Bengal and the Andaman Sea with an estimated 2,400km coastline. The majority of Myanmar people live in fertile flat lands or in coastal regions greatly affected by negative weather phenomena such as tropical cyclones, heavy rain and storm surges. This is why the extensive damage from tropical cyclones or heavy rain is a determining factor for the significant set-back of the national economy and development. Particularly, a tropical cyclone, the most terrible weather phenomenon to affect Myanmar, mainly inflicts devastating damages in the areas along the Bay of Bengal and its affected people and the total amount of damages are immeasurable.

In general, tropical depressions generated in the south of the Bay of Bengal move to the north and then turn to the east. They develop and reach the strength of a tropical cyclone by passing on the warm waters of the Bay of Bengal and a few of them make landfall in Myanmar. Landfall frequency has increased since 2000, almost every year, whereas it occurred once in three to four years before 2000. All of the hitting tropical cyclones killed people and mostly affected a huge number of people. Between April 27 and May 3, 2008, Cyclone “Nargis” attacked Myanmar, which has still been a fresh memory as a terrible nightmare not only to the Myanmar people but also to the rest of the world. Cyclone “Nargis” moved along the southern edge of Myanmar and a large scale of storm surge directly attacked Ayeyarwady Delta. Since the area around Ayeyarwady Delta is the center of population and economic activities in Myanmar, the cyclone paralyzed the socio-economic activities of the whole country (Killed or Missing: over 138,000, Affected people: over 2,400,000, Total amount of damages: approx. 4,000 million dollars). More recently, a tropical depression landing in the boundary area between Myanmar and Bangladesh caused the flash floods in Magway and Mandalay regions, in which 161 people were dead or missing and more than 35,000 people were affected. Bearing in mind these lessons, it is recognized that accurately monitoring the occurrences, intensities and movements of tropical cyclones beforehand is crucially important and necessary. Thus, the establishment of a meteorological radar system network to cover all the areas of the Bay of Bengal is an urgent task that needs to be accomplished in Myanmar.

In recent years, there is global concern that the intensity of tropical cyclones and the number of heavy rains will be increased and, consequently meteorological disasters expanded, as a result of abnormal climate change due to global warming. Myanmar is no exception. In order for Myanmar to contribute to the alleviation of the adverse effects of natural disasters in the Bay of Bengal, 1) the strengthening of the meteorological observation, communication, and forecasting/warning system (through monitoring with the meteorological radar system) and 2) the reinforcement of cooperation efforts with other countries in the Bay of Bengal (through the exchange of meteorological observation data and information about cyclones on a timely basis) are the most important and urgent tasks.

However, the only meteorological radar system in Kyauk Phyu, the American radar system installed by WMO/UNDP in 1979, completely stopped in 2004 due to aging. The Department of Meteorology and Hydrology (hereinafter referred to as the “DMH”) is unable to monitor the tropical cyclones and

accurately locate their center positions, intensities and movements, therefore, it is unable to implement the most important task, that is, the issuance of the timely and accurate forecast/warnings so as to mitigate the disasters by tropical cyclones.

After the new administration of Myanmar started in March 2011, the Central Committee for Natural Disaster Prevention, Relief and Resettlement was formed under the guidance of the State Peace and Development Council's Security and Management Committee as a national development plan for effective disaster preventive measure. The Government of Myanmar has enhanced its capability of dealing with natural disasters and its disaster prevention system, which is expected to reduce the risk of poor people particularly vulnerable to natural disasters. To mitigate the damages brought about by tropical cyclones and floods, it is important to transmit the prompt and accurate weather information/warnings to each disaster prevention organization, local governments and the mass media. Since the information issued by the DMH is a trigger for the first action of each disaster prevention organization, the improvement of the DMH's monitoring capability of meteorological phenomena is highly required and in accord with the key objective of the Project. Thus establishment of the meteorological radar stations in Kyauk Phyu, Yangon and Mandalay have been approved by the President of Myanmar on July 31, 2012.

Myanmar, however, lacks the financial and technical capabilities to procure and install the required equipment as well as to provide the relevant systems and facilities, etc. During the Japan-Myanmar Summit held in April 2012, the aid to Myanmar by the Government of Japan was discussed and the two leaders of Myanmar and Japan affirmed a common recognition that the improvement of the meteorological field is pivotal in order to protect the people from natural disasters. In line with the agreement made at the summit, the Government of Japan decided to conduct a Preparatory Survey for the establishment of a weather monitoring system (hereinafter referred to as the "Preparatory Survey"). The Japan International Cooperation Agency (hereinafter referred to as "JICA") sent the Preparatory Survey Team (1) to Myanmar from June 17 to August 24, 2012. The Team had a series of discussions with the officials concerned from the Government of Myanmar, conducted surveys and collected some necessary and pertinent information and data for the Project. In addition, the Team conducted further studies, including a feasibility, justification and scope of the Project, paying particular attention to the present situation in Myanmar from various perspectives such as the DMH's operation & maintenance capabilities, best equipment arrangement plan, etc.

JICA then sent the Preparatory Survey (2) Team again to Myanmar from January 4 to January 12, 2013 in order to explain and discuss the outline design & draft survey report. During the course of discussions and field survey, it was confirmed that the following items are required for the Project in consideration of the Project's objectives and effects. As a consequence of the further study of each item in Japan, it has been decided that the following components indicated in the table attached hereunder are object items of the Preparatory Survey for the Project.

Table 1: Object Items of the Preparatory Survey

Component	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Mandalay Meteorological Radar Observation Station	Yangon International Airport	Automatic Weather Observation Stations
Procurement and Installation of Equipment						
S-Band Doppler Pulse Compression Solid State Radar System including Power Back-up System, Lightning System Measuring Equipment and Spare Parts	-	1	1	1	-	-
Meteorological Rader Data Display System including Software	1	1	1	1	5	-
Meteorological Data Satellite Communication System (VSAT)	1	1	1	1	-	-
Meteorological Data Communication System	-	-	1	-	1	-
Automatic Weather Observation System	1 (Meteorological Data Management Unit)	-	1 (Meteorological Data Management Unit)	-	-	30
Construction of Radar Tower Building						
Construction of New Radar Tower Building	-	1	1	1	-	
Soft Component	1					

The population to be benefited both directly and indirectly by the Project will be the whole nation of Myanmar (approx. 63 million estimated for 2012). There is also real concern that the number of victims will proportionally increase, unless the problem is addressed soon, due to the fact that the population of Myanmar has been increasing by 2% annually, that is, 20% in 10 years. Furthermore, since the information to be gathered with the meteorological Doppler radar system is planned to be utilized for navigational safety in the Yangon International Airport, the Project is considered to contribute to the safety of passengers (approx. 2.5 million/year) of the civil aviation aircrafts which take off and land in the Yangon International Airport.

At the Japan-Myanmar Summit Meeting on April 21, 2012 indicated above, the policies of Japan's future cooperation with Myanmar were set as follows.

1. Assistance for the improvement of people's livelihoods
2. Assistance for capacity building and institutions development to sustain economy and society
3. Assistance for development of infrastructure and related systems necessary for sustainable economic development

As one of the concrete measures of assistance for the improvement of people's livelihoods among the above three policies, the study for the improvement of meteorological equipment is included to protect the people from natural disasters.

The key objective of the Project is the effective mitigation of the adverse effects of natural disasters caused by tropical cyclones, heavy rain, etc. To achieve this objective, the implementation of personnel training in addition to the installation of Meteorological Doppler Radar System, Meteorological Radar Data Display System and Meteorological Data Communication System are absolutely essential. These will

largely enhance the monitoring capability of hazardous meteorological phenomena such as tropical cyclones and heavy rain and will improve the forecasting/warning systems in Myanmar as well as create a positive spill-over effect on the neighboring countries in the Bay of Bengal. Given the history that the countries in the Bengal Bay received the most extensive human, social and economic damages resulting from tropical cyclones, and climate change caused by global warming will accelerate, it is expected that the Project will contribute to improving the lives of people and that of the socio-economy in the region.

The pulse compression solid state Doppler radar system which has already been put into practical use for meteorological observations and has confirmed its reliability, durability, accuracy and performance is only available and made in Japan. The equipment for the Project must be durable, reliable, of a high technical level, and cost effective. In addition, since almost all of the Japanese meteorological radar systems established under Japan's Grant Aid in the developing countries have been working well over the years, Japanese systems have received a high degree of confidence in the world. As a result of this, it is recognized, even by the WMO, that a Japanese system is the most suitable one for developing countries facing operation and maintenance difficulty.

Recently, climate change mainly due to global warming has a potential to become the greatest threat to the sustainability of the very foundations of human survival and has been a significant global issue which developed and developing countries alike must deal with through mutually beneficial cooperation. If global warming continues, there are concerns that the rainfall and wind velocity of tropical cyclones will be increased and the damage caused by one tropical cyclone will be extensive.

Under these circumstances, the implementation of the Project is, therefore, considered to be an appropriately suitable and worthwhile endeavor. Moreover, in order to reduce the DMH's operational and maintenance costs, the equipment was designed to minimize spare parts and consumables. Also, since the biggest recurrent cost of the Project is expected to be electricity, the equipment and facilities were designed in such a way so as to minimize power consumption. As a result, the DMH's budget is expected to be able to cover the Myanmar portion of the capital and recurrent costs of the Project. As adequately pointed out in the careful and comprehensive evaluation of the effects of the Project, considerable and enhanced benefits can be achieved vis-à-vis the DMH's capabilities in reducing human loss and the recurrent economic set-back brought about by meteorological disasters including tropical cyclone. The Project would substantially contribute to the mitigation of the adverse effects of meteorological disasters and effectively safeguard the basic human needs of the Myanmar people as well as those of its neighboring countries in the Bengal Bay.

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The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Kyauk Phyu Meteorological Radar Tower Building

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ABBREVIATIONS

ASEAN : Association of Southeast Asian Nations
AVR : Automatic Voltage Regulator
AWPT : Asia World Port Terminal
AWS : Automatic Weather Observation System
BMD : Bangladesh Meteorological Department
CAPPI : Constant Altitude Plan Position Indicator
DMH : Department of Meteorology and Hydrology
EIA : Environmental Impact Assessment
JICA : Japan International Cooperation Agency
MCDC : Mandalay City Development Committee
MIP : Myanmar Industrial Port
MITT : Myanmar International Terminal Thilawa
MTBF : Mean Time Between Failure
MTTR : Mean Time To Repair
OJT : On-the-Job Training
VSAT : Very Small Aperture Terminal
YCDC : Yangon City Development Committee
UNDP : United Nations Development Programme
WMO : World Meteorological Organization

Chapter 1
Background of the Project

Chapter 1 Background of the Project

1-1 Background of the Project

Myanmar is a country facing both the Bay of Bengal and the Andaman Sea with an estimated 2,400km coastline. The majority of Myanmar people live in fertile flat lands or in coastal regions greatly affected by negative weather phenomena such as tropical cyclones, heavy rain and storm surges. This is why the extensive damage from tropical cyclones or heavy rain is a determining factor for the significant set-back of the national economy and development. Particularly, a tropical cyclone, the most terrible weather phenomenon to affect Myanmar, mainly inflicts devastating damages in the areas along the Bay of Bengal and its affected people and the total amount of damages are immeasurable.

Figure on the right shows that about 5% of the tropical cyclones of the world are generated in the Bay of Bengal. Some of them become very strong and cause unimaginable catastrophic damages to the countries along the Bay of Bengal especially during high tide. Main countries around the Bay of Bengal are India, Bangladesh and Myanmar and they implement disaster countermeasures against tropical cyclones so as to protect life and property.

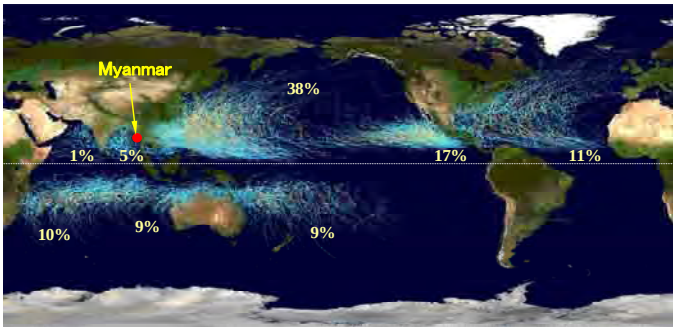


Figure 1: Tropical Cyclone Tracks Occurrence in the World

In general, tropical depression generated in the south of the Bay of Bengal moves to the north and then turns to the east. It develops and reaches the strength of a tropical cyclone by passing on the warm waters of the Bay of Bengal. Developed tropical cyclones have three destructive attributes: strong wind (maximum wind: over 53m/s (120miles/h)); heavy rain (rainfall: over 130mm (5inches)/24h); and storm surge (height: over 3m (10feet)). The damages brought about by a storm surge are closely related to the vulnerability of a cyclone's landing place which, in this case, is the coastal regions of the Bay of Bengal. On average, in the Bay of Bengal, about 10 tropical depressions occur per year and about 6 out of them develop into a tropical cyclone. Usually, tropical depressions/tropical cyclones are likely to have strong power and longer life span during the pre-monsoon period (April-May) and the post-monsoon period (October-November) while they are likely to have less power and shorter life span during the monsoon

Table 2: Tropical Cyclones in Myanmar (1887-2005)

Month	Number of Cyclones hitting Myanmar	Monthly Percentage of Cyclones hitting
January	2	2 (%)
February	1	1 (%)
March	-	-
April	15	19 (%)
May	24	30 (%)
June	1	1 (%)
July	-	-
August	-	-
September	-	-
October	14	18 (%)
November	14	18 (%)
December	9	11 (%)
Total	80	100 (%)

Source: DMH

(June-September). As shown in the table 2 on the previous page, the monthly percentage of tropical cyclones hitting Myanmar is at its highest during May (30%), second during April (19%) and followed by October and November (18%). What this means is that tropical cyclones with strong power and long spans tend to attack Myanmar.

The Department of Meteorology and Hydrology (hereinafter referred to as the "DMH") is expected to issue timely and accurate forecast/warnings so as to mitigate the disasters brought about by tropical cyclones. However, the only meteorological radar system in Kyauk Phyu, the American radar system installed by WMO/UNDP in 1979, completely stopped in 2004 due to aging. The DMH, therefore, is unable to monitor tropical cyclones and accurately locate their center positions, intensities and movements. As a result, the DMH Nay Pyi Daw and Yangon, the pivotal forecasting offices, could not receive the necessary information for forecasting. In 2006, Cyclone "Mala" (same scale of damage as Hurricane "Katrina" hitting the Unites States in 2005) caused enormous damage to Myanmar. It was identified that one of the reasons for the extensive damage brought about by the cyclone was the inability of the DMH to monitor the cyclone. In addition, since only 3 hourly manual observation is conducted at all the existing meteorological observation stations and more than 1 hour is required for collecting all the observed data of each observation at the DMH Multi-Hazard Early Warning Center, Nay Pyi Taw, the DMH was unable to promptly and quantitatively get the picture of heavy rainfalls which frequently create floods and landslides.

Kyauk Phyu Meteorological Radar Observation Station

Bay of Bengal from Kyauk Phyu Meteorological Radar Observation Station

In 2008, Cyclone "Nargis" attacked Myanmar, which was a nightmare and still a fresh memory not only to the Myanmar people but also to the rest of the world. It brought about unprecedented human losses of about 140,000 (died or missing people), and also disrupted production activities as it hit the south delta area, the center of economic activities in Myanmar. As a result, the cyclone paralyzed the socio-economic activities of the whole country. According to the Director General of the ASEAN, the total amount of damages was estimated to be about 4 billion dollars. Bearing in mind these lessons, it is recognized that accurately monitoring the occurrences, intensities and movements of tropical cyclones beforehand is crucially important and necessary. Thus, the establishment of the meteorological radar system network to cover all the areas of the Bay of Bengal is an urgent task that needs to be accomplished in Myanmar.

1-2 Tropical Cyclone

Disasters Caused by Tropical Cyclones

Landfalls of tropical cyclones in Myanmar during the past 30 years and their corresponding paths are shown in the following table and figure. Landfall frequency has increased since 2000, almost every year, whereas it occurred once in three to four years before 2000. The table also shows that all of the hitting tropical cyclones killed people and most affected a huge number of people. More recently, a tropical depression landing in the boundary area between Myanmar and Bangladesh caused the flash floods in Magway and Mandalay Regions, in which 161 people were dead or missing and more than 35,000 people were affected. (Tropical depressions are not indicated in the following table.)

Table 3: Landfall of Tropical Cyclones in Myanmar (1981-2010)

Year	Month-Date (Occurrence – Disappearance)	Name	(*) Maximum Wind (Km/h)	Lowest Pressure (hPa)	Killed/ Missing	Total Affected	Estimated Damage (US$ Million)
2010	October 21-23	Giri	195	950	45	260,049	57
2008	April 27-May 3	Nargis	165	962	138,373	2,420,000	4,000
2006	April 25-29	Mala	185	954	37	60,106	-
2004	May 17-19		165	952	600	25,000	30
2003	May 10-19		115	982	80	-	15
1994	April 29-May 2		215	940	17	64,970	10
1992	May 17-19		65	992	27	-	23
1982	May 1-4		233	-	11	36,000	-

(*) 3 minutes mean maximum wind

Source: DMH

The most unforgettable tropical cyclone is Cyclone “Nargis” whose damages were the worst during the past 30 years. As can be seen in the right figure, Cyclone “Nargis” (red dot-line) moved along the southern edge of Myanmar and a large scale of storm surge caused by the cyclone directly attacked Ayeyarwady Delta. Since the area around Ayeyarwady Delta is the center of population and economic activities in Myanmar, the cyclone paralyzed the socio-economic activities of the whole country (Killed or Missing: over 138,000, Affected people: over 2,400,000, Total amount of damages: approx. 4 billion dollars). The details of Cyclone “Nargis” are indicated in the following table.

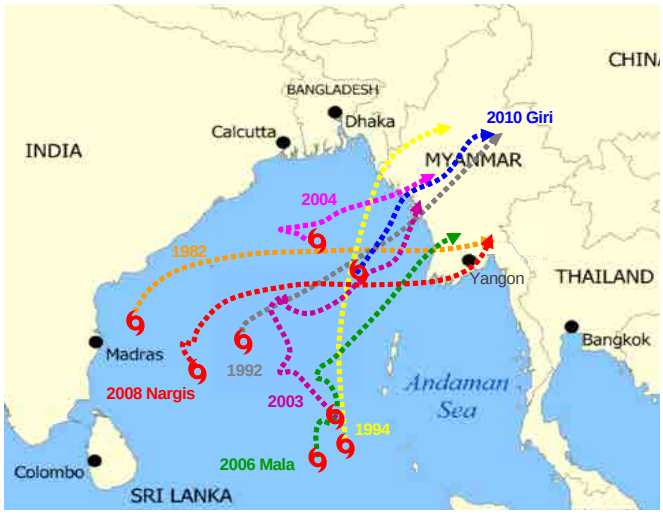
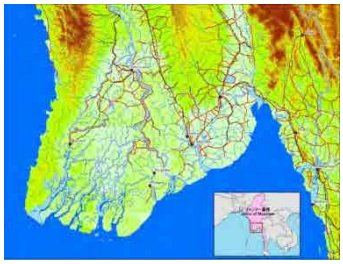


Figure 2: Track of cyclones which made landfall on Myanmar (1981-2010)

Table 4: Details of Cyclone “Nargis”

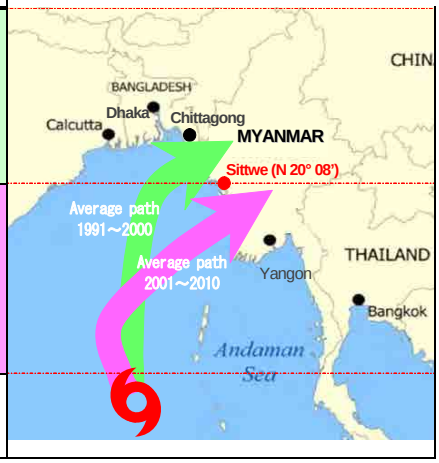
Date	Feature	Damage
April 27-May 3, 2008 Landfall at Ayeyarwady Delta, Myanmar on May 2	  Satellite & Path of Nargis ＜Feature＞ 1. **Path**: Although most of cyclones hitting Myanmar usually move northward or northeastward in the Bay of Bengal, Nargis moved **eastward** on the westerlies which stayed down south (Latitude N15°) than usual (Latitude N25°). 2. **Rapid Development**: Surface sea temperature was 0.2-0.6 °C higher than average. Maximum Wind (1 minute mean): 150miles/h (67m/s) by DMH Total Rainfall: 500-600mm (Estimated)	Killed/Missing: 138,373 Total Affected: 2,420,000 Estimated Damage: 4,000 (US$ Million) <Reason of damage> The center of Nargis moved along the southern shore of Myanmar. Decreased pressure (pressure surge) and strong south winds (wind-driven surge) caused the large scale effect of storm surge. The intricate landscape and the concentration of population (about half of the entire population) in the Ayeyarwady Delta also led to the immense damages including a large number of killed and affected people.  Landscape of the Ayeyarwady Delta

Southward Tendency of Tropical Cyclones

Recently, from Chittagong in Bangladesh to Myanmar along the Bay of Bengal, the landing place of a tropical cyclone has a tendency to shift southward. The following table indicates the number of tropical cyclone landfalls for each decade of 1991-2000 and 2001-2010 and the arrows in the right figure show the average paths of tropical cyclones.

Table 5: Number of Cyclone Landfalls along the Bay of Bengal (Chittagong–Myanmar)

Area of Cyclone Landfall	Number of Cyclone Landfalls	
	1991-2000	2001-2010
Northern Area from Sittwe	7	2
Southern Area from Sittwe (including Sittwe)	1	5
Total Number of Cyclone Landfalls along the Bay of Bengal (Chittagong-Myanmar)	8	7



The probability of tropical cyclone landfall in the northern area from Sittwe decreased to 2/7 (2001-2010) from 7/8 (1991-2000). On the other hand, the probability of tropical cyclone landfall in the southern area from Sittwe (including Sittwe) increased to 5/7 (2001-2010) from 1/8 (1991-2000). There is a perspective that the change of landfall point is associated with that of turning point where a tropical cyclone starts moving eastward, that is to say, the turning points shift to the south. If this situation continues, it is presumed that the number of tropical cyclones landing in the southern area from Sittwe (including Sittwe) will increase. Since the delta area is particularly vulnerable to storm surge (Wind-driven Surge + Pressure Surge) caused by tropical cyclones due to its low sea level, there is a fear that Myanmar people will have a nightmare of Cyclone "Nargis" again in the near future. Therefore, to effectively protect life and property from tropical cyclones, it is imperative to strengthen the monitoring capability of tropical cyclones in the Bay of Bengal and to provide timely and more accurate forecasts/warnings of tropical cyclones to the public by establishing the meteorological radar systems as soon as possible.

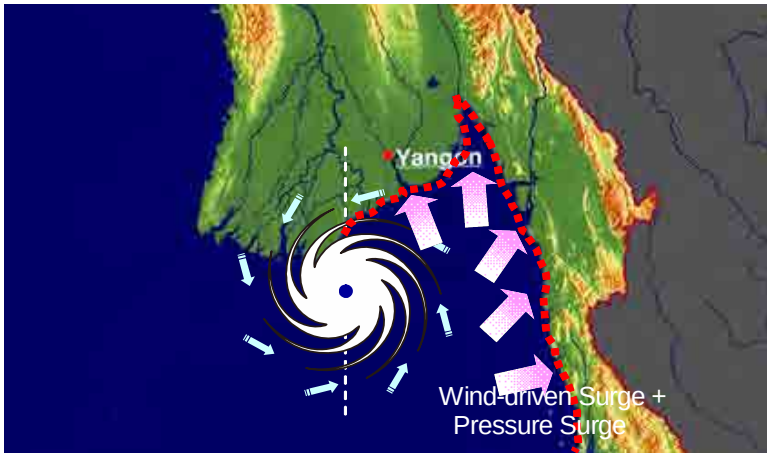


Figure 3: High Risk Areas seriously to be affected by Wind-driven Surge (Storm Surge) + Pressure Surge generated by Tropical Cyclone

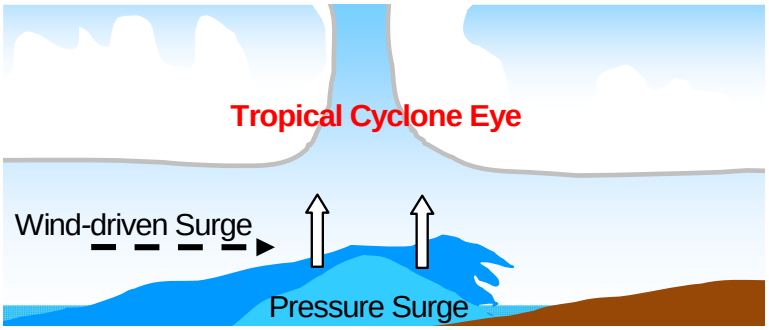


Figure 4: Wind-driven Surge (Storm Surge) and Pressure Surge generated by Tropical Cyclone

1-3 Flood-Prone Area

Floods including flash floods caused by heavy rain occur frequently from August to October in the middle stage of Monsoon. Floods in Myanmar are classified broadly into four kinds as indicated below.

1. Riverine floods
2. Flash floods caused by continuous heavy rain for 1-3 days in the upper river basin
3. Due to the negative factors such as high water saturation and low water permeability of the ground and also poor drainage system, localized floods happened in urban areas or dam or bank collapsing in rural areas
4. Floods due to tropical cyclone and storm surge

Recently, the number of times of heavy rain (torrential rain) has increased whereas the Monsoon period has been shorter. Myanmar has the high potential to be damaged by floods because (1) so many streams and rivers are running through the whole country, (2) precipitous mountainous ranges spread in the northern area, and (3) major cities or economically important areas are located along the major rivers such as the Ayeyarwady River. The following table shows the causes of floods in each area of the Ayeyarwady valley where 60% of the whole nation and the population is concentrated.

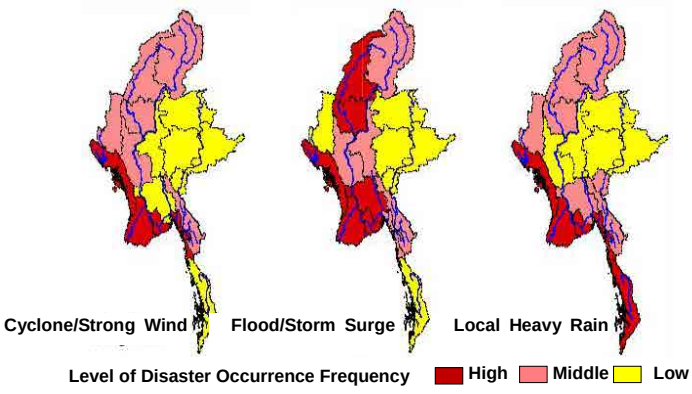
Table 6: Flood-Prone Area in the Ayeyarwady Valley and Cause of Occurrence

	Heavy Rain in the Upper Valley during Monsoon Period	Short-Term Heavy Rain by Monsoon Trough	Snowmelt in the North Mountainous Area during Summer	Storm by Cyclone
North Mountainous Area	River Flood	Flash Flood	Flash Flood	
Middle Inland Area	River Flood	Inundation	-	-
South Delta Area	River Flood	Inundation	-	Flood by Storm Serge

Furthermore, typhoons making landfall in Indochina from the South China Sea come to the west and bring heavy rain around the eastern part of Myanmar, which causes floods in the Thanlwin River basin.

1-4 Prediction of Disaster Occurrence Frequency by Climate Change

Right figure shows the predicted occurrence frequency of disasters caused by climate change due to global warming. The disasters include Cyclone/Strong Wind, Flood/Storm Surge, Local Heavy Rain. The areas with the high level of occurrence frequency of all the disasters are South Delta Area and the area along the Bay of Bengal. In the northern areas, floods are predicted to occur with high frequency.



Source: DMH

Figure 5: Prediction of Disaster Occurrence Frequency by Climate Change

1-5 Brief Summary on the Requests for the Project by Myanmar

At the Japan-Myanmar Summit in 2012, the aid to Myanmar by the Government of Japan was discussed and the two countries had common recognition that the capability of Myanmar in the meteorological field should be improved in order to protect the Myanmar people from natural disasters.

In line with the agreement made at the summit, the Government of Japan decided to conduct a Preparatory Survey for the establishment of a weather monitoring system (hereinafter referred to as the “Preparatory

Survey"). The Japan International Cooperation Agency (hereinafter referred to as "JICA") sent the Preparatory Survey Team (1) to Myanmar from June 17 to June 30 and July 14 to August 24, 2012. The Team had a series of discussions with the officials concerned from the Government of Myanmar, conducted surveys and collected some necessary and pertinent information and data for the Project. In addition, the Team conducted further studies, including a feasibility, justification and scope of the Project, paying particular attention to the present situation in Myanmar from various perspectives such as the DMH's operation & maintenance capabilities, best equipment arrangement plan, etc. On November 2, 2012, the Government of Myanmar finally made an official request to the Government of Japan for the implementation of the Project under Japan's Grant Aid based on the discussions with the Preparatory Survey Team.

JICA then sent the Preparatory Survey (2) Team again to Myanmar from January 4 to January 12, 2013 in order to explain and discuss the outline design & draft survey report. During the course of discussions and field survey, it was confirmed that the following items are required for the Project in consideration of the Project's objectives and effects. As a consequence of the further study of each item in Japan, it has been decided that the following components indicated in the table attached hereunder are object items of the Preparatory Survey for the Project.

Table 7: Object Items of the Preparatory Survey

Component	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Mandalay Meteorological Radar Observation Station	Yangon International Airport	Automatic Weather Observation Stations
Procurement and Installation of Equipment						
S-Band Doppler Pulse Compression Solid State Radar System including Power Back-up System, Lightning System Measuring Equipment and Spare Parts	-	1	1	1	-	-
Meteorological Radar Data Display System including Software	1	1	1	1	5	-
Meteorological Data Satellite Communication System (VSAT)	1	1	1	1	-	-
Meteorological Data Communication System	-	-	1	-	1	-
Automatic Weather Observation System	1 (Meteorological Data Management Unit)	-	1 (Meteorological Data Management Unit)	-	-	30
Construction of Radar Tower Building						
Construction of New Radar Tower Building	-	1	1	1	-	
Soft Component	1					

1-6 Negative Impact on the Development of the Myanmar Economy

The figure on the right shows the growth rate of GDP in Myanmar. In 2008, when Myanmar suffered from the catastrophic and historic damage brought about by Cyclone "Nargis," the growth rate of the GDP fell to 3.59% in spite of the fact that it had kept more than 10% until then. It clearly shows that the damages caused by meteorological disasters like tropical cyclones have serious negative impacts on the economic development of the whole country.

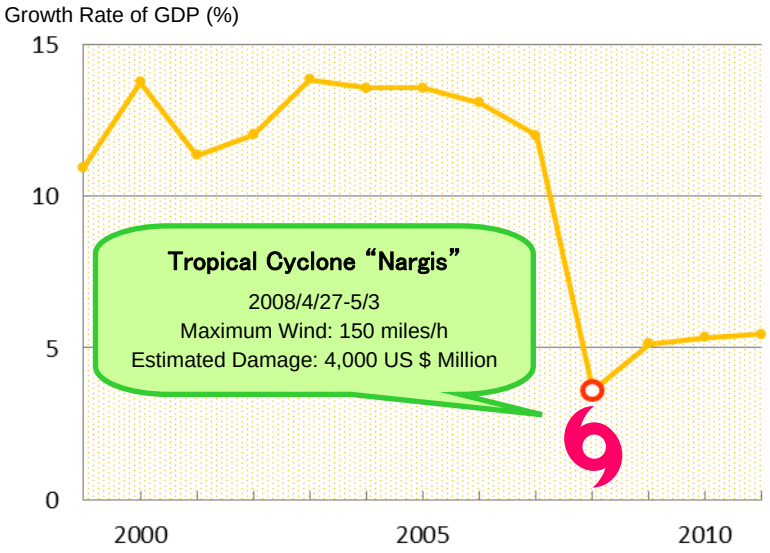


Figure 6: Growth Rate of GDP and Meteorological Disaster

1-7 Stability of Commercial Power

As shown in the table below, the stability of commercial power was measured by the Power Quality Analyzer at the DMH Multi-Hazard Early Warning Center, Nay Pyi Taw, existing Kyauk Phyu Meteorological Radar Observation Station, proposed Yangon Meteorological Radar Observation Station and proposed Mandalay Meteorological Radar Observation Station, and continuous data was recorded respectively. As a consequence, a conclusion was made that the installation of Power Backup System such as Diesel Engine Generator, Automatic Voltage Regulator (AVR), etc. is indispensable for around-the-clock operation.

Table 8: Stability of Commercial Power measured by Power Quality Analyzer

Site Name		DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Existing Kyauk Phyu Meteorological Radar Observation Station	Proposed Yangon Meteorological Radar Observation Station	Proposed Mandalay Meteorological Radar Observation Station
Nominal Voltage		400V/230V, 3-phase 4-wire, 50Hz	-	400V/230V, 3-phase 4-wire, 50Hz	400V/230V, 3-phase 4-wire, 50Hz
Voltage (V)	Max.	236.3	-	248.6	227.8
	Min.	199.4	-	188.0	196.0
Frequency (Hz)	Max.	50.49	-	50.50	50.50
	Min.	49.54	-	49.65	49.05
Power Stoppage	Dry Season	Once per week (approx. 0.2 hour)	-	Once per month (approx. 0.5 hour)	Twice per week (approx. 1 hour)
	Monsoon Season	Three times per week (approx. 0.5 hour)	-	Once per month (approx. 0.5 hour)	Once per day (approx. 8 hour)

1-8 Natural Conditions of Myanmar

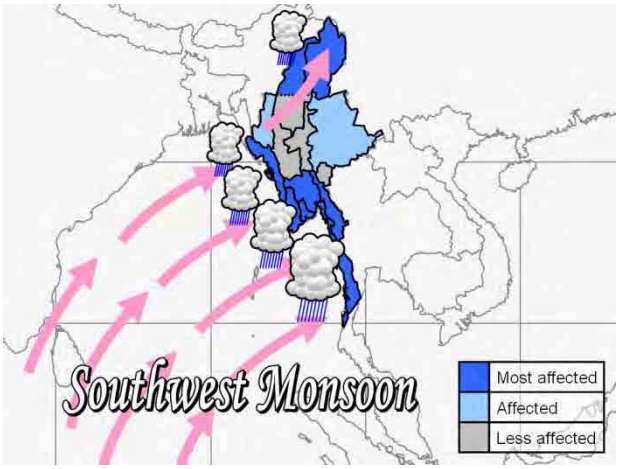
Precipitation events in Myanmar are caused not only by the southwest monsoon and tropical cyclones/tropical depressions from the Bay of Bengal but also by the typhoons/tropical depressions from the South China Sea, middle-latitude or local scale disturbances. Moreover, during the dry season from December to February, the northeast monsoon brings precipitation to Myanmar. The following tables show the period of typical precipitation events and their details including mechanism and influence on Myanmar.

Table 9: Calendar of Typical Precipitation Events in Myanmar

Season of each phenomenon
Peak Season of each phenomenon

Southwest Monsoon

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				←	━	━	━	→	→		



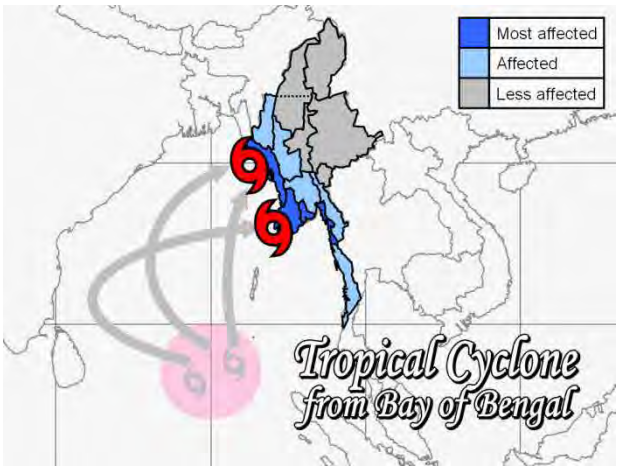
Mechanism:
From mid-May to mid-October, the Southwest Monsoon is prevailing over the Bay of Bengal. When the pressure difference (ΔP) along the whole Myanmar coast is 8.0hPa or more, the monsoon intensity is categorized under 'Vigorous' stage followed by 'Strong' stage when the ΔP is 6.0hPa or more. The coastal area receives heavy rain with strong wind when the monsoon intensity is strong or more. Torrential rain is also observed in the northern mountainous area due to the orographic effect. On the contrary, the inland/central area experiences less rainfall due to an adverse orographic effect when the monsoon intensity is stronger.

Expected Weather:
Heavy rainfall:
- Frequency -
  > 30mm/day = 15 to 20 days/month
  >100mm/day = 5 to 10 days/month
- Record -
  Coastal area = 739 mm/day (Taungkok ,21-Jul-2011)
  Mountain area = 527 mm/day (Hkamti, 29-Jun-1989)

Strong wind: Max. 17 to 20 m/s
Others: Severe thunderstorm occurs at the beginning and end of the season.

Tropical Cyclone/Depression from Bay of Bengal

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			←	←	→				←	→	

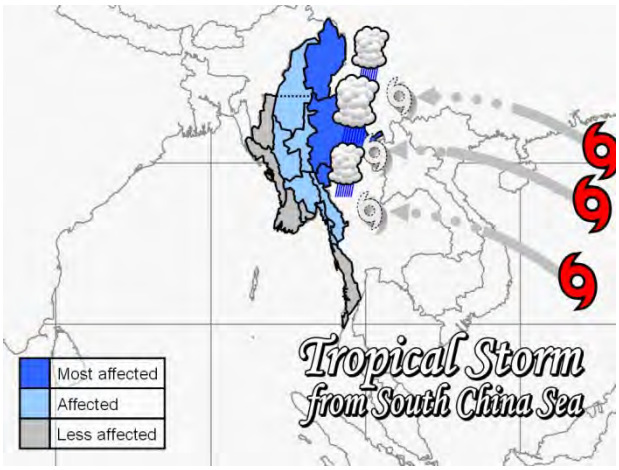


Mechanism:
Tropical Cyclone/Depression (TC/TD) season for Myanmar is nearly the same time as Pre-monsoon and post-monsoon. TC/TD formed over the south central Bay of Bengal tends to approach Myanmar. The most frequent month of TC/TD landfall is May followed by April, October and November. Rainfall can be prolonged and increased due to an intensification of the southwest monsoon after the passing of TC/TD.

Expected Weather:
Strong wind: Max. 34 to 45 m/s with 50 to 65 m/s gust
Heavy rainfall: Max. 250 to 350 mm/day
Kyauk Phyu (Rakhine) = 344 mm/day (23-Oct-2010, Cyclone Giri)
Thaton (Mon) = 256 mm/day (30-Apr-2008, Cyclone Nargis)
Storm surge: 3 to 9 meters is expected if an intense TC passes along low & flat delta area.
Frequency of landfall: Once every 1.5 years
Others: Tornado can occur in low & flat delta area when TC is approaching.

Tropical Cyclone/Depression from South China Sea

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				←	→	←	→	→	→		

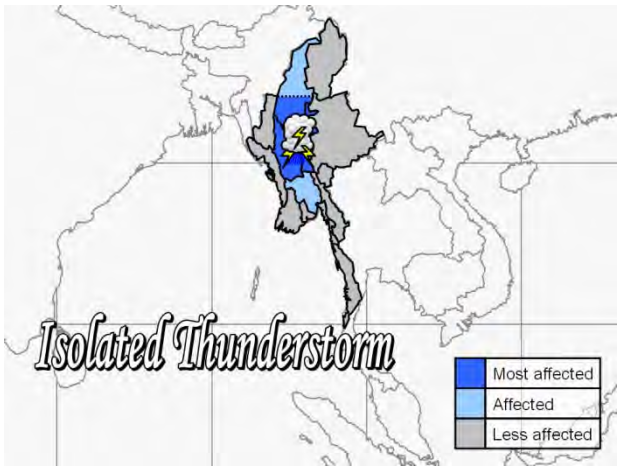


Mechanism:
Tropical Storm over the South China Sea sometimes continues to travel westward after landfall in Vietnam or China, then remnants of the storm bring heavy rain over the eastern area of Myanmar. Duration of rainfall tends to be long because rain starts when the storm is still located in South China Sea. Coupled with the Southwest Monsoon, heavy rain is expected to occur in a wider area.

Expected Weather:
Heavy rainfall: Max. 200 to 250 mm/day
Putao (Kachin) = 245 mm/day (17-Aug-2002)
Bhamo (Kachin) = 229 mm/day (26-Aug-2007)
Frequency: 2 to 3 times/year
Others: Wind speed is below 17 m/s

Thunderstorm

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			←	→					←	→	



Mechanism:

In Myanmar, April and May are the hottest months of the year because of long/intense sunshine and dry ground. Especially in the central area, temperature sometimes exceeds 40 ºC. Due to this, atmospheric stability becomes worse in the afternoon or much worse in case cold air comes into the middle/upper level. In this situation, cumulonimbus clouds are generated in a short time bringing squally weather for a few hours.

Expected Weather:

Heavy rainfall (locally): Max. 200 to 300 mm/day
- Kalewa (Sagain) = 306 mm/day (23-May-1981)
- Meiktila (Mandalay) = 194 mm/day (13-May-1989)

Gusty wind: 20 to 30 m/s

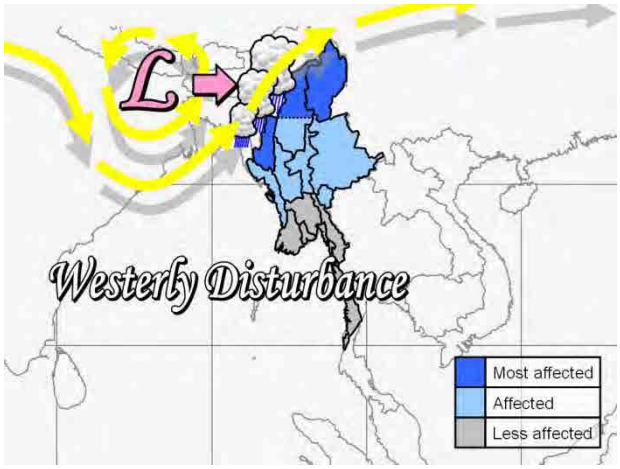
Max. Temp.: 35 to 45 ºC
- Myinmu (Mandalay) = 47.2 ºC (14-May-2011)

Frequency: Almost everyday in the central area

Others: Lightning, downburst and hail also occur under the cumulonimbus cloud.

Western Disturbance (Mid-Latitude-like Upper Level Trough/Low)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		←		→						←	



Mechanism:

During the dry and pre-monsoon season, northern Myanmar is affected by the mid-latitude disturbance called Westerly Disturbance because the mid-latitude westerlies sometimes meanders deeply down southward in the north hemispheric during winter and spring.

Expected Weather:

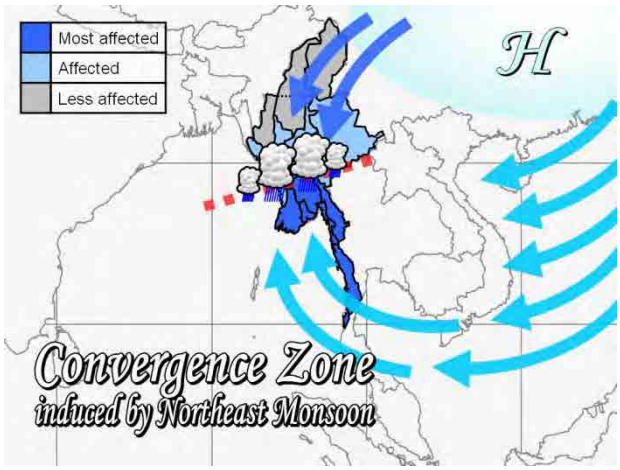
Heavy rainfall: Max. 50 to 100 mm/day
- Kyauk Phyu (Rakhine) = 97mm/day (29-Apr-2012)
- Mandalay = 50mm/day (9-Apr-2012)

Frequency: Once a week

Others: Strong or gusty wind occurs due to cold front passing.

Convergence Zone induced by Northeast Monsoon

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
←	→									←	↔



Mechanism:
In Southeast Asia, the Northeast Monsoon is prevailing in the north hemispheric winter due to a dominant high-pressure system formed over the Asian continent. The easterly dry wind from the High absorbs moisture & heat while traveling over the South China Sea, that is, 'air mass modification.' Between the easterly wet wind and northerly dry wind intruding directly from the High, a Convergence Zone is generated, along which convective clouds are easily developed.

Expected Weather:
Heavy rainfall: Max. 150 mm/day
Kyauk Phyu (Rakhine) = 144mm/day (10-Dec-2010)
Frequency: 3 times/month
Others: Strong or gusty wind occurs.

1-9 Topographic and Geotechnical Surveys

At the proposed Meteorological Radar Observation Station sites (Kyauk Phyu, Yangon and Mandalay), the topographic and geotechnical surveys indicated in the following tables were implemented by a local contractor consigned by the Preparatory Survey Team.

Table 10: Topographic Survey

Required Works	• Position of the existing building, observation facility, observation field • Bearing survey of the magnetic north • Calculation of the area planned
	• Plane surveying (0.5m contour line) - Position of the existing facilities (electrical lines, water lines, telephone lines, sewage, public roads, fences, vegetation, trees: more than 4m height, streetlights, manholes and other features)
	• Longitudinal profile and cross section - Indication of ground level at intervals of 10m - Public roads, ponds, river and each water level - Setting bench marks
Required Products	• Plane surveying map • Longitudinal profile and cross section • AutoCAD data file in CD-ROM

＜Geotechnical Survey＞

Table 11: Geotechnical Survey

Boring (All core boring)	Required number of borings: 3 Maximum depth of borings: 40m (Borings shall be continued to extend to suitable bearing layer for a building construction, even if borings have reached more than a depth of 40m. After reaching the bearing layer, borings shall be continued to a depth of at least 3m.)
Collecting soil samples	• Undisturbed soil sampling: 3 samples (at different level) x 3 holes • Disturbed soil sampling: 3 samples (at different level) x 3 holes • Adoption of standard: ASTM or JGS-Japanese geotechnical society
Standard Penetration Test	At intervals of every 1m till the bottom of each borehole
Laboratory Testing	Density Test of Soil Particle, Particle Size Distribution, Specific Gravity, Water Content , Liquid Limits, Plastic Limits, Unconfined Compression Test and Consolidation Test
Required Products	Geotechnical Survey Report: expected soil bearing capacity and calculation of consolidation coefficient

＜Geotechnical Survey Results＞

Table 12: Geotechnical Survey Result of Kyauk Phyu Meteorological Radar Observation Station

Boring No.	Depth (m)	Soil Type	N Value	RQD (%)	Moisture Content (%)
BH-1	0.0 - 5.0	Silty Sand	50	-	12.66
	5.0 - 10.0	Sand Stone	-	20 - 74	-
BH-2	0.0 - 3.0	Clay	2 - 23	-	26.50
	3.0 - 8.0	Clay	50	-	11.57
	8.0 - 13.0	Clay Shale	-	0 - 100	-
BH-3	0.0 - 1.0	Sandy Clay	50	-	-
	1.0 - 2.0	Clayey Silt	47 - 50		17.82
	2.0 - 7.0	Clay	50	-	14.43
	7.0 - 12.0	Clay Shale	-	25 - 93	-

Table 13: Geotechnical Survey Result of Yangon Meteorological Radar Observation Station

Boring No.	Depth (m)	Soil Type	N Value	Specific Gravity (g/cm^3)	Moisture Content (%)
BH-1	1.0 - 3.0	Sandy Clay	1 - 7	2.65	17.11
	3.0 - 5.0	Clayey Silt	14 - 15	2.71	18.31
	5.0 - 8.0	Clay	10 - 15	2.67	17.57
	8.0 - 10.0	Sandy Clay	7 - 11	2.71	24.08
	10.0 - 32.0	Silty Sand	8 - 21	2.65 - 2.67	22.38 - 24.88
	32.0 - 36.0	Sand	20 - 38	2.66	16.91
	36.0 - 50.0	Clay	22 - 50	2.72	24.23
	50.0 - 53.0	Sandy Clay	47 - 50	-	-
	53.0 - 59.0	Clay	40 - 50	2.72	23.06
BH-2	1.0 - 2.0	Sandy Clay	5	2.65	20.75
	2.0 - 4.0	Clayey Silt	8 - 12	2.66	18.36
	4.0 - 7.0	Clay	6 - 15	2.75	31.28
	7.0 - 9.0	Sandy Clay	5 - 8	2.67	23.67
	9.0 - 31.0	Silty Sand	7 - 29	2.67	16.58 - 20.96
	31.0 - 47.0	Clay	22 - 50	2.65 - 2.73	19.73 - 25.31
	47.0 - 52.0	Sandy Clay	35 - 50	2.77	25.18
	52.0 - 62.0	Clay	28 - 50	2.63	20.45
BH-3	1.0 - 3.0	Sandy Clay	1	2.64	21.75
	3.0 - 6.0	Clayey Silt	7 - 11	2.65	22.92
	6.0 - 12.0	Clay	2 - 9	2.69 - 2.71	33.02 - 45.46
	12.0 - 16.0	Sandy Clay	7 - 14	2.7	17.43
	16.0 - 31.0	Silty Sand	11 - 27	2.66	20.37 - 21.13
	31.0 - 38.0	Clay	25 - 50	2.69	26.03
	38.0 - 41.0	Silty Sand	40 - 50	2.64	13.61
	41.0 - 44.0	Clay	22 - 44	2.64	20.55
	44.0 - 47.0	Sandy Clay	34 - 49	2.64	12.79
	47.0 - 55.0	Clay	35 - 50	2.69	23.55

Table 14: Geotechnical Survey Result of Mandalay Meteorological Radar Observation Station

Boring No.	Depth (m)	Soil Type	N Value	Specific Gravity (g/cm^3)	Moisture Content (%)
BH-1	1.0 - 14.0	Clay	5 - 30	2.65 - 2.72	18.51 - 24.53
	14.0 - 22.0	Clay and Silt	12 - 29	2.71	26.45
	22.0 - 31.0	Silty Sand	27 - 50	2.68	16.67
	31.0 - 35.0	Silt	37 - 50	2.66	20.64
	35.0 - 41.0	Sand	38 - 50	2.67	21.09
	41.0 - 48.0	Silt	29 - 50	2.70	28.79
	48.0 - 52.0	Sand	50	2.68	20.57
BH-2	1.0 - 14.0	Clay	17 - 50	2.67 - 2.71	16.38 - 19.11
	14.0 - 23.0	Clay and Silt	12 - 31	2.70	25.66
	23.0 - 31.0	Silty Sand	23 - 45	2.68	28.61
	31.0 - 36.0	Silt	24 - 50	2.70	15.23
	36.0 - 40.0	Sand	34 - 50	2.69	20.83
	40.0 - 47.0	Silt	30 - 47	2.71	26.98
	47.0 - 51.0	Sand	50	2.68	22.15
BH-3	1.0 - 14.0	Clay	7 - 48	2.72 - 2.72	19.82 - 24.44
	14.0 - 22.0	Clay and Silt	11 - 22	2.71	25.85
	22.0 - 31.0	Silty Sand	16 - 44	2.68 - 2.71	15.91 - 26.31
	31.0 - 35.0	Silt	26 - 36	2.70	18.74
	35.0 - 40.0	Sand	38 - 48	2.68	22.89
	40.0 - 48.0	Silt	31 - 47	2.69	30.13
	48.0 - 52.0	Sand	50	2.68	24.75

1-10 Consideration for Environmental Conservation

The National Commission for Environmental Affairs (NCEA) under the Ministry of Forestry has already submitted the official view, according to the local regulations, to the DMH that the Environmental Impact Assessment (EIA) is not required in order to implement the Project.

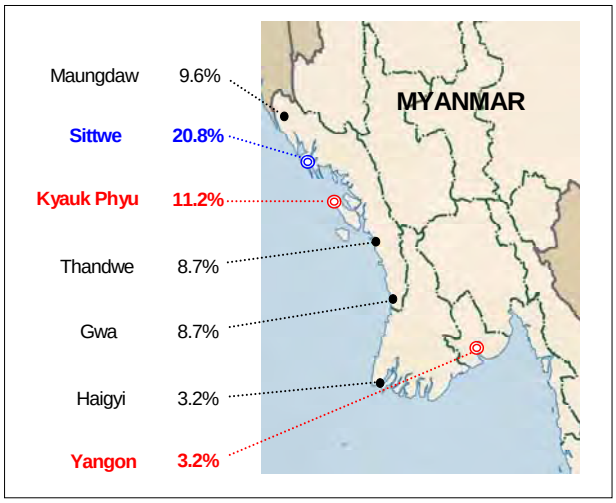
Chapter 2
Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

Myanmar is located in the westernmost part of Indochina along the Bay of Bengal and the Andaman Sea. There are high mountains in the north, eastern, and western area, and many small and large rivers flowing through the whole land of Myanmar. This geographical condition repeatedly causes floods, flash floods, and landslides everywhere whenever heavy rain falls. This is why Myanmar is considered to be a natural disaster-prone country.

One of the meteorological phenomena causing natural disasters in Myanmar is a tropical cyclone generated in the Bay of Bengal. Heavy rains, strong winds and storm surges brought by a tropical cyclone are destructive and have immeasurable adverse impacts. The right figure shows the average rate of cyclone landfall at each point along the Myanmar coast based on the data collected since 1946. According to the figure, Sittwe has the highest rate of cyclone landfall at 20.8% and is followed by Kyauk Phyu (11.2%). The rate of cyclone landfall in the south is relatively low as is the case in Yangon (3.2%). Recently, however, the landfall point of tropical cyclones has shifted to the south just as Cyclone "Nargis" hit the south delta area where the population is concentrated and where economic activities are vigorous.



Source: DMH

Figure 7: Average Rate of Cyclone Landfall along Myanmar Coast

The other meteorological phenomenon affecting Myanmar is the heavy rain created by the southwesterly wind from the Bay of Bengal hitting the mountains, so-called orographic precipitation, during the monsoon period. This heavy rain causes flash floods and landslides in the mountainous area and the massive floods which occur in the river basin of the plains or coastal areas.

In recent years, there is global concern that the intensity of tropical cyclone and the number of heavy rains will increase due to abnormal climate change brought about by global warming and, consequently, an increase in the intensity of the meteorological disasters. Myanmar is no exception. In order for Myanmar to contribute to the alleviation of the adverse effects of natural disasters in the Bay of Bengal, (1) the strengthening of the meteorological observation, communication, and forecasting/warning system (through monitoring with meteorological radar system) and (2) the reinforcement of the cooperation with

other countries in the Bay of Bengal (through the exchange of meteorological observation data and information about cyclones on a timely basis) are the most important and urgent tasks.

Under these circumstances, it is imperative that the meteorological radar system of Myanmar, which played the most important role in monitoring tropical cyclones generated in the Bay of Bengal and which completely stopped in 2004 due to aging deterioration, be restored. As more and more tropical cyclones have attacked Myanmar, especially the south delta area where the population and economic activities are concentrated, a key objective of the Project, therefore, is the effective mitigation of the adverse effects of natural disasters caused by tropical cyclones, heavy rain, etc. To achieve this objective, the implementation of personnel training in addition to the installation of a Meteorological Doppler Radar System, Meteorological Radar Data Display System and Meteorological Data Communication System are absolutely essential. These will largely enhance the capability to monitor hazardous meteorological phenomena such as tropical cyclones and heavy rain and will improve the forecasting/warning systems in Myanmar as well as create a positive spill-over effect on the neighboring countries in the Bay of Bengal.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Design Policy of the Project

a) To design a meteorological observation system which can contribute to disaster prevention for Myanmar and the neighboring countries along the Bay of Bengal.
b) To enable the DMH to provide the necessary weather information, forecasts, advisories and warnings to ensure the protection of people’s lives and properties from natural disasters and the improvement of socio-economic conditions in Myanmar.
c) To enable the DMH to monitor weather conditions around-the-clock on a real time basis.
d) To enable the DMH to promptly issue a weather information and/or a warning to the public.
e) To ensure the improvement of the DMH's overall function and capacity in reducing human loss and economic setback brought about by meteorological disasters through the upgrading of the DMH's monitoring capabilities of meteorological phenomena including tropical cyclones.
f) To determine and set up the size and components of the Project to match with the technical, operational and maintenance capabilities of the DMH.

[1] Design Policy of the Equipment

a) To design the equipment so that the meteorological radar system assumes a significant role in the

Tropical Cyclone Detecting Network of the Bay of Bengal.

b) To ensure that the equipment is compatible with and meets the technical requirements of the World Meteorological Organization (WMO).

c) To ensure that the equipment is suitable for the routine observation and forecasting work of the DMH.

d) To design the system in such a way that the radar system with functions relevant to quantitative rainfall observation and air-turbulence observation capabilities that enhances and upgrades the accuracy of the weather forecasts made by the DMH.

e) To design the radar system to acquire constant altitude information from 3-dimensional raw data obtained from scans of the radar system at multiple elevations to ensure wider coverage and detection of rainfall distribution at each altitude.

f) To design that all of the meteorological radar data produced are delivered to the DMH Head Office every 15 minutes by high-speed satellite communication to enable the timely dissemination of tropical cyclone forecasts.

g) To design the equipment so that the pictures taken by the radar systems are sent to/ ingested by Bangladesh Meteorological Department and also to ensure that the pictures taken by Bangladesh Meteorological Department's existing radar system are ingested by the DMH.

h) To design the system in such a way that it is within the DMH's capability to operate, maintain and repair.

i) To select equipment for which spare parts and consumables can be easily procured and replaced.

j) To select reliable and durable equipment suitable for the local environment.

k) To minimize the recurrent costs of the DMH for the operation, maintenance and repair of the equipment.

l) To ensure the accuracy of radar data through meticulous adjustment and proper calibration.

m) To design the equipment in such a way so as to minimize lightning damage.

n) To design the equipment to operate using 440V 3-Phase 4-Wire ±20%, 50Hz power.

[2] Design Policy of the Radar Tower Building

The primary design policy is to construct a meteorological radar tower building that will ensure appropriate and effective operations and will accommodate the required systems, equipment and personnel. It is a basic policy that the designed Radar Tower Building satisfies the following requirements:

a) To ensure as much as possible that the height of the radar tower building is free from obstructions (e.g. surrounding mountains, existing facilities) to avoid blind areas during radar observations.

b) To select the most suitable foundation structures to ensure that the permissible horizontal deflection of the proposed radar tower buildings is not more than 0.075 degrees.

c) To adopt the basic wind speed (Kyauk Phyu 140miles/hour (62.6m/sec.), Yangon: 120miles/hour (53.7m/sec.), Mandalay: 100 miles/hour (44.7m/sec.)).
d) To ensure that the working environment for the DMH's 24-hour/day work schedule of observations is conducive to ensuring effective and efficient performance.
e) To have the necessary power supply back-up equipment (diesel generator, radar power backup unit, auto voltage regulator, etc.) for performing around-the-clock meteorological services every day all throughout the year (24 hours a day, 365 days a year).
f) To be sufficiently robust enough to withstand extreme weather and ensure uninterrupted radar observations and the continuous provision of weather forecast & warnings to the public, even in the event of a cyclone attack.
g) To make use of local building materials for the easy maintenance of the radar tower building by the DMH.
h) To design the equipment in such a way so as to minimize lightning damage.

(2) Design Policy on Environmental Conditions

1) Temperature/Humidity

Air-conditioning systems are required for rooms where the equipment is to be installed since Myanmar has a hot and humid climate throughout the year.

2) Rainfall

The meteorological data should be transmitted and received even when tropical cyclones hit Myanmar. A maintenance stair-case is located at the center of the building, covered by an upper concrete slab, to enable the DMH personnel to easily access each room for the regular maintenance of the radar equipment without getting wet during rainy season.

3) Lightning

Lightning may cause a serious damage to each system. A lightning protector is, therefore, planned to be installed to prevent damage to the building and equipment.

4) Wind

For calculating the wind load of the proposed Radar Tower Buildings, the basic wind speed (Kyauk Phyu 140miles/hour: 62.6m/sec., Yangon 120miles/hour: 53.7m/sec., Mandalay 100miles/hour: 44.7m/sec.) to be applied by the Myanmar Engineering Society will be utilized.

5) Earthquake

Currently the Myanmar Engineering Society has been preparing the seismic zone factors in Myanmar

according to the Uniform Building Code 97, USA. Therefore, for the calculation of the seismic load, the seismic zone factors (Kyauk Phyu: Zone 2B, Yangon: Zone 2B, Mandalay: Zone 4) matched with the Uniform Building Code 97 will be applied. The seismic base shear: C0 = 0.1 and the importance factor (I) = 1.25 will be used since the importance of the radar tower buildings is considered.

6) Load Bearing Layer

The structural design of the radar tower building is implemented according to the result of the geotechnical survey by a local contractor consigned by the Preparatory Survey Team. Foundation type of the radar tower buildings are as follows:

Table 15: Foundation Type of the Proposed Radar Tower Building

	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Nay Pyi Taw Meteorological Radar Observation Station
Foundation type	Spread foundation	Pile foundation (cast in site concrete)	Pile foundation (cast in site concrete)

(3) Design Policy for Construction Work

1) Environmental Regulation

Waste water discharged from the radar tower building must undergo initial treatment before filtering the treatment into the soil at each site.

2) Use of Locally Procurable Materials

Most of the construction materials can be procured in the local market. For the Project, durable maintenance materials not containing asbestos will be selected from locally available materials.

3) Use of Local Construction Methods and Local Workers

Laborers are classified according to their skills (i.e. as carpenters, plasterers, steel fitters, etc.) and skill level is variable in Myanmar. In order to utilize local laborers as much as possible, reinforced concrete structure which local workers are familiar with, will be used.

(4) Policy for Use of Local Construction Companies

1) Construction Work of the Radar Tower Buildings

In general, the technical skills and competence level of the major local construction companies in Myanmar are adequate. Thus, they will be used in the construction of the radar tower building.

2) Equipment Installation Work

Under the supervision of a Japanese engineer, a local electrical work contractor will be hired during the installation work of the equipment.

(5) Design Considerations to Simplify Operation and Maintenance for the DMH

1) User-friendly equipment

The equipment to be supplied under the Project is to be used to support the DMH's routine work as the national meteorological agency for meteorological disaster prevention. A variety of data processing, analysis, display and communications capabilities must be readily available for the DMH, using simple operational procedures.

2) Easy maintenance and affordable recurrent costs of the equipment

The equipment must be designed in such a way so as to minimize the spare parts and consumables required and to simplify regular maintenance. Replacement parts must be quickly and readily available. The expected biggest recurrent cost of the Project is electricity so, therefore, the equipment and facility should be designed in such a way so as to minimize power consumption.

3) Consideration of minimizing operation & maintenance costs

In order for the DMH to meet the increased operational and maintenance costs of the system, the following measures have been included in the plan for the equipment and radar tower buildings:

- The ability to restrict the operation of air-conditioning systems and electricity supply in the operational rooms only within the radar tower buildings
- The utilization of natural light to reduce energy requirements by minimizing the hours of artificial lighting required.
- Usage of LED for artificial lightning
- Incorporation of solid-state parts into the radar system to reduce the cost and frequency of parts replacement.

(6) Design Policy for Equipment & Building Grade

To ensure the uninterrupted dissemination of forecasts and warnings to the public, even during tropical cyclone attacks, the equipment and buildings must be sufficiently robust enough to withstand tropical cyclones, local severe storms and lightning strikes to enable the provision of meteorological services 24 hours per day.

(7) Design Policy regarding Construction/Procurement Method and Schedule

The equipment for the Project must be durable, reliable, of high technical level, and cost effective. Though some of the equipment to be installed in the radar tower building, such as the specialized power backup systems and meteorological equipment, is not available in the local market, locally procurable materials and local construction methods must be used in the building design. The pulse compression solid state Doppler radar system which has already been put into practical use for meteorological observation and has confirmed its reliability, durability, accuracy and performance is only available and made in Japan.

2-2-2 Basic Plan

The finalized components in the basic design for the Project are as follows.

Table 16: Object Items of the Preparatory Survey

Component	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Mandalay Meteorological Radar Observation Station	Yangon International Airport	Automatic Weather Observation Stations
Procurement and Installation of Equipment						
S-Band Doppler Pulse Compression Solid State Radar System including Power Back-up System, Lightning System, Measuring Equipment and Spare Parts	-	1	1	1	-	-
Meteorological Rader Data Display System including Software	1	1	1	1	5	-
Meteorological Data Satellite Communication System (VSAT)	1	1	1	1	-	-
Meteorological Data Communication System	-	-	1	-	1	-
Automatic Weather Observation System	1 (Meteorological Data Management Unit)	-	1 (Meteorological Data Management Unit)	-	-	30
Construction of Radar Tower Building						
Construction of New Radar Tower Building	-	1	1	1	-	
Soft Component	1					

According to the design policies aforementioned, the basic design plan of the Equipment and the Radar Tower Building are clarified below.

(1) Equipment Plan

1) Meteorological Radar System

A meteorological radar system is the only system able to observe, in real time, the occurrence, movement, distribution and intensity of rainfall, and of the meteorological phenomena related to rainfall, as well as provide quantitative measurements over a large area, in real time. The requested meteorological radar systems are S band. As S band radar system is the most suitable type of radar

system for the observation of precipitation over a very wide area. It has several important characteristics, including lower attenuation by rain and the atmosphere than other types of radar, and the ability to transmit at high power, providing a “long range”, “real time” system. For these reasons, it has been selected as the most suitable system to monitor large-scale and distant phenomena such as tropical cyclones. In addition, the S band radar system must be a Doppler system with a changeable function accurately having quantitative rainfall observation and air-turbulence observation capability for monitoring rapidly changing weather conditions (air-turbulence, storm wind of tropical cyclone, storm, tornado) in real time.

2,796MHz of the existing Kyauk Phyu Meteorological Radar System (as the center frequency) ±5MHz frequency band will be used for the proposed Doppler radar systems supplied under the Project. Technical features of the S band meteorological Doppler radar system are as follows.

Table 17: Major Features of Meteorological Radar System

Major Features	Proposed Radar System
Frequency	2.7-2.9GHz
Frequency Band Width	10MHz (Center Frequency ±5MHz)
Wavelength	Approx. 10cm
Detectable Maximum Range of Precipitation Intensity 1mm/h or more	450km
Detectable Maximum Range of Wind Velocity	200km
Data Grid	0.625km
Observable Maximum Wind	More than 70m/s
Transmission Power	10kW (Peak Value)
Doppler Function	Available
Accumulated Rainfall	Available
Rainfall Data	0-250mm/h rainfall intensity quantitative data

In order to accomplish the project targets, the proposed radar system must meet the following requirements.

[1] Doppler Mode

The meteorological radar system is designed to work in Doppler mode, which detects the wind motion and wind patterns of severe weather phenomena such as tropical cyclones, local severe storms and tornadoes within a 200km radius. This will help the DMH to monitor the movement and development of severe weather systems in preparation for a more accurate and timely weather forecast and warning. The Doppler mode is essential to allow for more accurate forecasting and longer forecast prediction times.

[2] CAPPI (Constant Altitude PPI (Plan Position Indicator)) Mode

CAPPI is a horizontal cross-section display at an altitude which can be specified by the user. It is derived from the interpolation of volumetric data. Data from all azimuth and elevation points are used in the calculation of precipitation intensity in order to generate the display for a specified altitude. The

product displays constant altitude information from 3-dimensional raw data obtained from scans at multiple elevations. To acquire 3 dimensional data, the radar antenna can operate in "volumetric scan" mode, changing the antenna elevation at regular time intervals. For the estimation of rainfall from a convective system and the preparation of composite pictures using multiple radar systems, accurate observed data, especially CAPPI data at an altitude of 2km or 3km, is required. An automatic multi-level CAPPI function will be provided with the proposed radar systems.

[3] Required Radar Display and Output Information Functions

The following functionality must be provided by the meteorological Doppler radar system to enable the DMH to accomplish its role as a national meteorological service.

Table 18: Required Radar Display and Output Information Functions

	Radar Display and Output Information Functions	Purpose of Observation/Utilization
1	PPI Display (Intensity, Doppler Velocity, Velocity Width)	Rainfall
2	RHI Display (Intensity)	
3	Cyclone Eyes Location Manual Data Input and Cyclone Track Display	
4	Identified Heavy Rainfall Level Display	
5	Accumulated Rainfall (1H, 2H, 3H, 6H, 12H, 24H)	
6	Z-R Parameter Registration	
7	Dissemination of Accumulated Rainfall Data	
8	Specific District Rainfall Amount Display	
9	Surface Rain Display	
10	Range Time Indicator	
11	Composite Picture Display	
12	Wind Velocity and Direction	Wind Velocity and Direction
13	Wind Profile of Upper Layer	
14	Wind Shear Information Display	
15	Overlay Display of Plural Products	
16	Specific District Strong Wind Display	
17	CAPPI Display	3-dimensional
18	Echo Height Display	
19	Vertically Integrated Liquid	
20	Maximum Rainfall Display	
21	3-dimensional Data Display	
22	Cross Section	
23	Radar Control and Monitoring	Radar Control and Monitoring
24	Observation Scheduling	
25	Stored Data Listing on Each External Storages	Storing and Retrieving
26	Storing To External Storages	
27	Retrieved Data Listing From External Storages	
28	Various Weather Products Retrieving from External Storages	
29	Data Receiving	Display, Data Input and Output
30	JPG Image Output	
31	Multi-Window Display	
32	Map Overlay Feature	
33	Information of Pointed Locations (Location, Numerical Radar Echo Value, Distance of Specified Span)	
34	Zooming Display (2 Times or 4 Times Selectable)	
35	Animation	
36	Map Edit	
37	Product Output to Web (GIF Animation Format)	Web
38	Radar Images to Internet Server at Http Style	
39	Login From Internet Browser and Download	

Figure of the “Composite Picture of the Proposed Meteorological Radar Observation Network in Myanmar” after completion of the Project are attached hereunder.

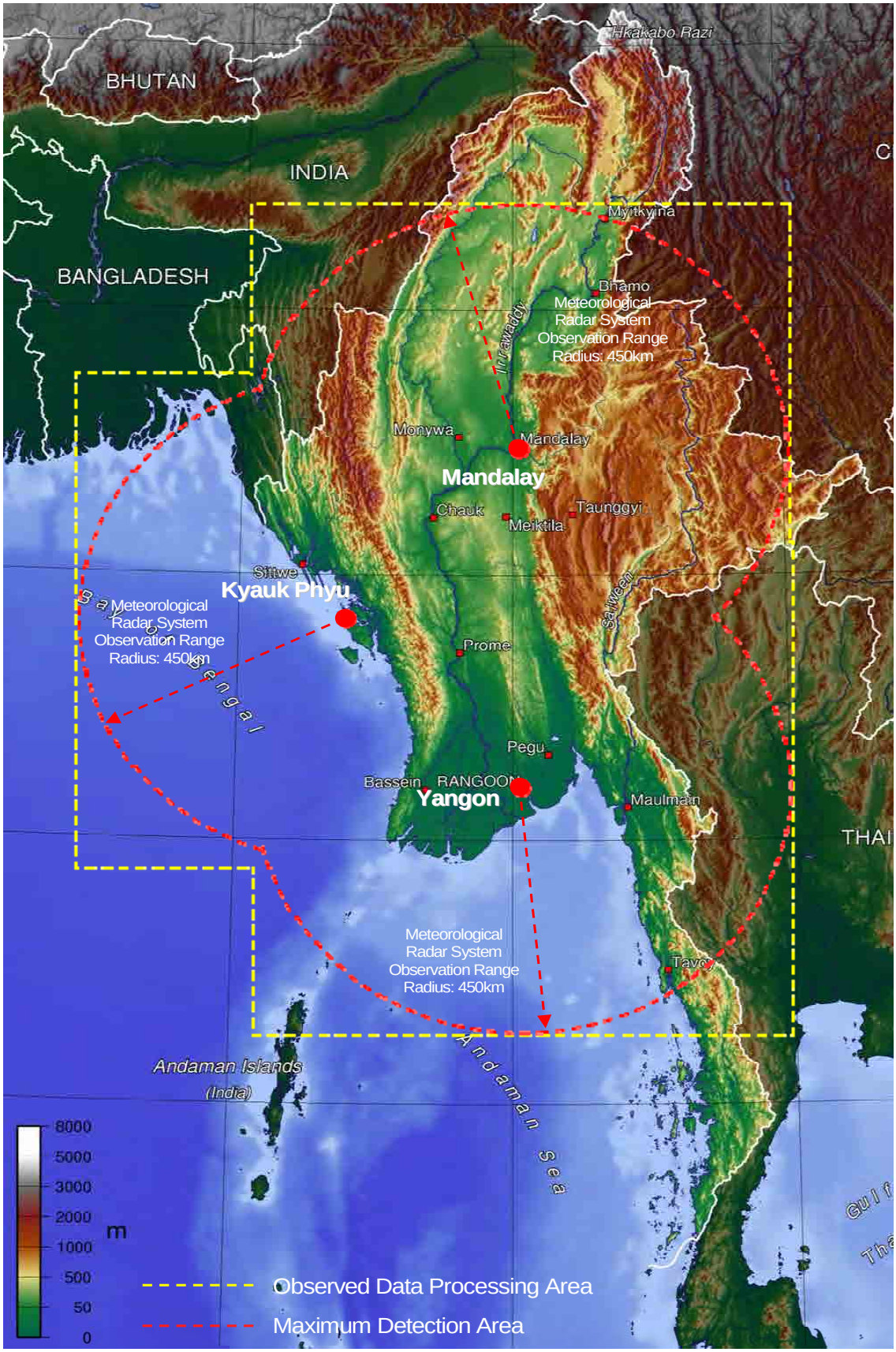


Figure 8: Composite Picture of the Proposed Meteorological Radar Observation Network in Myanmar

2) Meteorological Radar Data Display System

A meteorological radar data display system must have the ability to receive and display all meteorological products in real time because the DMH's forecasters must obtain the meteorological radar data in real time for routine weather forecasting & warning. In addition, the DMH's forecasters are required to do a substantial amount of work in a short period of time so the meteorological radar data display systems are to be installed in the DMH Multi-Hazard Early Warning Center in Nay Pyi Taw, the proposed Radar Tower Buildings and the Yangon International Airport (Airport Meteorological Office, Area Control Center and Air Traffic Control Room) so that they do not need to leave the area. Displays of the system must have minimized heat production for effective room cooling, are of the power-saving type and have less screen reflections for a smoother and long time operation. The meteorological radar data display system will be designed to store data file of the radar pictures as binary data of hourly accumulated precipitation data of 2.5 km mesh.

3) Meteorological Data Satellite Communication System (VSAT)

In order to improve the tropical cyclone monitoring and forecasting work and to enable the timely dissemination of products, all of the meteorological radar data produced by the proposed Kyauk Phyu, Yangon and Mandalay Meteorological Radar Systems must be delivered to the DMH Multi-Hazard Early Warning Center in Nay Pyi Taw, every 15 minutes in view of CAPPI mode observation. The required data transmission speed is 32kbps or more between Kyauk Phyu, Yangon and Mandalay Meteorological Radar Systems and the DMH Multi-Hazard Early Warning Center. To facilitate this, a data acquisition system is required, employing the most suitable band for high-speed satellite communication links using C-band, because of its low attenuation by rain.

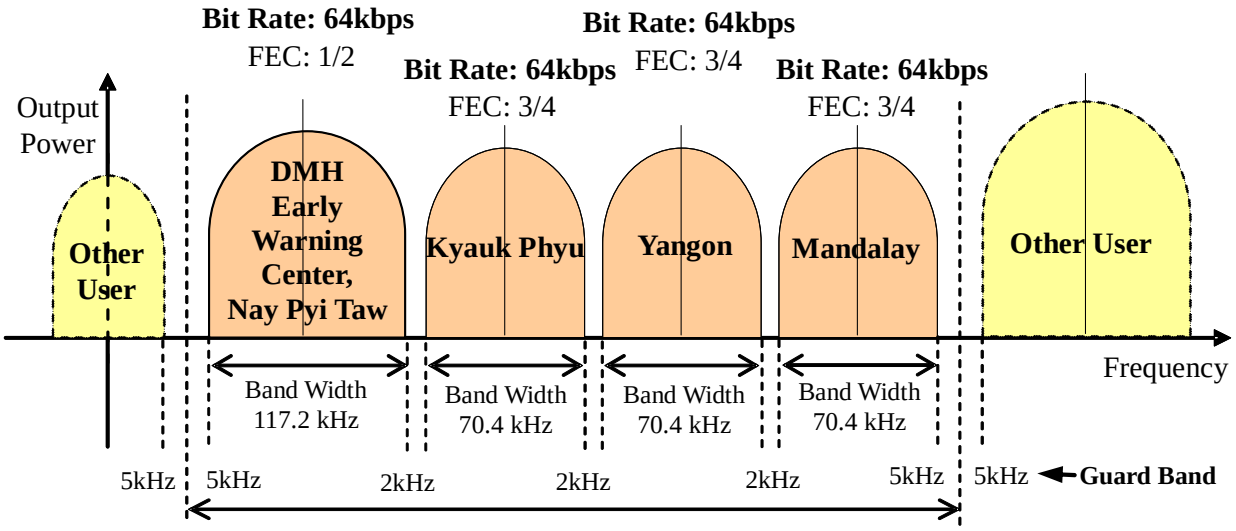


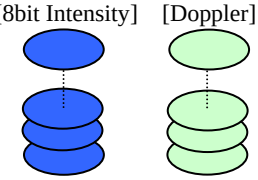
Figure 9: Estimation of Minimum Required Space Segment

The required transmission time for the radar products to be transmitted by the Meteorological Data Satellite Communication System (VSAT) from Kyauk Phyu, Yangon and Mandalay Meteorological Radar Systems to the DMH Multi-Hazard Early Warning Center is indicated in the following tables.

Table 19: Required Transmission Time
at Transmission Speed 64kbps (Effective Speed: more than 32kbps)

Meteorological Radar Data	Data Transmission Time to DMH Multi-Hazard Early Warning Center	Total	Required Time
Intensity RAW Data and Doppler RAW Data for a Fixed Elevation Angle (120kBytes)	0.6min	⇒ 13.4min	⇒ **15min**
Intensity RAW Data and Doppler RAW Data for 10 elevation Angle (2.4MBytes)	12.8min		

Table 20: Data Volume and Products of the Proposed Meteorological Radar System

Descriptions of Data	Data Volume of Single Observation	Radar Display
1 Elevation Angle: Long Pulse Observation (450km radius) Intensity RAW Data [8bit Intensity] 	・Polar coordinate format ・320range×360 angle ・8bit data (Intensity) **Total:120kbytes**	<Radar Products> ・PPI/RHI Display ・Cyclone Tracking Indication and Forecast ・Heavy Rainfall Warning Output ・N-hour Accumulated Rainfall ・Composite Display ・Catchment Area Rainfall Amount Display
10 Elevation Angles: Short Pulse Observation (200km radius) Intensity RAW Data and Doppler RAW Data [8bit Intensity] [Doppler] 	・Polar coordinate format ・320range×360 angle ・ 8bit data (Intensity /Doppler) ・10 elevation angle **Total: 2.4Mbytes**	<Radar Products indicated above + below> ・CAPPI Display ・Echo Top Display ・Vertical Cross Section ・Surface Rain Indication ・Vertical Integrated Liquidation ・3-Dimensional Data Display ・Wind Velocity and Direction ・Wind Profile of the Upper Layer ・Wind Shear Alert

For transmitting all the meteorological radar data from Kyauk Phyu, Yangon and Mandalay Meteorological Radar Systems to the DMH Multi-Hazard Early Warning Center, the transponder to be selected for the Programme must satisfy the following requirements.

- ✧ Geographic Coverage : Southeast Asia area including Myanmar
- ✧ Satellite Beam : C band beam
- ✧ Frequency (C band) : Up Link: 5,850MHz – 6,425MHz
  Down Link: 3,625MHz - 4,200MHz
- ✧ Polarizations : Orthogonal Linear
- ✧ Satellite EIRP : more than 40 [dBW]
- ✧ Satellite G/T : more than 0 [dB/K]
- ✧ Satellite SFD : less than -92 [dBW/m2]
- ✧ Satellite Orbital Slot : 76°E - 140°E

<EIPR>
Effective Isotropic Radiated Power – This term describes the strength of the signal leaving the satellite antenna or the transmitting earth station antenna, i.e., final amplifier output power + antenna gain in dB. The unit dBW is the logarithmic expression of Power in Watt.

<G/T>
G/T is called “Figure of merit” and represents the receive system performance. G/T is the ratio of the receive antenna gain and the system thermal noise including the antenna noise.

<SFD – Saturation Flux Density>
This means the flux density at the satellite receive antenna required to saturate a satellite transponder.

4) Meteorological Data Communication System

Scan Test and Diagnostic Test of Wireless LAN (2.4GHz、4.9GHz、5.6GHz) have been conducted between Yangon DMH Compound and the Air Traffic Control Tower in the Yangon International Airport (direct distance: approx. 5km). The test results are indicated below.

Table 21: Results of the Occupied Channel Scanning Test (as of Aug. 2012)

Project Site	Occupied Channel																							
	2.4GHz Band													4.9GHz Band										5.6GHz Band
														20mW System				10mW System						
																		H						
	1	2	3	4	5	6	7	8	9	10	11	12	13	184	188	192	196	183	184	185	187	188	189	
Yangon DMH Compound																								Unusable due to a long distance transmission
Yangon International Airport																								

: Occupied channel

As indicated in the table above, almost all the 2.4GHz Band channels have already been occupied. Therefore, the 2.4GHz Band is unusable or, at least, inadequate in this case. In addition, considering the attenuation of transmission/receiving signal due to heavy rain, the 5GHz Band is also unsuitable for a long distance communication. As a consequence of the technical study indicated above, it has been decided that a 4.9GHz Band will be used. This type of band channel is effective for avoiding frequency interference with any other communication equipment in the future and the Equivalent Isotropically Radiated Power (EIRP = Transmission Power + Antenna Gain) is bigger than the 5GHz Band which will, in turn, reduce signal attenuation. Given the above, a 4.9GHz Band high-speed communication link (Orthogonal Frequency Division Multiplexing: OFDM) should be used to transmit the continuous observed data of the Meteorological Radar Observation System in the DMH Yangon to the Air Traffic Control Tower in the Yangon International Airport.

Table 22: Features of 4.9GHz Band OFDM Transmission System

Items	4.9GHz Band OFDM Radio Communication Link
Frequency	4.9GHz Band (4,915-4,980MHz)
Data Transmission Rate (Max.)	54Mbps (20MHz system)
Transmission Power	+15dBm (20MHz System: 2mW/MHz, 10MHz System: 4mW/MHz)
Power Consumption	Not more than 5W
Communication Fee	Free
Reliability and Durability	High
Maintainability	Easy
Maintenance Cost	Low

The OFDM transmission system of the 4.9GHz Band has the following advantages.

- Very high data communication speed.
- The specifications and modulation standard of an OFDM radio communication equipment is based on the International Standard IEEE802.11j (IEEE: the Institute of Electrical and Electronic Engineers under the International Telecommunication Union, ITU).
- The system has a 10Base-T/100Base-T Ethernet Interface (IEEE802.3/IEEE802.3u) and runs the TCP/IP protocol for easy networking and expandability. It also allows the unification of all digital equipment signal interfaces.
- The system has a two-way communication function for data collection and remote control & monitoring of the system.
- Deploying a microwave system allows the use of a high gain antenna which is smaller and lighter than an ordinary yagi antenna.
- Attenuation of the radio signal by rain is 0.3dB per 1 km for rainfall rates of more than 100mm/h rain (that is, there is virtually no attenuation by rain).
- The system has security based on the IEEE802.11 standard; the Wi-Fi Protected Access (WPA), Wired Equivalent Privacy Algorithm (WEP), using Media Access Control ID (MAC) address and Set (ESS-ID).

5) Automatic Weather Observation System (Operating Electric Power: Solar Energy (Solar Panel))

As indicated in the following table, observed data transmission methods and routes for the Automatic Weather Observation System (AWS) are as follows.

Table 23: Observed Data Transmission Method and Route for AWS

Surface Observation		Data Transmission Method		DMH Multi-Hazard Early Warning Center, Nay Pyi Taw		Data Transmission Method		DMH Yangon
Automatic Weather Observation System (AWS)	⇒	GSM/GPRS quad band Modem (Mobile Telecommunication Network)	⇒	Automatic Weather Observation System Data Acquisition Unit-1	⇒	Meteorological Data Satellite Communication System (VSAT)	⇒	Automatic Weather Observation System Data Acquisition Unit-2 (Mirroring)

As indicated in the following table, the required observation sensors and the outputs of the Automatic Weather Observation System (AWS) are as follows.

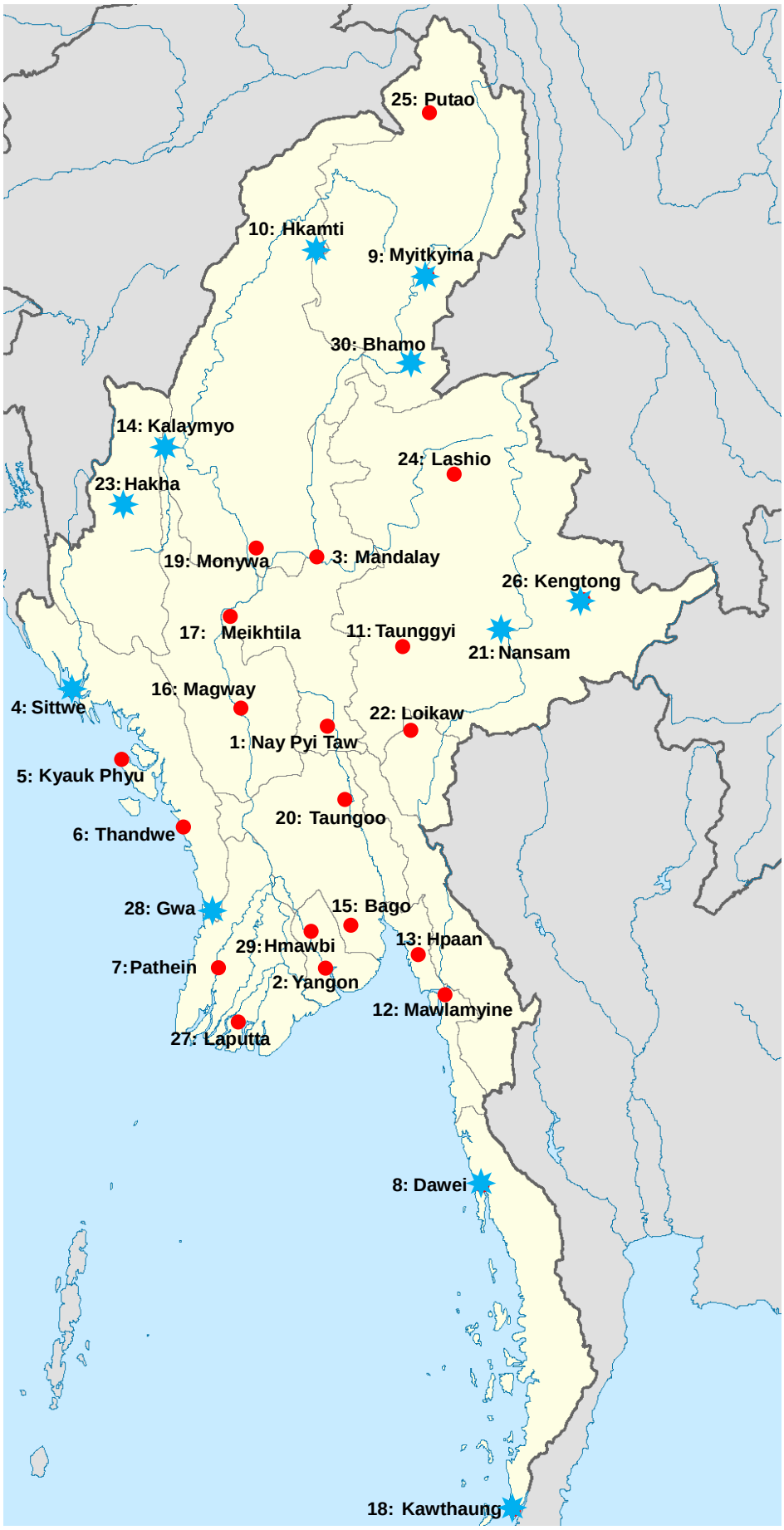
Table 24: Observation Elements and Outputs of AWS

Observation Element	Output	
Wind Speed & Direction	Wind Speed and Direction Sensor	Instantaneous value (1 minute average as per WMO) 2 minute speed and direction average 10 minute speed and direction average Minimum and maximum daily wind speed instantaneous values
Temperature	Temperature Sensor	Instantaneous value (1 minute average as per WMO)

		• Dew point (calculated from most recent "instantaneous" value for temperature and humidity) • Minimum and maximum daily instantaneous values
Humidity	Humidity Sensor	• Instantaneous humidity value (1 minute average as per WMO) • Minimum and maximum daily instantaneous values
Pressure	Barometer	• Instantaneous averaged value (1 minute average as per WMO): averaged across all 3 sensors • Pressure adjusted for mean sea level • Minimum and maximum daily instantaneous values
Precipitation	Rain Gauge	• Latest measured value (Typically total for the last hour) • Daily total
Sunshine Duration	Sunshine Duration Sensor	• Latest measured value (total minutes of sunshine since last measurement) • Daily total

Note:

- According to the WMO the Instantaneous value should actually be a short term average as per *Manual 8: Guide to Meteorological Instruments and Methods of Observation.*
- Instantaneous: in order to exclude the natural small-scale variability and the noise, an average value over a period of 1 min is considered as a minimum and most suitable.



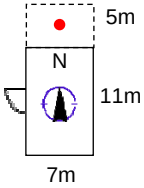
Legend

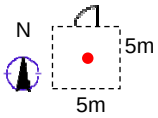
● (19 sites)
Site Survey implemented by JICA Study Team

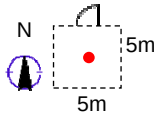
✸ (11 sites)
Site Survey implemented by DMH

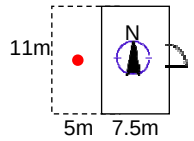
Figure 10: Map of Automatic Weather Observation System (AWS) Network

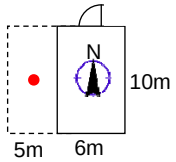
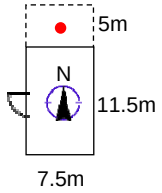
Table 25: Automatic Weather Observation System (AWS) Site Information

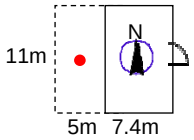
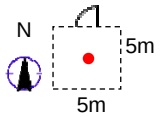
Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
1	Nay Pyi Taw	-	Lat: N 19º 46' 45.5" Long: E 96 º 08' 14.5" Altitude: 157m	Office No.5, Dept. of Met. Hydro., Ministry of Transport, Nay Pyi Taw	SMS Text : OK			Surrounding Environment: No problem for the Observation
2	Yangon	48097	Lat: N 16 º 51' 52.6" Long: E 96 º 09' 14.7" Altitude: 30m	DMH, Kaba-Aye Pagoda Road, Mayangon 11061, Yangon	SMS Text : OK			Surrounding Environment: No problem for the Observation
3	Mandalay	48042	Lat: N 21° 56' 31.4" Long: E 96° 05' 19.0" Altitude: 79m	Director Office, Upper Myanmar, 28 street between 70/71 st., Park Kone Compaund, Chan Aye Tharzan Township, Mandalay Region	SMS Text : OK			Surrounding Environment: No problem for the Observation Fence extension is required 
4	Sittwe	48062	Lat: N 20º 08' Long: E 93º 52' Altitude: 5m	State Office, Dept. of Met. Hydro., Ye Neve Su Ward, Sittwe, Rakhine State	SMS Text : OK			Surrounding Environment: No problem for the Observation

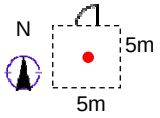
Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
5	Kyauk Phyu	48071	Lat: N 19° 25’ 54.4” Long: E 93° 32’ 10.7” Altitude: 18m	Met. Office, Dept. of Met. & Hydro., Ah Soe Ya Ward, Airport Road, Kyauk Phyu, , Rakhine State	SMS Text : OK			Surrounding Environment: No problem for the Observation
6	Thandwe	48080	Lat: N 18º 27’ 50.1” Long: E 94º 22’ 03.1” Altitude: 7m	Met. Office, Swe Sam Taw Pagoda Road, No (4) Ward, Thandwe, Rakhine State	SMS Text : OK			Surrounding Environment: No problem for the Observation
7	Pathein	48094	Lat: N 16º 47’ 31.1” Long: E 94º 44’ 59.0” Altitude: 14m	Regional Office, Dept. of Met. Hydro., Kan Thone Sint Ward, Mahabandula st., Pathein, Ayeyarwady Region	SMS Text : OK			Surrounding Environment: No problem for the Observation A new fence is required for protecting AWS to be installed 
8	Dawei	48108	Lat: N 14º 06’ Long: E 98º 13’ Altitude: 16m	Regional Office, Airport Road, Yan Taw Wa Ward, Dawei, Tanintharyi Region	SMS Text : OK			Surrounding Environment: No problem for the Observation

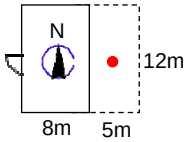
Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
9	Myitkyina	48008	Lat: N 25 º 22’ Long: E 97 º 24’ Altitude: 145 m	State Office, Xso(1), Yan Kyi Aung Ward, Dept. of Met. Hydro., Myktkyina, Kachin State	SMS Text : OK			Surrounding Environment: No problem for the Observation
10	Hkamty	48004	Lat: N 26º 00’ Long: E 95º 42’ Altitude: 142m	Office of Met. & Hydro., Near Hospital, Zee Phyu Kone Ward, Hkamti, Sagaing Region	SMS Text : OK			A new fence is required for protecting AWS to be installed 
11	Taunggyi	48052	Lat: N 20º 46’ 06.9” Long: E 97º 02’ 03.0” Altitude: 1466m	State Office, Dept. of Met. Hydro., War Pyat street, Taunggyi, Shan State	SMS Text : OK			Surrounding Environment: No problem for the Observation
12	Mawlamyine	48103	Lat: N 16º 26’ 28.6” Long: E 97º 39’22.6” Altitude: 21m	State office, Dept. of Met. Hydro., Taungwine st. Zaycho ward, Mawlamyine, Mon State	SMS Text : OK			Surrounding Environment: No problem for the Observation

Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
13	Hpaan	48099	Lat: N 16º 53’ 06.9” Long: E 97º 37’ 51.4” Altitude: 9m	State Office, Dept. of Met. Hydro., Daw Na Road, No. (3) ward, Hpaan, Kayin State	SMS Text : OK			Surrounding Environment: No problem for the Observation
14	Kalaymyo	48024	Lat: N 23º 12’ Long: E 94º 04’ Altitude: 152m	Met. Office, Mingalar Garden Ward, Kalaumyo, Sagaing Region	SMS Text : OK			Surrounding Environment: No problem for the Observation
15	Bago	48093	Lat: N 17º 20’ 14.0” Long: E 96º 29’ 04.0” Altitude: 22m	No. (50), Kaba-aye Pagoda Road, Dept. of Met. Hydro., Mayangone Township, Yangon Region	SMS Text : OK			Surrounding Environment: No problem for the Observation
16	Magway	48065	Lat: N 20° 08’ 21.8” Long: E 94° 55’ 30.0” Altitude: 91m	Regional Office, Dept. of Met. Hydro., Tha Ha Ya Road, Oo Kaw Min Ward, Magway , Magway Region	SMS Text : OK			Surrounding Environment: No problem for the Observation Fence extension is required 

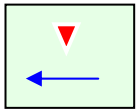
Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
17	Meikhtila	48053	Lat: N 20° 53' 05.26" Long: E 95° 53' 29.74" Altitude: 222m	Aviation Met. Office, Airforce Compaund, Meikhtila, Mandaley Region	SMS Text : OK			Surrounding Environment: No problem for the Observation Fence extension is required 
18	Kawthaung	48112	Lat: N 09º 58' Long: E 98º 35' Altitude: 46m	Met. Office, Upper Air Station, Yone Gyi Road, Padauk Shwewa Road, Kawthaung, Tanintharyi Region	SMS Text : OK			Surrounding Environment: No problem for the Observation
19	Monywa	48037	Lat: N 22° 07' 01.6" Long: E 95° 08' 34.1" Altitude: 80m	Regional Office, Dept. of Met. Hydro., Kyaukar Road, West Parr of Yan Kin Monatry, Monywa, Sagaing Region	SMS Text : OK			Surrounding Environment: No problem for the Observation Fence extension is required 
20	Taungoo	48078	Lat: N 18° 55' 45.9" Long: E 96° 26' 52.4" Altitude: 79m	District Office, Dept. of Met. Hydro., Taungoo, Bago Region	SMS Text : OK			Surrounding Environment: No problem for the Observation

Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
21	Nansam	-	Lat: N 11º 58’ Long: E 97º 09’ Altitude: 965m	Auahtn Met. Office, Airforce Compaund, Nam Sam, Shan State	SMS Text : OK			
22	Loikaw	48075	Lat: N 19º 41’ 05.2” Long: E 97º 12’ 21.8” Altitude: 901m	State. Office, Dept. of Met. Hydro., Oo Ni Road, Xlaung Yam Road, (B) Ward, Near State Primary School No. (2), Loiikaw, Kayah State	SMS Text : OK			Surrounding Environment: No problem for the Observation Fence extension is required 
23	Hakha	48030	Lat: N 22º 39’ Long: E 93º 37’ Altitude: 1866m	State Office, Dept. of Met. Hydro., Zay Thir Ward, Bo Choke Road, Hakha, Chin State	SMS Text : OK			Surrounding Environment: No problem for the Observation
24	Lashio	48035	Lat: N 22° 58’ 42.4” Long: E 97° 45’ 14.7” Altitude: 769m	Met. Office, Lashio Airport, Shan State	SMS Text : OK			Surrounding Environment: No problem for the Observation A new fence is required for protecting AWS to be installed 

Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
25	Putao	48001	Lat: N 27º 20'48.5" Long: E 97º 23'50.4" Altitude: 429m	Met. Office, Myone ward, Kathin State, Putao	SMS Text : NG			Surrounding Environment: No problem for the Observation CDMA SMS Text: OK The observatory to be in the GSM service area in 2013
26	Kengtong	48060	Lat: N 21º 18' Long: E 99º 37' Altitude: 827m	Met. Office, Su Paung Pone Road, No (1) Ward, Kengtong, Shan State	SMS Text : OK			Surrounding Environment: No problem for the Observation
27	Laputta	-	Lat: N 16º 11'39.4" Long: E 94º 46'53.5" Altitude: 18m	-	SMS Text : OK			Surrounding Environment: No problem for the Observation The observation field to be established in Laputta DMH Compound by March 2013 
28	Gwa	48085	Lat: N 17º 35' Long: E 94º 35' Altitude: 3m	Met. Office, Dept. of Met. Hydro., Gwa, Rakhine State	SMS Text : OK			Surrounding Environment: No problem for the Observation

Priority	Site Name	Code	Location	Address	GSM Signal Level	Site Picture		Remarks
29	Hmawbi	48092	Lat: N 17º 07' 18.4" Long: E 96º 04' 25.0" Altitude: 25m	Aviation Met. Office, Bureau for Maintenance & Production of Aircraft, Hmawbi, Yangon Region	SMS Text : OK			Surrounding Environment: No problem for the Observation Fence extension is required 
30	Bhamo	48019	Lat: N 24º 16' Long: E 97º 12' Altitude: 111m	Met. & Hydro. Office, Shan Wine New Ward, Pauk Kone, Bhamo, Kachin State	SMS Text : OK			Surrounding Environment: No problem for the Observation

The site surveys at the sites (4-Sittwe, 8-Dawei, 9-Myitkyina, 10-Hkamty, 14-Kalaymyo, 18-Kawthaung, 21-Nansam, 23-Hakha, 26-Kengtong, 28-Gwa and 30-Bhamo) indicated in the light green colored columns were implemented by the DMH.



Proposed Location of AWS Installation

Azimuth Direction (North)

The "Schematic Diagram of the Meteorological Observation Network in Myanmar" is attached hereto.

Schematic Diagram of Meteorological Observation Network in Myanmar

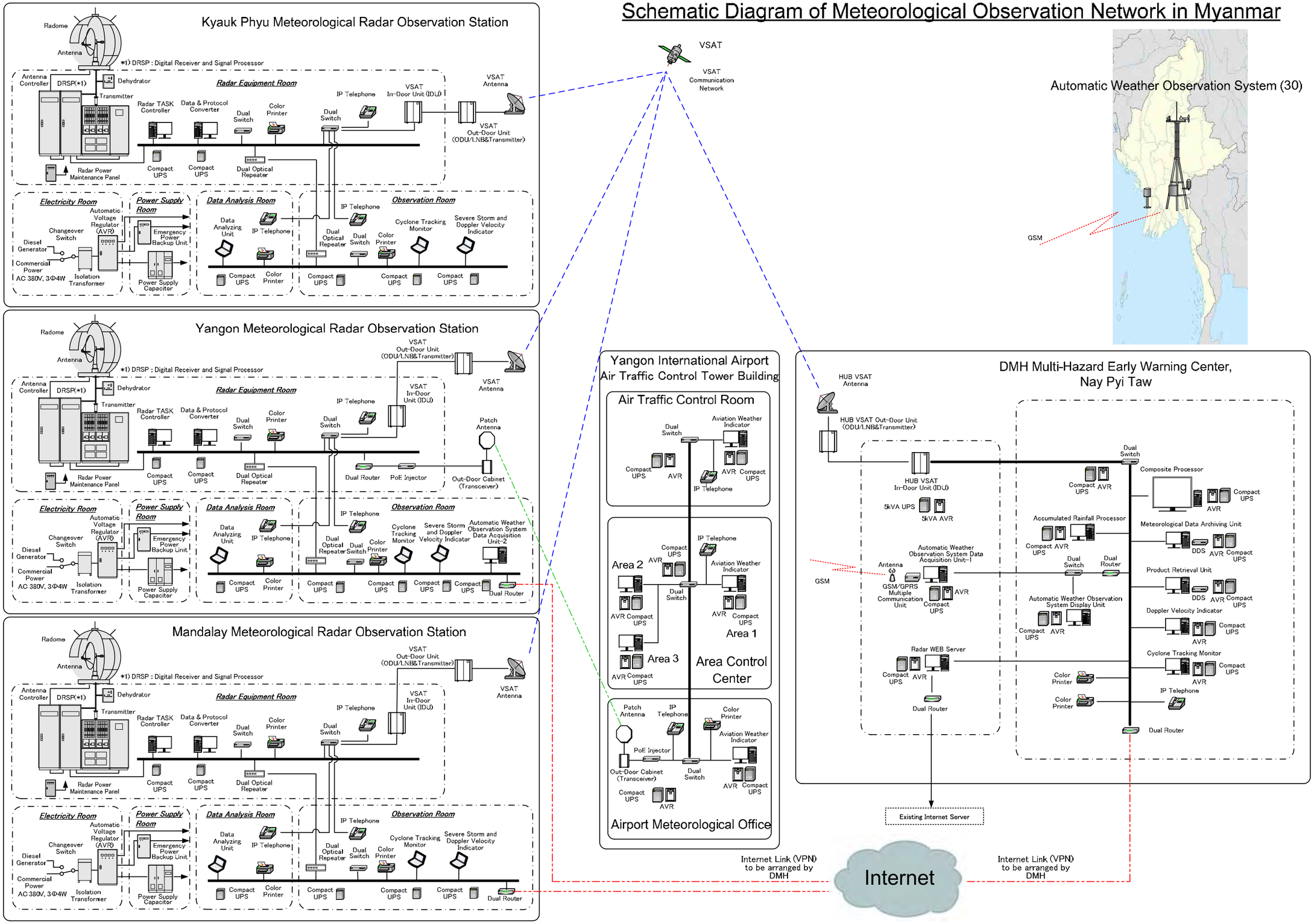


Figure 11: Schematic Diagram of Meteorological Radar Observation Network in Myanmar

(2) Major Equipment List

As a consequence of the basic design study, the major components of the Project are described below.

Table 26: Main Equipment Components

Component	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Mandalay Meteorological Radar Observation Station	Yangon International Airport	Automatic Weather Observation Stations
Procurement and Installation of Equipment						
S-Band Doppler Pulse Compression Solid State Radar System including Power Back-up System, Lightening System Measuring Equipment and Spare Parts	-	○	○	○	-	-
Meteorological Rader Data Display System including Software	○	○	○	○	○	-
Meteorological Data Satellite Communication System (VSAT)	○	○	○	○	-	-
Meteorological Data Communication System	-	-	○	-	○	-
Automatic Weather Observation System	○	-	○	-	-	○

Major Equipment List

Meteorological Radar System (Kyauk Phyu Meteorological Radar Observation Station)

Name of Site: Kyauk Phyu Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
Radome	1 set	To protect the radar antenna assembly (a parabolic dish reflector) and maintenance personnel from severe weather conditions and lightning attacks.
Antenna	1 set	To radiate radar beam into the atmosphere and to receive scatter waves while rotating the parabola antenna as azimuth and elevation direction.
Antenna Controller	1 set	To rotate the parabolic dish reflector and to control the antenna in azimuth and elevation by both horizontal and vertical drive motor units.
Transmitter	1 set	To amplify the pulse-modulated power with stable frequency and transmitting the power to the antenna.
Digital Receiver and Signal Processor (DRSP)	1 set	To receive, pulse compression and processing echo signal from the Antenna. To suppress unnecessary echo such as clutter signals reflected from the ground and to send ingest data to the radar TASK controller.
Dehydrator	1 set	To supply dried and pressurized air into the wave-guide to reduce wave propagation loss.
Wave-guide Configuration	1 set	For feeder line propagation wave traveling between the antenna and TX/RX.
Radar TASK Controller	1 set	To operate the radar system, to monitor condition of the radar system and to generate raw product data. Control and monitoring items: Radiate control/status, Azimuth/elevation position control/status, TX standby status, Pulse width control/status, Antenna local/maintenance mode status.
Data & Protocol Converter	1 set	To send raw data to the central system according to the specified interval.
Radar Power Maintenance Panel	1 set	To distribute and supply AC power to the radar system.
Compact UPS	2 sets	To supply back-up AC power to the computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Dual Switch	1 set	To connect all the computing equipment on LAN.
Color Printer	1 set	To print radar image.
Dual Optical Repeater	1 set	To convert electrical signal and optical signal on LAN for surge protection.

Isolation Transformer		1 set	To protect each equipment from surges in voltage in the main power.
Automatic Voltage Regulator (AVR)		1 set	For supplying the constant or regulated voltage to the radar system.
Power Supply Capacitor		1 set	To supply uninterrupted power by Electric Dual Layer Capacitor energy to the radar system when power failure occurs.
Spectrum Analyzer		1 set	For maintenance of the system.
Test signal Generator		1 set	
Power Meter		1 set	
Power Sensor		1 set	
Frequency Counter		1 set	
Detector		1 set	
Attenuator Set		1 set	
Terminator for Detector		1 set	
Oscilloscope		1 set	
Digital Multimeter		1 set	
CW Converter		1 set	
Network Camera		1 set	
Tool Kit		1 set	
Extension Cable		1 set	
Leveler		1 set	
Step Ladder		1 set	
Clump Current Meter		1 set	
Vacuum Cleaner		1 set	
Radar Antenna Maintenance Deck		1 set	
Spare Parts	Timing belt for antenna (for azimuth drive)	1 set	For maintenance of the system.
	Timing belt for antenna (for elevation drive)	1 set	
	Encoder for antenna (for azimuth angle signal)	1 set	
	Encoder for antenna (for elevation angle signal)	1 set	
	Motor for antenna (for azimuth drive)	1 set	
	Motor for antenna (for elevation drive)	1 set	
	Servo unit for antenna controller (for azimuth drive)	1 set	
	Servo unit for antenna controller (for elevation drive)	1 set	
	Power supply unit for antenna controller	1 set	
	Power supply unit for transmitter	1 set	
	Power supply unit for digital receiver and signal processor	1 set	
	Fan unit for radar equipment	2 sets	
	Obstruction light	2 sets	
Consumables	Grease with pump and oil with jug for antenna	1 set	For maintenance of the system.
	Antenna carbon brush for power	1 set	
	Antenna carbon brush for signal	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar System (Yangon Meteorological Radar Observation Station)

Name of Site: Yangon Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
Radome	1 set	To protect the radar antenna assembly (a parabolic dish reflector) and maintenance personnel from severe weather conditions and lightning attacks.
Antenna	1 set	To radiate radar beam into the atmosphere and receiving scatter waves while rotating the parabola antenna as azimuth and elevation direction.
Antenna Controller	1 set	To rotate the parabolic dish reflector and to control the antenna in azimuth and elevation by both horizontal and vertical drive motor units.

Transmitter		1 set	To amplify the pulse-modulated power with stable frequency and transmitting the power to the antenna.
Digital Receiver and Signal Processor (DRSP)		1 set	To receive, pulse compression and processing echo signal from the Antenna. To suppress unnecessary echo such as clutter signals reflected from the ground and to send ingest data to radar TASK controller.
Dehydrator		1 set	To supply dried and pressurized air into the wave-guide to reduce wave propagation loss.
Wave-guide Configuration		1 set	For feeder line propagation wave traveling between the antenna and TX/RX.
Radar TASK Controller		1 set	To operate the radar system, to monitor condition of the radar system and to generate raw product data. Control and monitoring items: Radiate control/status, Azimuth/elevation position control/status, TX standby status, Pulse width control/status, Antenna local/maintenance mode status.
Data & Protocol Converter		1 set	To send raw data to central system according to the specified interval.
Radar Power Maintenance Panel		1 set	To distribute and supply AC power to radar system.
Compact UPS		2 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Dual Switch		1 set	To connect all the computing equipment on LAN.
Color Printer		1 set	To print radar image.
Dual Optical Repeater		1 set	To convert electrical signal and optical signal on LAN for surge protection.
Isolation Transformer		1 set	To protect each equipment from surges in voltage in the main power.
Automatic Voltage Regulator (AVR)		1 set	To supply the constant or regulated voltage to the radar system.
Power Supply Capacitor		1 set	To supply uninterrupted power by Electric Dual Layer Capacitor energy to the radar system when power failure occurs.
Spectrum Analyzer		1 set	For maintenance of the system.
Test signal Generator		1 set	
Power Meter		1 set	
Power Sensor		1 set	
Frequency Counter		1 set	
Detector		1 set	
Attenuator Set		1 set	
Terminator for Detector		1 set	
Oscilloscope		1 set	
Digital Multimeter		1 set	
CW Converter		1 set	
Network Camera		1 set	
Tool Kit		1 set	
Extension Cable		1 set	
Leveler		1 set	
Step Ladder		1 set	
Clump Current Meter		1 set	
Vacuum Cleaner		1 set	
Radar Antenna Maintenance Deck		1 set	
Spare Parts	Timing belt for antenna (for azimuth drive)	1 set	For maintenance of the system.
	Timing belt for antenna (for elevation drive)	1 set	
	Encoder for antenna (for azimuth angle signal)	1 set	
	Encoder for antenna (for elevation angle signal)	1 set	
	Motor for antenna (for azimuth drive)	1 set	
	Motor for antenna (for elevation drive)	1 set	
	Servo unit for antenna controller (for azimuth drive)	1 set	
	Servo unit for antenna controller (for elevation drive)	1 set	

	Power supply unit for antenna controller	1 set	
	Power supply unit for transmitter	1 set	
	Power supply unit for digital receiver and signal processor	1 set	
	Fan unit for radar equipment	2 sets	
	Obstruction light	2 sets	
Consumables	Grease with pump and oil with jug for antenna	1 set	For maintenance of the system.
	Antenna carbon brush for power	1 set	
	Antenna carbon brush for signal	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar System (Mandalay Meteorological Radar Observation Station)

Name of Site: Mandalay Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
Radome	1 set	To protect the radar antenna assembly (a parabolic dish reflector) and maintenance personnel from severe weather conditions and lightning attacks.
Antenna	1 set	To radiate radar beam into the atmosphere and receiving scatter waves while rotating the parabola antenna as azimuth and elevation direction.
Antenna Controller	1 set	To rotate the parabolic dish reflector and to control the antenna in azimuth and elevation by both horizontal and vertical drive motor units.
Transmitter	1 set	To amplify the pulse-modulated power with stable frequency and transmitting the power to the antenna.
Digital Receiver and Signal Processor (DRSP)	1 set	To receive, pulse compression and processing echo signal from the Antenna. To suppress unnecessary echo such as clutter signals reflected from the ground and to send ingest data to radar TASK controller.
Dehydrator	1 set	To supply dried and pressurized air into the wave-guide to reduce wave propagation loss.
Wave-guide Configuration	1 set	For feeder line propagation wave traveling between the antenna and TX/RX.
Radar TASK Controller	1 set	To operate the radar system, to monitor condition of the radar system and to generate raw product data. Control and monitoring items: Radiate control/status, Azimuth/elevation position control/status, TX standby status, Pulse width control/status, Antenna local/maintenance mode status.
Data & Protocol Converter	1 set	To send raw data to central system according to specified interval.
Radar Power Maintenance Panel	1 set	To distribute and supply AC power to radar system.
Compact UPS	2 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Dual Switch	1 set	To connect all the computing equipment on LAN.
Color Printer	1 set	To print radar image.
Dual Optical Repeater	1 set	To convert electrical signal and optical signal on LAN for surge protection.
Isolation Transformer	1 set	To protect each equipment from surges in voltage in the main power.
Automatic Voltage Regulator (AVR)	1 set	To supply the constant or regulated voltage to the radar system.
Power Supply Capacitor	1 set	To supply uninterrupted power by Electric Dual Layer Capacitor energy to the radar system when power failure occurs.
Spectrum Analyzer	1 set	For maintenance of the system.
Test signal Generator	1 set	
Power Meter	1 set	
Power Sensor	1 set	
Frequency Counter	1 set	
Detector	1 set	
Attenuator Set	1 set	
Terminator for Detector	1 set	
Oscilloscope	1 set	
Digital Multimeter	1 set	
CW Converter	1 set	

Network Camera		1 set	
Tool Kit		1 set	
Extension Cable		1 set	
Leveler		1 set	
Step Ladder		1 set	
Clump Current Meter		1 set	
Vacuum Cleaner		1 set	
Radar Antenna Maintenance Deck		1 set	
Spare Parts	Timing belt for antenna (for azimuth drive)	1 set	For maintenance of the system.
	Timing belt for antenna (for elevation drive)	1 set	
	Encoder for antenna (for azimuth angle signal)	1 set	
	Encoder for antenna (for elevation angle signal)	1 set	
	Motor for antenna (for azimuth drive)	1 set	
	Motor for antenna (for elevation drive)	1 set	
	Servo unit for antenna controller (for azimuth drive)	1 set	
	Servo unit for antenna controller (for elevation drive)	1 set	
	Power supply unit for antenna controller	1 set	
	Power supply unit for transmitter	1 set	
	Power supply unit for digital receiver and signal processor	1 set	
	Fan unit for radar equipment	2 sets	
	Obstruction light	2 sets	
Consumables	Grease with pump and oil with jug for antenna	1 set	For maintenance of the system.
	Antenna carbon brush for power	1 set	
	Antenna carbon brush for signal	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar Data Display System (Kyauk Phyu Meteorological Radar Observation Station)

Name of Site: Kyauk Phyu Meteorological Radar Observation Station			
Equipment		Quantity	Purpose
Severe Storm and Doppler Velocity Indicator		1 set	To monitor and alert severe storm conditions through various Doppler radar products.
Cyclone Tracking Monitor		1 set	To track cyclone course and to predict cyclone course and time.
Color Printer		2 sets	To print radar image.
Dual Switch		1 set	To connect all the computer equipment with LAN.
Dual Optical Repeater		1 set	To convert electrical signal and optical signal on LAN for surge protection.
Compact UPS		4 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Data Analyzing Unit		1 set	To analyze weather phenomena by using observed radar data.
SIP IP Telephone		3 sets	For voice communication through IP network.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	1 set	For maintenance of the system.
	Battery Unit for Computer	3 sets	
	LAN Arrester	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar Data Display System (Yangon Meteorological Radar Observation Station)

Name of Site: Yangon Meteorological Radar Observation Station			
Equipment		Quantity	Purpose
Severe Storm and Doppler Velocity Indicator		1 set	To monitor and alert severe storm condition through various Doppler radar products.
Cyclone Tracking Monitor		1 set	To track cyclone course and predicting cyclone course and time.
Color Printer		2 sets	To print radar image.
Dual Switch		1 set	To connect all the computer equipment with LAN.
Dual Optical Repeater		1 set	To convert electrical signal and optical signal on LAN for surge protection.
Dual Router		1 set	To forward data packets between computer networks.
Compact UPS		4 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Data Analyzing Unit		1 set	To analyze weather phenomena by using observed radar data.
SIP IP Telephone		3 sets	For voice communication through IP network.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	1 set	For maintenance of the system.
	Battery Unit for Computer	3 sets	
	LAN Arrester	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar Data Display System (Mandalay Meteorological Radar Observation Station)

Name of Site: Mandalay Meteorological Radar Observation Station			
Equipment		Quantity	Purpose
Severe Storm and Doppler Velocity Indicator		1 set	To monitor and alert severe storm condition by various Doppler radar products.
Cyclone Tracking Monitor		1 set	To track cyclone course and predicting cyclone course and time.
Color Printer		2 sets	To print radar image.
Dual Switch		1 set	To connect all the computer equipment with LAN.
Dual Optical Repeater		1 set	To convert electrical signal and optical signal on LAN for surge protection.
Dual Router		1 set	To forward data packets between computer networks.
Compact UPS		4 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Data Analyzing Unit		1 set	To analyze weather phenomena by using observed radar data.
SIP IP Telephone		3 sets	For voice communication through IP network.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	1 set	For maintenance of the system.
	Battery Unit for Computer	3 sets	
	LAN Arrester	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar Data Display System (DMH Multi-Hazard Early Warning Center (Nay Pyi Taw))

Name of Site: DMH Multi-Hazard Early Warning Center (Nay Pyi Taw)		
Equipment	Quantity	Purpose
Composite Processor	1 set	For the generation of composite pictures from incoming data of all the radar stations.
Meteorological Data Archiving Unit	1 set	To store radar and weather information to a selected media.
Product Retrieval Unit	1 set	To retrieve and display radar data.
Accumulated Rainfall Processor	1 set	To generate and send accumulated rainfall data.
Doppler Velocity Indicator	1 set	To generate various wind profile with each mesh by Doppler data.
Cyclone Tracking Monitor	1 set	To track cyclone course and to predict cyclone course and time.
Radar WEB Server	1 set	For output of various products with WEB based image.
Color Printer	2 sets	To print radar image.
Dual Router (Dedicated Internet Link)	1 set	To forward data packets between computer networks.
Dual Router (Existing Internet Server)	1 set	To forward data packets between computer networks.
Dual Switch	1 set	To connect all the computer equipment with LAN.
DDS Drive	2 sets	To store radar and weather information in DDS media.
SIP IP Telephone	1 set	For voice communication through IP network.

Compact UPS		8 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Automatic Voltage Regulator (AVR)		8 sets	To supply constant or regulated voltage to the computer system.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	4 sets	For maintenance of the system.
	LAN Arrester	4 sets	
Service Manuals		1 set	For maintenance of the system.

Meteorological Radar Data Display System
(Airport Meteorological Office (Air Traffic Control Tower Building, Yangon International Airport))

Name of Site: Airport Meteorological Office (Air Traffic Control Tower Building, Yangon International Airport)			
Equipment		Quantity	Purpose
Aviation Weather Indicator		1 set	To monitor aviation weather by using various Doppler radar products.
Color Printer		1 set	To print radar image.
Dual Switch		1 set	To connect all the computer equipment with LAN.
SIP IP Telephone		1 set	For voice communication through IP network.
Compact UPS		2 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Automatic Voltage Regulator (AVR)		2 sets	To supply constant or regulated voltage to the computer system.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	1 set	For maintenance of the system.
	LAN Arrester	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar Data Display System
(Area Control Center (Air Traffic Control Tower Building, Yangon International Airport))

Name of Site: Area Control Center (Air Traffic Control Tower Building, Yangon International Airport)			
Equipment		Quantity	Purpose
Aviation Weather Indicator		3 sets	To monitor aviation weather by using various Doppler radar products.
Dual Switch		1 set	To connect all the computer equipment with LAN.
SIP IP Telephone		1 set	For voice communication through IP network.
Compact UPS		4 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Automatic Voltage Regulator (AVR)		4 sets	To supply constant or regulated voltage to the computer system.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	1 set	For maintenance of the system.
	LAN Arrester	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Radar Data Display System
(Air Traffic Control Room (Air Traffic Control Tower Building, Yangon International Airport))

Name of Site: Air Traffic Control Room (Air Traffic Control Tower Building, Yangon International Airport)			
Equipment		Quantity	Purpose
Aviation Weather Indicator		1 set	To monitor aviation weather by various Doppler radar products.
Dual Switch		1 set	To connect all the computer equipment with LAN.
SIP IP Telephone		1 set	For voice communication through IP network.
Compact UPS		2 sets	To supply back-up AC power to computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Automatic Voltage Regulator (AVR)		2 sets	To supply constant or regulated voltage to the computer system.
Spare Parts	Hard Disk Unit for Computer (not less than 250GB)	1 set	For maintenance of the system.
	LAN Arrester	1 set	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Data Satellite Communication System
(Kyauk Phyu Meteorological Radar Observation Station)

Name of Site: Kyauk Phyu Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
VSAT Out-Door Unit (ODU/Transmitter)	1 set	Transmitter for radar data transmission via satellite.
VSAT Out-Door Unit (ODU/LNB)	1 set	Receiver for radar data transmission via satellite.
VSAT Antenna	1 set	Antenna for radar data transmission via satellite.
VSAT In-Door Unit (IDU)	1 set	Modulator/Demodulator for radar data transmission via satellite.
Arrester Box	1 set	To protect VSAT equipment from lighting.
Emergency Power Backup Unit	1 set	To supply back-up power to VSAT equipment for uninterrupted or continued IP Telephone to DMH Head Office in case of power failure.
Dual Switch	1 set	To connect all the computer equipment with LAN.
Maintenance Terminal	1 set	For maintenance of the system.
Directional Coupler	1 set	
Spare Unit Arrester Terminal Set	1 set	For maintenance of the system.
Service Manuals	2 sets	For maintenance of the system.

Meteorological Data Satellite Communication System
(Yangon Meteorological Radar Observation Station)

Name of Site: Yangon Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
VSAT Out-Door Unit (ODU/Transmitter)	1 set	Transmitter for radar data transmission via satellite.
VSAT Out-Door Unit (ODU/LNB)	1 set	Receiver for radar data transmission via satellite.
VSAT Antenna	1 set	Antenna for radar data transmission via satellite.
VSAT In-Door Unit (IDU)	1 set	Modulator/Demodulator for radar data transmission via satellite.
Arrester Box	1 set	To protect VSAT equipment from lighting.
Emergency Power Backup Unit	1 set	To supply back-up power to VSAT equipment for uninterrupted or continued IP Telephone to DMH Head Office in case of power failure.
Dual Switch	1 set	To connect all the computer equipment with LAN.
Maintenance Terminal	1 set	For maintenance of the system.
Directional Coupler	1 set	
Spare Unit Arrester Terminal Set	1 set	For maintenance of the system.
Service Manuals	2 sets	For maintenance of the system.

Meteorological Data Satellite Communication System
(Mandalay Meteorological Radar Observation Station)

Name of Site: Kyauk Phyu Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
VSAT Out-Door Unit (ODU/Transmitter)	1 set	Transmitter for radar data transmission via satellite.
VSAT Out-Door Unit (ODU/LNB)	1 set	Receiver for radar data transmission via satellite.
VSAT Antenna	1 set	Antenna for radar data transmission via satellite.
VSAT In-Door Unit (IDU)	1 set	Modulator/Demodulator for radar data transmission via satellite.
Arrester Box	1 set	To protect VSAT equipment from lighting.
Emergency Power Backup Unit	1 set	To supply back-up power to VSAT equipment for uninterrupted or continued IP Telephone to DMH Head Office in case of power failure.
Dual Switch	1 set	To connect all the computer equipment with LAN.
Maintenance Terminal	1 set	For maintenance of the system.
Directional Coupler	1 set	
Spare Unit Arrester Terminal Set	1 set	For maintenance of the system.
Service Manuals	2 sets	For maintenance of the system.

Meteorological Data Satellite Communication System
(DMH Multi Hazard Early Warning Center, Nay Pyi Taw)

Name of Site: Nay Pyi Taw DMH Multi Hazard Early Warning Centre		
Equipment	Quantity	Purpose
HUB VSAT Out-Door Unit (ODU/Transmitter)	1 set	Transmitter for radar data transmission via satellite.
HUB VSAT Out-Door Unit (ODU/LNB)	1 set	Receiver for radar data transmission via satellite.

HUB VSAT Antenna		1 set	Antenna for radar data transmission via satellite.
HUB VSAT In-Door Unit (IDU)		1 set	Modulator/Demodulator for radar data transmission via satellite.
Arrester Box		1 set	To protect VSAT equipment from lighting.
5kVA UPS		1 set	To supply uninterrupted power to VSAT system in case of power failure.
5kVA Automatic Voltage Regulator (AVR)		1 set	To supply constant or regulated voltage to the system.
Spectrum Analyzer		1 set	For maintenance of the system.
Maintenance Terminal		1 set	
Power Meter		1 set	
Power Sensor		1 set	
Frequency Counter		1 set	
Directional Coupler		1 set	
Spare Unit	Transmitter (10W)	1 set	For maintenance of the system.
	LNB	1 set	
	Modem (for HUB IDU)	1 set	
	Modem (for VSAT IDU)	1 set	
	Arrester Terminal Set	1 set	
	Battery (for 5kVA UPS)	1 set	
Service Manuals		1 set	For maintenance of the system.

Meteorological Data Communication System (Yangon Meteorological Radar Observation Station)

Name of Site: Yangon Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
OFDM Wireless Transceiver (4.9GHz)	1 set	To receive and transmit meteorological information and observed data between Yangon Radar Observation Station and Airport Meteorological Office in Yangon International Airport
Patch Antenna (21dBi)	1 set	To receive and transmit data from OFDM Wireless Transceiver
Outdoor Cabinet	1 set	To accommodate transceiver and related devices.
PoE Injector	1 set	To supply electric power to OFDM Wireless Transceiver over Ethernet cable.
Dual Router	1 set	To forward data packets between computer networks.
Spare Unit OFDM Wireless Transceiver (4.9GHz)	1 set	For maintenance of the system.
Patch Antenna (21dBi)	1 set	
PoE Injector	1 set	
Service Manuals	2 sets	For maintenance of the system.

Meteorological Data Communication System (Airport Meteorological Office (Air Traffic Control Tower Building, Yangon International Airport)

Name of Site: Airport Meteorological Office (Air Traffic Control Tower Building, Yangon International Airport)		
Equipment	Quantity	Purpose
OFDM Wireless Transceiver (4.9GHz)	1 set	To receive and transmit meteorological information and observed data between Yangon Radar Observation Station and Airport Meteorological Office in Yangon International Airport
Patch Antenna (21dBi)	1 set	To receive and transmit data from OFDM Wireless Transceiver
Outdoor Cabinet	1 set	To accommodate transceiver and related devices.
PoE Injector	1 set	To supply electric power to OFDM Wireless Transceiver over Ethernet cable.
Service Manuals	1 set	For maintenance of the system.

Automatic Weather Observation System (AWS)

Name of Site:		
Equipment	Quantity	Purpose
Wind Speed and Direction Sensor	30 set	To observe wind speed and direction
Temperature and Humidity Sensor	30 set	To observe temperature and humidity
Barometer	30 set	To observe air pressure
Rain Gauge	30 set	To observe precipitation
Pedestal for Rain Gauge	30 set	To set-up rain gauge
Sunshine Duration Sensor	30 set	To observe Sunshine Duration
AWS Data Logger Module	30 set	To collect weather observation data from each sensors and transmit such data to the Data Management Unit at the DMH Head Office
GSM/GPRS Modem	30 set	To transmit observation data over a cell phone network

AWS and Solar Power System Enclosure		30 set	To accommodate Data Logger Module and GSM/GPRS Modem
Solar Power Supply System		30 set	To generate and supply electric power to the AWS.
10m Freestanding Tower		30 set	To mount the observation equipment and other related devices.
AWS Maintenance Terminal		2 sets	For maintenance of the system.
Tool Kit		2 sets	
Digital Multimeter		2 sets	
Spare Parts	Wind Speed and Direction Sensor	2 sets	For maintenance of the system.
	Temperature and Humidity Sensor Base	1 set	
	Temperature Sensor Module and Humidity Sensor Module	2 sets	
	Barometer	2 sets	
	Rain Gauge	2 sets	
	Sunshine Duration Sensor	2 sets	
	AWS Data Logger Module	2 sets	
	GSM/GPRS Modem	2 sets	
	Solar Panel	2 sets	
	Regulator	2 sets	
	Battery (for Solar Power Supply System)	2 sets	
Service Manuals		2 sets	For maintenance of the system.

Meteorological Data Management Unit (DMH Multi-Hazard Early Warning Center, Nay Pyi Taw)

Name of Site: DMH Multi-Hazard Early Warning Center, Nay Pyi Taw		
Equipment	Quantity	Purpose
Automatic Weather Observation System Data Acquisition Unit-1	1 set	To collect and process observed data from each observation point for recording.
GSM/GPRS Multiple Communication Unit	2 sets	To receive observation data to be sent over cell phone network.
Automatic Weather Observation System Display Unit	1 set	To display weather observation data and information.
Dual Switch	1 set	To connect all the computer equipment with LAN.
Dual Router	1 set	To forward data packets between computer networks.
Compact UPS	2 sets	To supply back-up AC power to a computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Automatic Voltage Regulator (AVR)	2 sets	To supply stable power to each equipment and peripheral
Spare Parts Hard Disk Unit for Computer (not less than 500GB)	1 set	For maintenance of the system.
Spare Parts LAN Arrester	1 set	
Service Manuals	1 set	For maintenance of the system.

Meteorological Data Management Unit (Yangon Meteorological Radar Observation Station)

Name of Site: Yangon Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
Automatic Weather Observation System Data Acquisition Unit-2	1 set	To collect and process observed data from each observation point for recording.
Compact UPS	1 set	To supply back-up AC power to a computer equipment in order to enable proper shutdown procedure of the system in case of power failure.
Spare Parts LAN Arrester	1 set	For maintenance of the system.
Service Manuals	1 set	For maintenance of the system.

Power Back-up System (DMH Multi-Hazard Early Warning Center, Nay Pyi Taw)

Name of Site: DMH Multi-Hazard Early Warning Center, Nay Pyi Taw			
Equipment		Quantity	Purpose
Diesel Engine Generator		1 set	To generate stable electric power by diesel engine.
Consumables	Air Filter for Diesel Engine Generator	2 sets	For maintenance of the system.
	Oil Filter for Diesel Engine Generator	2 sets	
Service Manuals		1 set	For maintenance of the system.

(3) Basic Plan of the Facility

1) Site and Facility Layout Plan

The outline and current situation of infrastructures of the proposed Meteorological Radar Observation Stations are as follows.

Table 27: Outline and Current Situation of Infrastructures at the Proposed Project Sites for the Establishment of Meteorological Radar Observation Stations (1)

	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Mandalay Meteorological Radar Observation Station
Latitude(N) Longitude(E)	N19°17'10.4" E93°31'26.7"	N 16 º 51' 56.1" E 96 º 09' 13.0"	N 21 º 56' 31.4" E 96 º 05' 19.0"
Altitude	30m	21m	80m
Site Status	Existing Meteorological Radar Observation Station	Yangon DMH Compound	DMH Mandalay Observatory
Area of Property (Inside of the existing fence/boundary wall)	Approximately 1,400m^2	Approximately 25,000m^2	Approximately 4,900m^2
Space availability for the construction of the proposed radar tower building	Enough space is available.	Enough space is available.	For the construction of the proposed radar tower building, an expansion of the site 30m forward to the south side is required.
Access Road	Gravel/Concrete pavement of the unpaved existing access road from the main road to the site.	Poses no problem for the construction of the proposed radar tower building.	Poses no problem for the construction of the proposed radar tower building.
Description/Outline of the Premises	The area is developed by cut and fill, with some leveling of the top portion of the hill.	The very moderate slope premises are located in Yangon City (urban area). Public facilities and private houses surround the area.	The flat premises are located in the old Mandalay Airport (Not operational as of August 2012), Mandalay City (urban area). Public facilities and private houses surround the area.
Commercial Power	-	440V, 3-phase 4-wire, 50Hz	440V, 3-phase 4-wire, 50Hz
Water Supply	Deep well water	Deep well water + public water supply (unstable)	Deep well water
Waste water and Sewage	Septic tank and seepage pit in the site	Septic tank and seepage pit in the site	Septic tank and seepage pit in the site
Telephone	Not available	Available	Available
Internet Connection	Not available	Available	Not available
Mobile phone in the property area	Service is available	Service is available	Service is available

Table 28: Outline and Current Situation of Infrastructures at the Proposed Project Sites for the Establishment of Meteorological Radar Observation Stations (2)

	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw (Construction of a new Multi-Hazard Early Warning Center has been commenced from August 2012)	Air Traffic Control Tower in Yangon International Airport
Latitude(N) Longitude(E)	N19°46'45.5" E96°08'14.5"	N16°53'32.5" E96°08'42.6"
Altitude	145m	32m
Site Status	Existing Meteorological Radar Observation Station	Yangon International Airport Compound
Space availability for construction of the proposed radar tower building	Enough space is available.	Enough space is available.
Access Road	The unpaved existing access road (length: approx. 200m) from the main road to the site is available (under construction since August 2012).	Asphalt paved road already established.
Commercial Power	440V, 3-phase 4-wire, 50Hz	440V, 3-phase 4-wire, 50Hz
Water Supply	Public water supply (unstable)	Public water supply (unstable)
Waste water and Sewage	Septic tank and seepage pit in the site	Septic tank and seepage pit in the site
Telephone	Available	Available
Internet Connection	Available	Available
Mobile phone in the property area	Service is available	Service is available

2) Architectural Design

[1] Floor Plan

The floor plan is virtually symmetrical, making possible a structural design that is safe and avoids any kind of eccentricity. The floor plan for the central portion of the radar tower building allows the various rooms to be arranged with great flexibility, since there are no obstructing structures such as columns and beams protruding into the internal staircase (which will also serve as an evacuation route). Construction methods and materials follow local practice and the building is of standard grade in Myanmar.

The floor area of each room, the number of working staff, the room's function and the method of calculation of the size of each room are presented in the following tables.

Table 29: Calculation Base of Each Room In the Proposed Meteorological Radar Tower Building

Name of Room	Kyauk Phyu Meteorological Radar Tower Building Floor Area (m^2)	Yangon Meteorological Radar Tower Building Floor Area (m^2)	Mandalay Meteorological Radar Tower Building Floor Area (m^2)	Room Function	Calculation Base
Radome Room	30.19	30.19	30.19	Installation space for radar antenna apparatus.	Maintenance space for radar antenna apparatus. Room area depends upon radome base of 6.2m in diameter.
Radar Equipment Room (including Spare Parts Room)	77.03	90.02	77.03	Installation space for antenna controller, transmitter, solid state power amplifier, digital	Operation and maintenance space for all the apparatuses described in the left column.

				receiver, signal processor, dehydrator, wave-guide configuration, radar task controller, power distribution box, optical repeater, compact link transmitter/receiver, maintenance box, maintenance cabinet, measuring instrument cabinet, air-conditioning units, etc.	For installation of all the required equipment, at least 77m^2 is required.
Observation Room	124.46	125.83	124.46	For the following equipment and furniture. - weather observation terminals, - data analysis terminal, - VoIP exchange, - optical repeater, - dual switch, - printer, - IP telephone, - UPS for PCs, - desk for the terminal, - filing cabinets, - white board, - data storage cabinets, - data storage cabinets for keeping observation records and observed data of the radar system for analysis, - cabinets for maintenance instruments and operation & maintenance manuals Space for keeping spare parts & consumables.	For radar observation space and installation space for all the equipment described in the left column. A space for data analysis terminal (1), desk, data storage cabinets and also working space. Necessary space for keeping all data secured. Maintenance space for various type of the equipment and keeping space for maintenance instruments, measuring equipment.
Engine Generator Room	59.56	74.62	59.56	For 2 engine generators, oil pumps: 2, service tank, accessories, etc	Operation and maintenance space for 75kVA engine generators (2) with service tank (1,000 liter/tank), automatic change-over switch, etc.
Electricity Room	33.45	39.15	33.45	For isolation transformers, power distribution boards, cable rack, test terminals, AVR, etc. For radar power back-up unit and control rack.	Installation, operation and maintenance space and cabling space for all the apparatuses described in the left column.
Toilet	16.16	20.06	16.16	European Style Commode: M1+F1, Wash Basin: M1+F1, Urinal:1, Slop Sink: 1	—
Tea Kitchen	9.82	9.20	9.82	Kitchen: 1	—
Changing Room	2.22	2.02	2.22	Changing space for taking shower	—
Shower Room	2.53	2.46	2.53	Space for taking shower.	—
Storage	56.17	74.62	56.17	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
Pump Room	7.54	9.72	7.54	Well pump: 2 Pump for water reservoir tank: 2	For maintenance space and installation space for pumps: approx. 8 m^2 required.

[2] Sectional Plan

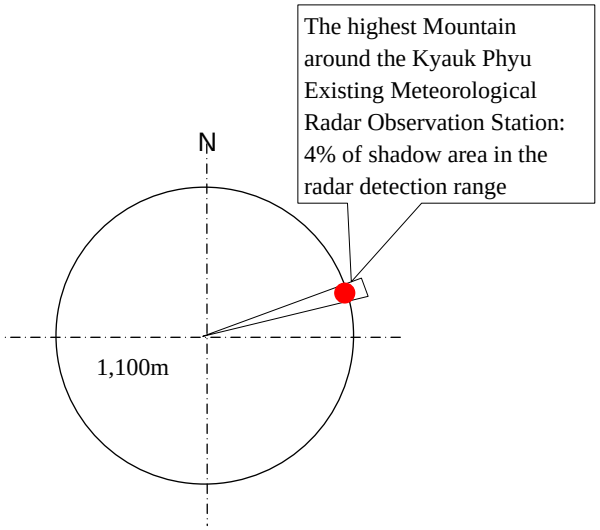
I. Height of the Radar Tower Building

- Kyauk Phyu Meteorological Radar Observation Station

If the radar antenna center height is brought to about 40m, the upper part of the radar beam can clear the highest point of the mountains (which create the blind areas in the existing radar observation range) on the south side of the Kyauk Phyu Existing Meteorological Radar Observation Station. After the completion of Project implementation, it is deemed that there will be no problem/blind spots for the radar observation. Thus, the required radar antenna center height for the proposed radar system in the Kyauk Phyu Meteorological Radar Observation Station is set at 40.0m.

<Shadow Area Calculation>

- The tallest Mountain as encircled in the picture around the Kyauk Phyu Existing Meteorological Radar Observation Station is 95m high
- Width of the Mountain from the Kyauk Phyu Existing Meteorological Radar Observation Station: approximately 300m
- Distance between the Mountain and the Kyauk Phyu Existing Meteorological Radar Observation Station: approx.1,100m
- $2\pi r$ = (1,100m + 1,100m) × 3.14 = 6,908m (the circumference of the following circle)
- 300m/6,908m = 0.043 = approx. 4% of the radar detection range is a shadow area at the radar antenna angle 0 degree.
- There is no disturbance within 360 degrees at the radar antenna angle +2.1degrees.



- Yangon Meteorological Radar Observation Station

<Existing Obstructive Building/Facility>

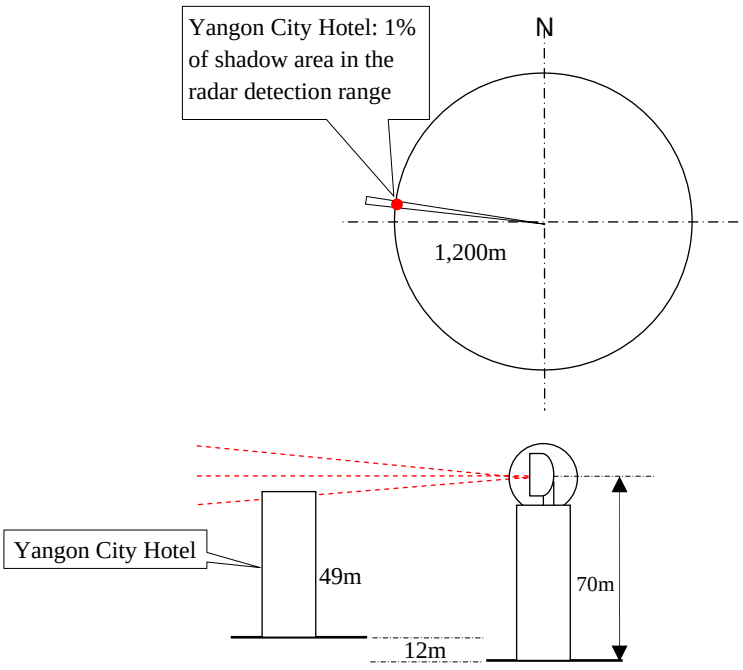
The ground level of the Yangon City Hotel which is the highest point of Yangon City is approximately 12.2m (practically measured by the theodolite) higher than the ground level of the DMH Yangon Compound and the height of the Yangon City Hotel, which is the tallest building from the mean sea level is 48.6m (physically measured by the theodolite).

12.2m ≈ 13m + 48.6m ≈ 49m = 62m

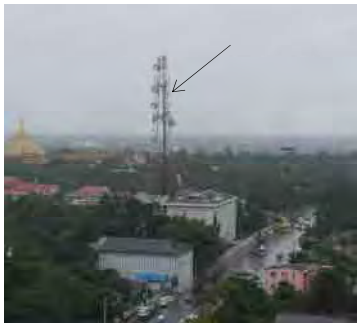
62m + 8m clearance = 70m (Required Height)

< Calculation of Shadow Area created by the Existing Obstructive Building/Facility>

- Width of the Yangon City Hotel Building from the DMH Yangon: 68.5m
- Distance between the Yangon City Hotel and the DMH Yangon: approx.1,200m
- 2πr = (1,200m + 1,200m) × 3.14 = 7,536m (the circumference of the following circle)
- 68.5m/7,536m = 0.009 = approx. 1% of the radar detection range is a shadow area at the radar antenna angle 0 degree.



1% of shadow area caused by the Yangon City Hotel in the radar detection range does not pose a serious problem or disturbance for radar observation.



Several self-standing (approx. 70m) and guided telecommunication steel towers (approx. 130m) which are unsurpassable and unavoidable obstructions for radar observation can be found in Yangon City as seen in the picture shown above. Since these telecommunication steel towers are not completely solid structures, it is not considered major obstruction for radar observation.

<Planned Obstructive Building/Facility>

Currently, in Yangon, there are plans to construct a building that is higher than the designed radar antenna center height (70m, the information from the Yangon City Development Committee (YCDC)). These are indicated in the table attached in the next page.

It is technically possible to complement the shadow areas created by the identified buildings in the radar detection range as indicated in the following table with the CAPPI (Constant Altitude PPI (Plan Position Indicator)) data. It is unfortunately an inescapable fact that the radar observation range will become shorter due to the higher elevation angle of the radar antenna to eliminate the shadow areas caused by the identified buildings.

It is also being considered that urban development in Yangon be additionally accelerated. The buildings which were already constructed or have obtained the necessary building construction permits are unavoidable. However, it is necessary to take appropriate measures in Myanmar to establish a consultation framework for discussions between the YCDA and the DMH for the building construction permit of a tall building within 10km radius from the Yangon Meteorological Doppler Radar System in order to restrict the height of any building that could hamper radar observation.

Table 30: Existing/Planned Obstructive Buildings to Radar Observation in Yangon (as of January, 2013)

	Existing		Planned								
Location Map No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Name of Building	Yangon City Hotel	Sakura Tower	Traders Square	Sedona Hotel (Phase II)	-	-	-	-	-	(Under Construction)	-
Number of Stories	13	20	27	30	18	44	12	27	25	-	18
Building Height	49m	83m	Estimated 114m	Estimated 111m	Estimated 77m	Estimated 160m	Estimated 67m	Estimated 74m	Estimated 89m	Estimated 78m	Estimated 72m
Latitude(N) Longitude(E)	N16º 51’57.6” E96º 08’36.1”	N16º 46’45.5” E96º 09’34.1”	N16º 46’40.2” E96º 09’31.3”	N16º 49’42.9” E96º 09’18.7”	N16º 48’35.7” E96º 08’07.4”	N16º 46’45.5” E96º 09’42.9”	N16º 47’25.5” E96º 07’55.1”	N16º 48’05.6” E96º 10’06.7”	N16º 49’08.6” E96º 09’22.9”	N16º 48’36.1” E96º 09’38.5”	N16º 50’00.4” E96º 07’58.7”
Altitude (from Mean Sea Level)	33m	20m	19m	26m	33m	15m	25m	25m	31m	28m	23m
Distance from DMH Yangon	Approx.1.2km	Approx.9.6km	Approx.9.7km	Approx.4.2km	Approx.6.5km	Approx.9.6km	Approx.8.7km	Approx.7.3km	Approx.5.2km	Approx.6.2km	Approx.4.2km
Direction from DMH Yangon	271°	176°	176°	178°	197°	174°	195°	167°	176°	173°	211°
Approximate height difference (Estimated Height – 70m: planned height of radar antenna center)	-9m (Ground level is 12m higher than DMH Yangon)	12m (Ground level is 1m lower than DMH Yangon)	42m (Ground level is 2m lower than DMH Yangon)	46m (Ground level is 5m higher than DMH Yangon)	19m (Ground level is 12m higher than DMH Yangon)	84m (Ground level is 6m lower than DMH Yangon)	1m (Ground level is 4m higher than DMH Yangon)	8m (Ground level is 4m higher than DMH Yangon)	29m (Ground level is 10m higher than DMH Yangon)	15m (Ground level is 7m higher than DMH Yangon)	4m (Ground level is 2m higher than DMH Yangon)
Required radar antenna angle to eliminate the shadow area caused by the identified buildings	+0.4°	+0.9°	+1.0°	+1.4°	+1.0°	+1.3°	+0.9°	+0.9°	+1.1°	+1.0°	+0.9°

	Planned									
Location Map No.	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Name of Building	-	-	-	-	-	-	-	-	-	-
Number of Stories	17	34	-	-	-	-	-	-	-	-
Building Height	Estimated 63m	Estimated 110m	Estimated 176m	Estimated 79m	Estimated 93m	Estimated 70m	Estimated 112m	Estimated 107m	Estimated 90m	Estimated 64m
Latitude(N) Longitude(E)	N16º 48’16.9” E96º 08’12.8”	N16º 51’46.6” E96º 07’17.4”	N16°46'48.4" E96°08'26.7"	N16°46'45.0" E96°09'40.7"	N16°46'18.0" E96°09'39.0"	N16°49'02.3" E96°07'55.7"	N16°49'32.2" E96°07'50.7"	N16°51'11.2" E96°09'27.0"	N16°47'47.3" E96°10'20.3"	N16°49'56.5" E96°07'45.8"
Altitude (from Mean Sea Level)	24m	14m	21m	16m	20m	28m	25m	21m	20m	16m
Distance from DMH Yangon	Approx.7.0km	Approx.3.5km	Approx.9.5km	Approx.9.6km	Approx.10.4km	Approx.5.8km	Approx.5.0km	Approx.1.4km	Approx.7.9km	Approx.4.5km
Direction from DMH Yangon	194°	265°	188 °	175 °	175 °	203 °	208 °	163 °	165 °	215 °
Approximate height difference (Estimated Height – 70m: planned height of radar antenna center)	-4m (Ground level is 3m higher than DMH Yangon)	33m (Ground level is 7m lower than DMH Yangon)	106m (Ground level is the same as DMH Yangon)	4m (Ground level is 5m lower than DMH Yangon)	22m (Ground level is 1m lower than DMH Yangon)	7m (Ground level is 7m higher than DMH Yangon)	46m (Ground level is 4m higher than DMH Yangon)	37m (Ground level is the same as DMH Yangon)	19m (Ground level is 1m lower than DMH Yangon)	-11m (Ground level is 5m lower than DMH Yangon)
Required radar antenna angle to eliminate the shadow area caused by the identified buildings	+0.8°	+1.3°	+1.5°	+0.8°	+0.9°	+0.9°	+1.3°	+2.3°	+0.9°	+0.6°

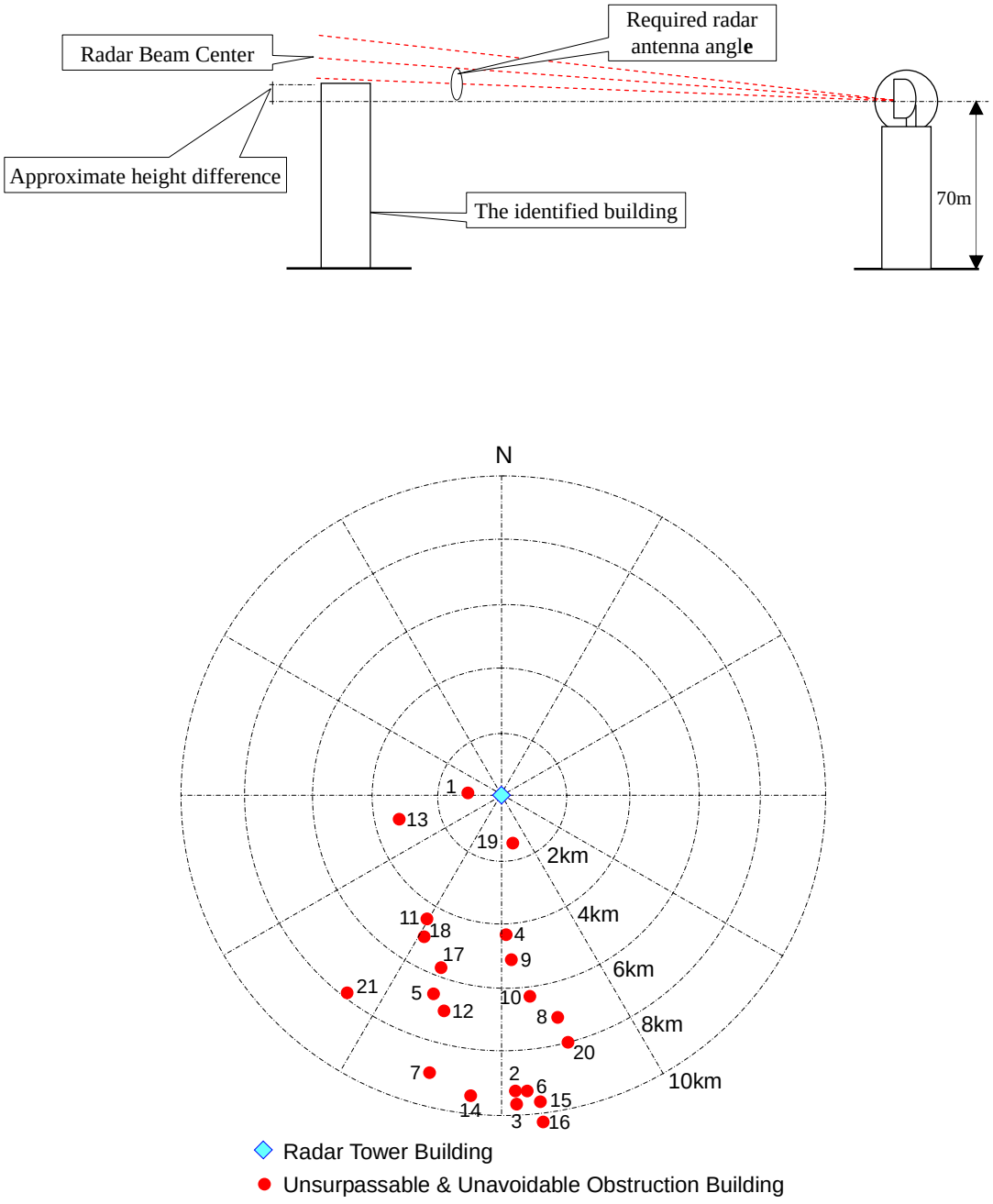


Figure 12: Location Map of Planned and Existing Obstructive Buildings in Yangon

- Mandalay Meteorological Radar Observation Station

<Existing Obstructive Building/Facility>

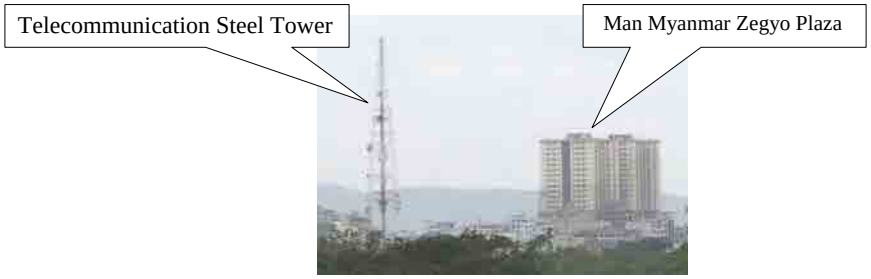
The mobile telecommunication steel tower (41m from the ground level) in the picture shown at the right is the tallest facility (distance from the Old Airport: approx. 3.5km) around the Old Airport.

- Altitude of the Old Airport: 79m
- Mobile Telecommunication Steel Tower: 41m
- 4m + 41m + 5m clearance=approx. 50m

	Mobile Telecommunication Steel Tower
Latitude (N) Longitude (E)	N 21 º 55' 19.7" E 96 º 03' 45.3"
Altitude	83m

However, a telecommunication steel tower and a building, the Man Myanmar Zegyo Plaza with 25 floors, which are unsurpassable and unavoidable obstructions for radar observation, can be found within Mandalay City as seen in the picture attached hereunder.

Since the telecommunication steel tower is not a completely solid structure and the distance between the tower and the Old Airport is 4.7km, it is not expected to become a serious obstruction for radar observation.



<Calculation of Shadow Area made by the Existing Obstructive Building/Facility>

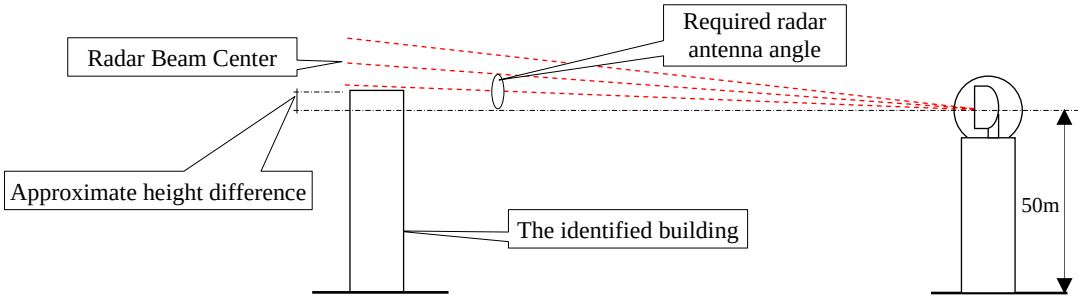
- Width of the Man Myanmar Zegyo Plaza from the Old Airport: 80m
- Distance between the Man Myanmar Zegyo Plaza and the Old Airport: approx. 4,500m
- $2\pi r$ = (4,500m + 4,500m) × 3.14 = 28,260m (the circumference of the following circle)
- 80m/28,260m = 0.0028 = approx. 0.28% of the radar detection range is a shadow area at the radar antenna angle 0 degree.
- It is technically possible to complement the shadow area (0.28%) created by the Man Myanmar Zegyo Plaza in the radar detection range with the CAPPI data.

It is also being considered that the urban development in Mandalay be additionally accelerated. The buildings which were already constructed or have obtained the necessary building construction permits are unavoidable. However, it is necessary to take appropriate measures in Myanmar to establish a consultation framework for discussions between the MCDA and the DMH for the building construction permit of a tall building within 10km radius from the Mandalay Meteorological Doppler Radar System in order to restrict the height of any building that could hamper radar observation.

The existing/planned obstructive buildings/facilities in Mandalay are indicated in the following table.

Table 31: Existing/Planned Obstructive Buildings/Facilities to Radar Observation in Mandalay (as of January, 2013)

	Existing		Planned	
Location Map No.	**1**	**2**	**3**	**4**
Name of Building	Telecommunication Steel Tower	Man Myanmar Zegyo Plaza	Planned hotel building	-
Number of Stories	-	25	28	-
Height	105m	83m	Estimated 90m	Estimated 51m
Latitude(N) Longitude(E)	N 21 º 59’ 01.5” E 96 º 05’ 03.6”	N 21 º 58’ 50.9” E 96 º 04’ 38.7”	N 21 º 57’ 45.5” E 96 º 04’ 33.8”	N21º 57’51.0” E96º 04’59.2”
Altitude	85m	77m	77m	80m
Distance from the Old Airport	approx. 4.7km	approx. 4.5km	approx. 2.6km	approx. 2.5km
Direction from the Old Airport	0°/360°	345°	331°	348º
Approximate height difference (Estimated Height – 50m: planned height of radar antenna center)	61m (Ground level is 6m higher than the Old Airport)	31m (Ground level is 2m lower than the Old Airport)	38m (Ground level is 2m lower than the Old Airport)	2m (Ground level is 1m higher than the Old Airport)
Required radar antenna angle to eliminate the shadow area caused by the identified buildings	-	+1.2degrees	+1.6degrees	+0.9 degrees



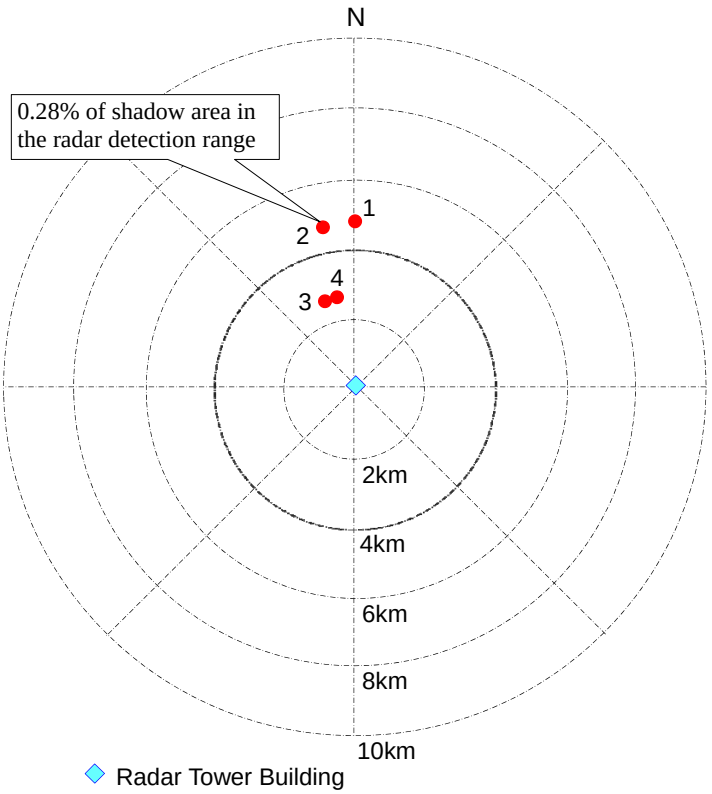


Figure 13: Location Map of Planned and Existing Obstructive Buildings in Mandalay

II. Ground Level

During the course of the topographic survey work at the project site, a benchmark was identified to be the reference ground level. Such reference will be used for the construction of the radar tower building.

III. Equipment Installation

In order to install all the equipment inside the radar equipment room, a large opening would be needed to allow equipment ingress. However, the large opening would be undesirable from the standpoint of air-tightness and dust proofing. The equipment will, therefore, be brought in via a loading balcony through the adjacent staircase room. For lifting the equipment, a lifting hook with a capacity of 2-tons will be installed on the upper part of this balcony.

[3] Elevation Plan

The structural columns and beams will extend outside the building, enhancing the building design. Given that the columns and beams will not intrude into the staircase, the staircase will be able to comfortably handle traffic in both directions.

[4] Internal and External Finishing Plan

I. Finishing of Major Rooms (Radar Equipment Room and Observation Room)

a) Floor

The radar equipment room and the observation room will have an access floor with a clearance of 15cm for easy wiring of power and signal cables, trouble-free maintenance and simple future expansion. An antistatic, heavy-duty access floor has been selected for the radar equipment room in which a high power radar transmitter weighing about 1 ton would be installed.

b) External Walls

To combat the effects of local temperature and humidity, the external walls of the radar equipment room are designed as cavity walls which glass wool is sandwiched in for heat insulation. Because of the thermal insulation provided by the building design, the recurrent cost to the DMH for air-conditioning systems will be minimized.

c) Ceiling

The radar equipment cable rack, which is located in the radar equipment room and the observation room (the major rooms of the proposed radar tower building), must be protected against dust. In addition, so as to improve the air tightness of these rooms and to reduce equipment noise, the ceilings will be finished with acoustic boards. Since both of these rooms are to be air-conditioned, the use of ceiling

boards will also improve the efficiency of air-conditioning.

d) Window

The sustained wind pressures of the Radar Tower Buildings are as follows. A laminated glass with reinforced film will be used. In order to ensure double protection from wind and rain water entering into the room, two aluminum windows will be individually installed inside and outside.

- Kyauk Phyu Meteorological Radar Tower Building: 8,200N/m^2 (Height of windows of the Radar Observation Room from the ground level: approx. 25m)
- Yangon Meteorological Radar Tower Building: 4,500N/m^2 (Height of windows of the Radar Observation Room from the ground level: approx. 55m)
- Mandalay Meteorological Radar Tower Building: 2,700N/m^2 (Height of windows of the Radar Observation Room from the ground level: approx. 35m)

II. Material Plan

Materials specified for both the exterior and interior finishing, which are all available locally, have been selected with a view to ease maintenance for the DMH and are stated as follows.

Table 32: Finishing Materials of Proposed Meteorological Radar Tower Buildings

		Finishing Materials
Exterior Finishing	**Observation Deck**	Cement sand mortal base, Asphalt waterproofing, Insulation, Protection concrete, Base mortal, Cement tiles
	Roof Floor	Cement sand mortal base, Asphalt waterproofing, Insulation, Protection concrete, Base mortal, Cement tiles
	Walls	Concrete blocks Cement sand mortar base, Spray tile finish
Interior Finishing	**Floors**	Carpet tiles Vinyl tiles Porcelain tiles Cement sand mortal base, Epoxy resin paint finish
	Skirtings	Wooden skirting, Synthetic resin oil paint finish Cement sand mortar base, Vinyl paint finish Cement sand mortar base, Epoxy resin paint finish Porcelain tiles
	Walls	Cement Sand mortal base, Vinyl paint finish Glazed ceramic tiles Glass wool with glass cloth
	Ceilings	Acoustic panels (Grid ceiling system) Cement board (Grid ceiling system) Cement sand mortar base Emulsion paint finish Glass wool with glass cloth
Window and Door	**Exterior**	Aluminum windows and doors Aluminum grilles Aluminum doors, Steel doors
	Interior	Aluminum doors, Steel doors, Wooden doors

Table 33: Bases for Adoption of Materials
of Proposed Meteorological Radar Tower Buildings

		Bases for adoption of materials	Procurement
Exterior Finishing	**Roof Floor**	Since external temperatures are high (reaching over 35 degrees) an insulation board t=30mm will be required. Asphalt waterproofing is the most reliable waterproofing material to be protected by protection concrete, cement sand mortal and cement tiles.	To be procured locally
	Walls	Bricks will be applied. Bricks are generally used locally and are considered highly reliable in terms of both ease and accuracy of construction.	To be procured locally
Interior Finishing	**Floors**	Materials will be selected on the basis of superior durability and ease of maintenance. Vinyl tiles around offices, corridors and staircases will be applied. In rooms where dust must be avoided, a dust-proof paint finish will be specified.	To be procured locally
		In the offices where computer systems will be installed, access floors shall be applied for cabling under floor.	To be procured locally
	Walls	Cement sand mortal (trowel-coated) will be applied primarily for its durability, and vinyl paint will be applied to avoid dirt. Glazed ceramic tiles will be laid in the toilets and the slop sink booth.	To be procured locally
	Ceilings	In order to enhance the environment and efficiency of air-conditioning, non-asbestos acoustic mineral boards will be used. Other rooms which will not require any ceiling board will be directly applied with emulsion paint finish on cement and sand mortal.	To be procured locally
Windows and Door	**Exterior**	Aluminum and steel will be chosen all throughout for reasons of durability, ease of handling and accuracy.	To be procured locally
	Interior	Wooden and steel with synthetic oil resin paint will be employed throughout for its handling ease during construction and from a maintenance standpoint.	To be procured locally

[5] Structural Plan

I. Structural Design Standard

There is no exclusive structural design standard in Myanmar. A structural design is made according to a major structural design standard in Europe and the United States. For the Project, the Building Standard Law of Japan and other building codes for government facilities will be applied.

II. Soil Condition and Foundation Plan

To ensure radar observation accuracy, building robustness is important and the permissible horizontal deflection of the building must be not more than 0.075 degree. Due to this, the foundation structures must prevent the building differential settlement. The bearing layer and foundation of the Proposed Meteorological Radar Tower Buildings are indicated in the following table.

Table 34: Bearing Layer, Pile and Foundation of the Proposed Meteorological Radar Tower Buildings

	Kyauk Phyu Meteorological Radar Observation Station	Yangon Meteorological Radar Observation Station	Mandalay Meteorological Radar Observation Station
Depth of Bearing Layer	GL-3.1m	GL-51.5m	GL-36.2m
N value of Bearing Layer	Over 50	40-50	40-48
Piling	Not Required	Required	Required
Designed Pile Length	-	45.5m	32.5m
Required Number of the Designed Pile	-	24 pcs	16 pcs
Diameter of the Designed Pile	-	1.2m	1.2m
Foundation type	Spread foundation	Pile foundation (cast in site concrete)	Pile foundation (cast in site concrete)

III. Structure Type

Reinforced concrete has been selected as the construction material for the proposed radar tower buildings because reinforced concrete construction is the most typical structural type in Myanmar. The floor slabs are to be reinforced concrete while exterior walls and partition walls are made of locally procured bricks.

IV. Design Load

a) Dead load

The weight of all the structural and finishing materials has been included in the dead weight calculation for the radar tower buildings. The following combined weight as a special dead load will be considered.

Table 35: Weight of Meteorological Radar System Unit

Installation Place (Room Name)	Name of Meteorological Radar System Unit	Weight
Roof Top	Radom, Antenna and Pedestal	4.5 tons
Radar Equipment Room	Transmitter/Receiver, Signal Amplifier, etc.	3.0 tons
	Signal Processor, Antenna Controller	2.0 tons
Electricity Room	Isolation Transformer, Auto Voltage Regulator (for Equipment and Building) and Capacitor	6.0 tons

b) Live load

Since virtually most of all the major rooms in the radar tower buildings are equipment installation spaces, the live load of the radar tower buildings is deemed to be identical to that of telecommunication equipment rooms in Japan.

c) Wind load

Currently, the Myanmar Engineering Society has been preparing area wise basic wind speed (velocity) in Myanmar. For calculating the wind load of the proposed Radar Tower Buildings, the basic wind speed (Kyauk Phyu 140mile/hour: 62.6m/sec., Yangon 120mile/hour: 53.7m/sec., Mandalay 100 mile/hour: 44.7m/sec.) to be applied by the Myanmar Engineering Society will be utilized.

- $q=1/2\times1.22\times Vs^2$ $k=1/2\times1.22=0.61=1/1.639$ (constant)

- $F=Cf \cdot q \cdot Ac$

- F= wind pressure
- Cf= coefficient of wind force (due to building type and part)
- q= velocity pressure (Kg/m^2)
- Vs=design wind speed (m/s)
- Ac=projected net area (m^2)
- k=constant value (BS: =1/1.639)

d) Seismic load

Currently the Myanmar Engineering Society has been preparing the seismic load in Myanmar. Therefore, for calculation of the seismic load, the seismic zone factors matched with the Uniform Building Code 97, USA (Kyauk Phyu: Zone 2B, Yangon: Zone 2B, Mandalay: Zone 4) will be applied. The seismic base shear: C0 = 0.1 and the importance factor: I = 1.25 will be used, since the importance of the radar tower buildings is considered.

V. Structural Building Material

All the materials for the building structure will be procured in Myanmar.

- Concrete (conventional concrete)
  : specified concrete strength for Kyauk Phyu and Mandalay Fc= $21N/mm^2$
  : specified concrete strength for Yangon Fc= $24N/mm^2$ (Foundation to 10F Slab)
  Fc= $21N/mm^2$ (over 10F Slab)
- Cement : Japan Industrial Standard (JIS) or equivalent
- Deformed reinforcing bars : JISS or equivalent

[6] Electrical Facility Design

I. Power intake facility

Table 36: Power Intake Facility

	Kyauk Phyu Meteorological Radar Tower Building	Yangon Meteorological Radar Tower Building	Mandalay Meteorological Radar Tower Building
Intake Power (Nominal Voltage)	-	440V, 3-phase 4-wire, 50Hz	440V, 3-phase 4-wire, 50Hz

II. Power generating facility

Table 37: Power Generating Facility

	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Kyauk Phyu Meteorological Radar Tower Building	Yangon Meteorological Radar Tower Building	Mandalay Meteorological Radar Tower Building
Number of Engine Generator	1	2	2	2
Capacity	75KVA	75KVA	75KVA	75KVA
Output	400V, 3-phase 4-wire, 50Hz	400V, 3-phase 4-wire, 50Hz	400V, 3-phase 4-wire, 50Hz	400V, 3-phase 4-wire, 50Hz
Fuel Tank Capacity	1,000 liters	1,000 liters×2	1,000 liters	1,000 liters

III. Trunk line and power facility

Power will be distributed to the switchboard for lighting and to the electricity control panel from the distribution panel in the electrical room. The trunk line for distribution and the power line will use suitable cabling through conduits. An alarm for the power equipment will be shown on an alarm panel in the observation room. The electrical systems for the trunk line and branch circuits are as follows.

Table 38: Trunk Line and Power Facility

	Kyauk Phyu Meteorological Radar Tower Building	Yangon Meteorological Radar Tower Building	Mandalay Meteorological Radar Tower Building
Trunk line for power and lighting	400V/230V, 3-phase 4-wire	400V/230V, 3-phase 4-wire	400V/230V, 3-phase 4-wire
Branch power circuits	400V, 3-phase 4-wire	400V, 3-phase 4-wire	400V, 3-phase 4-wire
Branch lighting circuits	230V, single-phase 2-wire	230V, single-phase 2-wire	230V, single-phase 2-wire
Branch equipment circuits	400V, 3-phase 4-wire	400V, 3-phase 4-wire	400V, 3-phase 4-wire

IV. Lighting and power outlet

The voltage required for lighting and power sockets is a single-phase 230V and all the fixtures must be grounded. Steel pipes will be used for wiring conduits. Lighting fixtures will be mainly fluorescent, for their low power consumption, though incandescent fixtures will also be used to some extent, depending on a particular situation. The lighting levels in the various rooms will be approximately as shown below.

Table 39: Approximate Lighting Levels in the Various Rooms

	Kyauk Phyu Meteorological Radar Tower Building	Yangon Meteorological Radar Tower Building	Mandalay Meteorological Radar Tower Building
Radome Room	200 Lx	200 Lx	200 Lx
Radar Equipment Room	300 Lx	300 Lx	300 Lx
Observation Room	300 Lx	300 Lx	300 Lx
Maintenance Room	200 Lx	200 Lx	200 Lx
Engine Generator Room	200 Lx	200 Lx	200 Lx
Electricity Room	200 Lx	200 Lx	200 Lx
Pump Room	200 Lx	200 Lx	200 Lx
Entrance Hall	200 Lx	200 Lx	200 Lx

General-purpose power outlets will be equipped with switches. Dedicated power outlets are required in the radar equipment room, the observation room (including the data analysis space and the data storage space) and the maintenance room for the Project computing equipment.

V. Telephone system

A service terminal box and a relay terminal box will be installed inside the radar tower building and telephone lines will be installed to outlets in those rooms requiring a telephone.

VI. Intercom system

In order to control night shift personnel and visitors, intercom systems will be installed in the various operating rooms (radar equipment room and observation room) and outside of the building entrance, as a security measure.

VII. Alarm system

An alarm panel will be installed at the observation room. The following building equipment warnings will be provided.

- System failure of air-conditioning units in the radar equipment room
- System failure of radar power backup unit
- System failure and overheating of the engine generators
- Breaker tripping of the distribution boards

VIII. Grounding system

Grounding cables for the equipment installed on the 1st floor will be connected to the terminal box for earthing. All the equipment to be installed in the electricity room and the power supply room will be grounded via the terminal box, while the telephone equipment will be grounded by erecting a grounding electrode and running a wire from there to the terminal box.

IX. Lightning protection system

A lightning rod will be installed on top of the radome (included in the equipment portion of the Project), with roof conductors on the concrete handrails of parapets, the roof top, and the observation deck, to protect all the equipment and the radar tower buildings. A connection box will be placed at the radome room for the lightning rod. Inside the building structure, copper tapes will be laid in a vinyl pipe and grounded via the test terminal boxes.

X. Aviation obstruction light

A connection box for two obstruction lights on the top of the radome (which is part of the equipment portion of the Project) will be placed in the radome room. Four obstruction lights (LED), to be installed at the radome roof floor, will be included in the building portion of the Project. For all of the obstruction lights, two power distribution boards will be installed on the first floor and in the radar equipment room and an automatic blinking switch will be installed on the first floor. All the aviation obstruction lights will be furnished with surge arresters. Connecting work between the obstruction lights on top of the radome and a connection box placed in the radome will be included in the equipment portion of the Project.

XI. Fire detection and alarm system

Fire detectors will be installed in the radar equipment room, the electricity room and the engine generator room, and an alarm system will be installed in the observation room.

[7] Water Supply, Drainage and Sanitary Fixture Design

I. Water supply system

Public water supply is unavailable (the available public water service is extremely unstable and unusable). As such, the construction of a well is required for the construction work of the radar tower building at each site. After the construction phase, this well would be used as the water supply facility for the radar tower buildings. For the well water intake for the radar tower buildings, a water supply gate valve will be installed.

II. Drainage system

Drainage will be divided into 2 systems - sewage and miscellaneous drainage. Sewage will primarily be treated in a septic tank and then be permeated by a seepage pit into the ground. Miscellaneous drainage will be fed directly into a seepage pit. A septic tank and a seepage pit must be constructed. The capacity of the septic tank and seepage pit for the radar tower building has been designed for 12 DMH personnel in the operations area and for some visitors.

III. Sanitary fixtures

- Closet bowl: tank type western-style
- Urinal: stall type
- Washbasin: wall-mounted type
- Slop sink: wall-mounted type

IV. Fire extinguisher

Fire extinguishers will be supplied in the following rooms.

Table 40: Fire Extinguisher

	DMH Multi-Hazard Early Warning Center, Nay Pyi Taw	Kyauk Phyu Meteorological Radar Tower Building	Yangon Meteorological Radar Tower Building	Mandalay Meteorological Radar Tower Building
Radome Room	-	CO_2 type	CO_2 type	CO_2 type
Radar Equipment Room	-	CO_2 type	CO_2 type	CO_2 type
Observation Room	-	CO_2 type	CO_2 type	CO_2 type
Engine Generator Room	ABC type	ABC type	ABC type	ABC type
Electricity Room	-	CO_2 type	CO_2 type	CO_2 type
Pump Room	-	CO_2 type	CO_2 type	CO_2 type
Tea Kitchen	-	ABC type	ABC type	ABC type

[8] Air-conditioning and Ventilation System Design

Air-conditioning systems will be installed in the rooms listed below. It is essential to have a good operating environment, especially for the equipment in the radar equipment room and the observation room. Therefore, a substantial number of air-conditioning systems is indispensable. Package type air-conditioning systems have been selected to minimize any impact to the operation of the radar system if an air-conditioning system fails.

Table 41: Air-conditioning and Ventilation System

	Kyauk Phyu Meteorological Radar Tower Building	Yangon Meteorological Radar Tower Building	Mandalay Meteorological Radar Tower Building
Radome Room	Fan forced ventilation	Fan forced ventilation	Fan forced ventilation
Radar Equipment Room	Air-conditioning system Heat exchange system	Air-conditioning system Heat exchange system	Air-conditioning system Heat exchange system
Observation Room	Air-conditioning system Fan forced ventilation	Air-conditioning system Fan forced ventilation	Air-conditioning system Fan forced ventilation
Engine Generator Room	Fan forced ventilation	Fan forced ventilation	Fan forced ventilation
Electricity Room	Air-conditioning system Fan forced ventilation	Air-conditioning system Fan forced ventilation	Air-conditioning system Fan forced ventilation
Pump Room	Fan forced ventilation	Fan forced ventilation	Fan forced ventilation
Shower Room	Fan forced ventilation	Fan forced ventilation	Fan forced ventilation
Toilet (M & F)	Fan forced ventilation	Fan forced ventilation	Fan forced ventilation
Tea Kitchen	Fan forced ventilation	Fan forced ventilation	Fan forced ventilation

Ceiling fan forced ventilation will be installed in the tea kitchen and the toilets. Due to the heat generated by the equipment in the radar equipment room, the engine generator room, the electricity room, pump room, etc., forced ventilation systems will be adopted. Furthermore, appropriate ventilation systems will be installed in the other rooms to meet the following conditions.

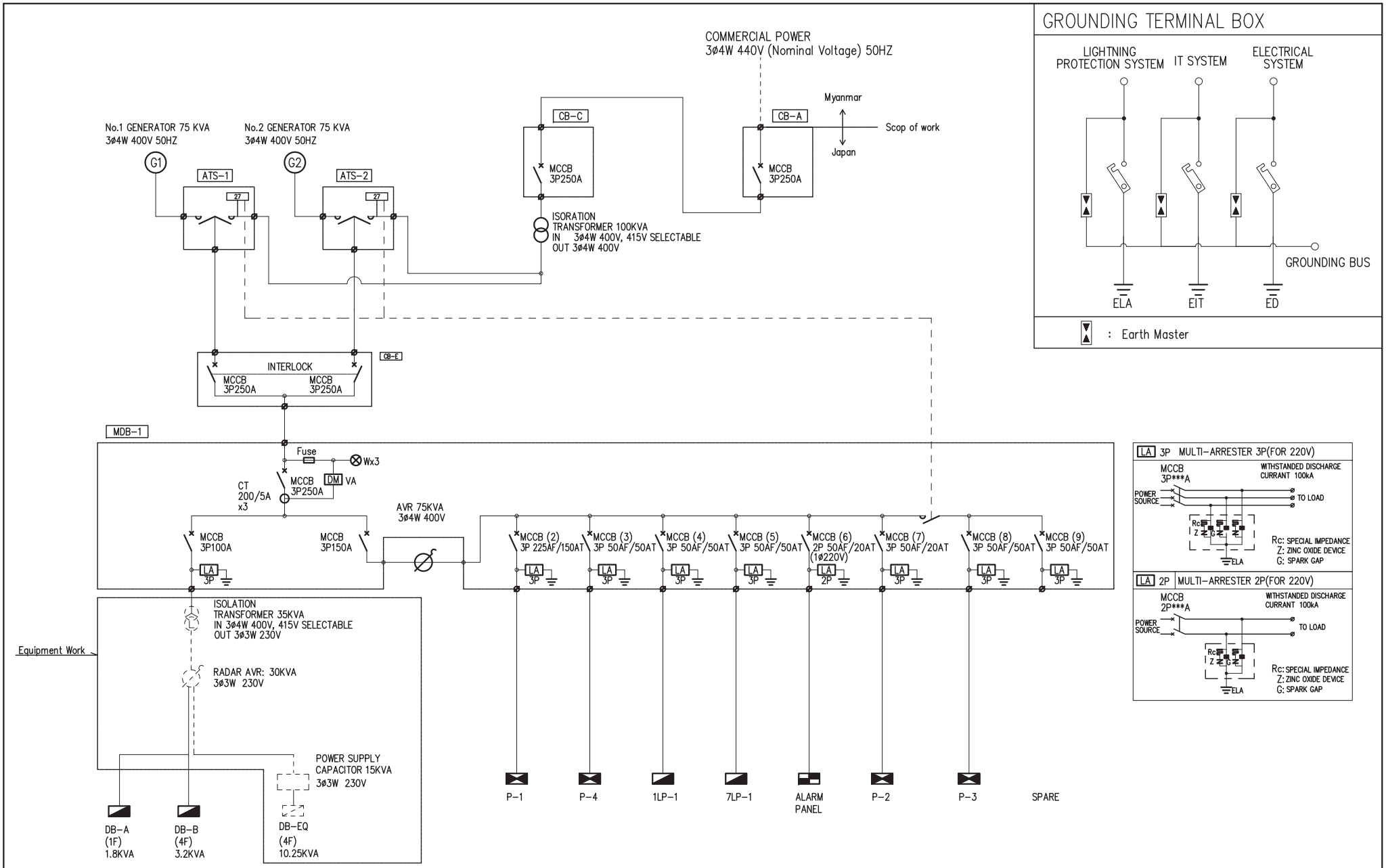
<Environmental conditions>

- Outside condition: 31°C (maximum temperature in 2102 Kyauk Phyu: 36°C, Yangon: 41°C, Mandalay: 42°C)
- Indoor condition: temperature 26°C humidity 40-60%
  In the radar equipment room and the electricity room: temperature 25°C humidity 40-60%

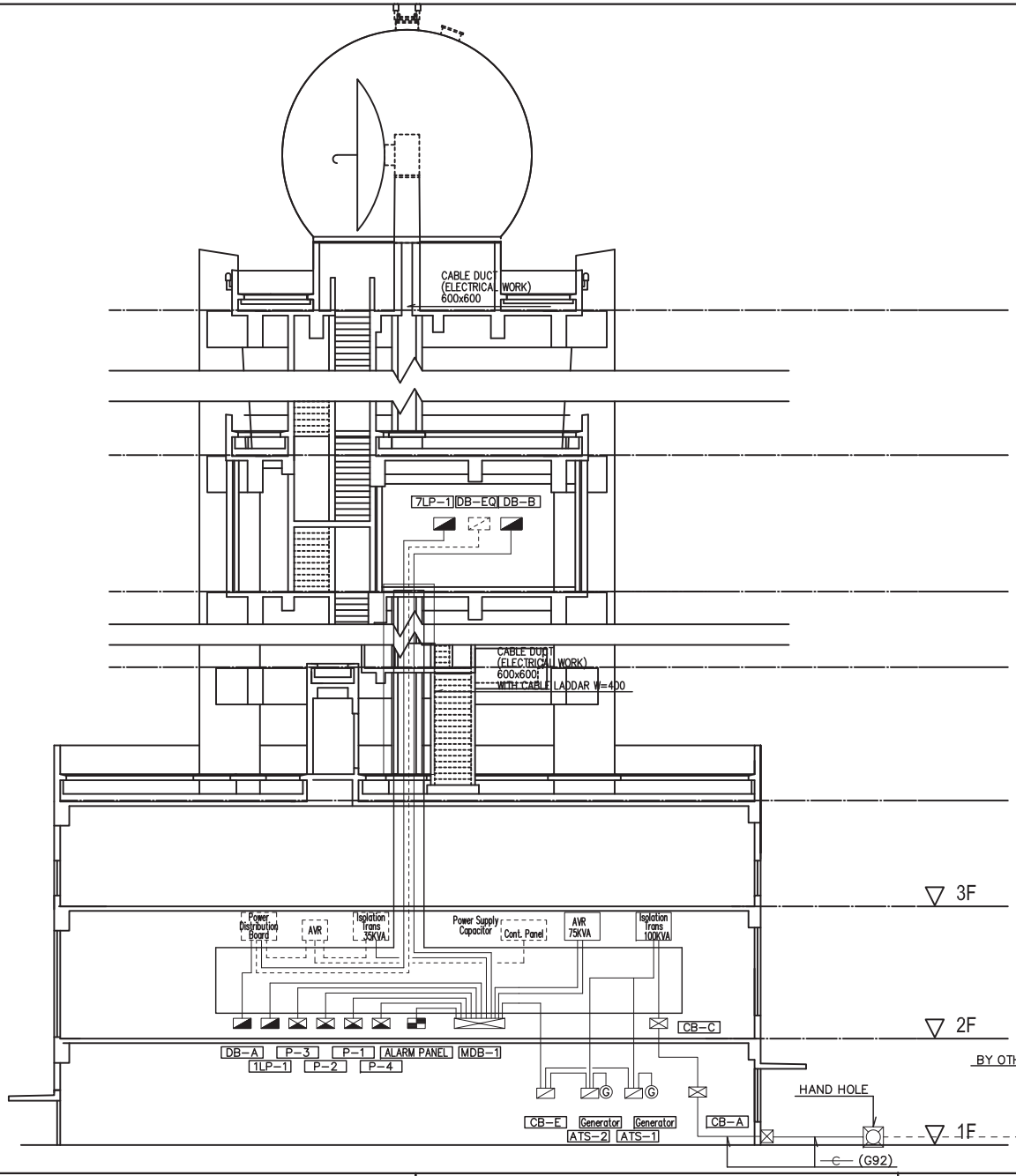
The diagrams of the building equipment plan for the radar tower buildings can be found in the subsequent pages immediately hereafter.

<Kyauk Phyu, Yangon and Mandaly Meteorological Radar Tower Building>

- Power Feeder Diagram : SD-01
- Power Riser System : SD-02
- Interphone System & Tel Diagram : SD-03
- Riser Fire Alarm System : SD-04
- Alarm System Diagram : SD-05
- Riser Diagram Lighting Protection & Grounding System : SD-06
- Riser Diagram Obstruction Lighting : SD-07
- Water Supply & Drainage System : SD-08
- Air-Conditioning & Ventilation Diagram : SD-09



Joint Venture of Japan Weather Association and International Meteorological Consultant Inc.	THE PROJECT FOR ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR	DRAWING TITLE METEOROLOGICAL RADAR TOWER BUILDING POWER FEEDER DIAGRAM	SCALE NONE / DRAWING No. SD - 01



POWER CABLE LIST

FROM	TO	CABLE SIZE	CONDUIT
CB-A	CB-C	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
CB-C	ISOLATION TRANS 100KVA	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
ISOLATION TRANS	ATS-1	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
ISOLATION TRANS	ATS-2	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
GENERATOR	ATS-1	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
GENERATOR	ATS-2	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
ATS-1	CB-E	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
ATS-2	CB-E	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
CB-E	MDB-1	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDAR
MDB-1	ISOLATION TRANS 35KVA(EQUIP WORK)	XLPE/PVC 4C-30sq +E22sq	(G50) / CABLE LADDAR
MDB-1	P-1	XLPE/PVC 1C-4x70sq +E50sq	(G70) / CABLE LADDAR
MDB-1	P-2	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDAR
MDB-1	P-3	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDAR
MDB-1	P-4	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDAR
MDB-1	1LP-1	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDAR
MDB-1	7LP-1	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDAR
MDB-1	ALARM PANEL	XLPE/PVC 2C- 6sq +E 6sq	(G32) / CABLE LADDAR
PowerDistributionBoard	DB-A	XLPE/PVC 2C-10sq +E10sq	(G40) / CABLE LADDAR
PowerDistributionBoard	DB-B	XLPE/PVC 2C-10sq +E10sq	(G40) / CABLE LADDAR
MDB-1	AVR 75kVA	XLPE/PVC 1C-4x95sq +E50sq	(G70) / CABLE LADDAR
AVR 75kVA	MDB-1	XLPE/PVC 1C-4x95sq +E50sq	(G70) / CABLE LADDAR

SPARE PARTS FOR LIGHTNING DAMAGE LIST

FROM	DESCRIPTION	UNIT
CB-A	MCCB 3P250A	1
CB-C	MCCB 3P250A	1
ATS-1	UNDER VOLTAGE RELAY	1
	CHANGE OVER SWITCH	1
	RELAY	4
MDB-1	MCCB 3P250A	1
	FUSE	6
	INDICATING LAMP	3
	VOLTAGE AMPERE INDICATOR	1
	ARRESTER 2P	2
	ARRESTER 3P	7
CB-E	MCCB 3P250A	1
	RELAY	4
	FUSE	4
GENERATOR	CONTROL CIRCUIT BOARD	1
	RELAY	4
	FUSE	4
	VOLT METER	1

EQUIPMENT WORK

Joint Venture of
Japan Weather Association and
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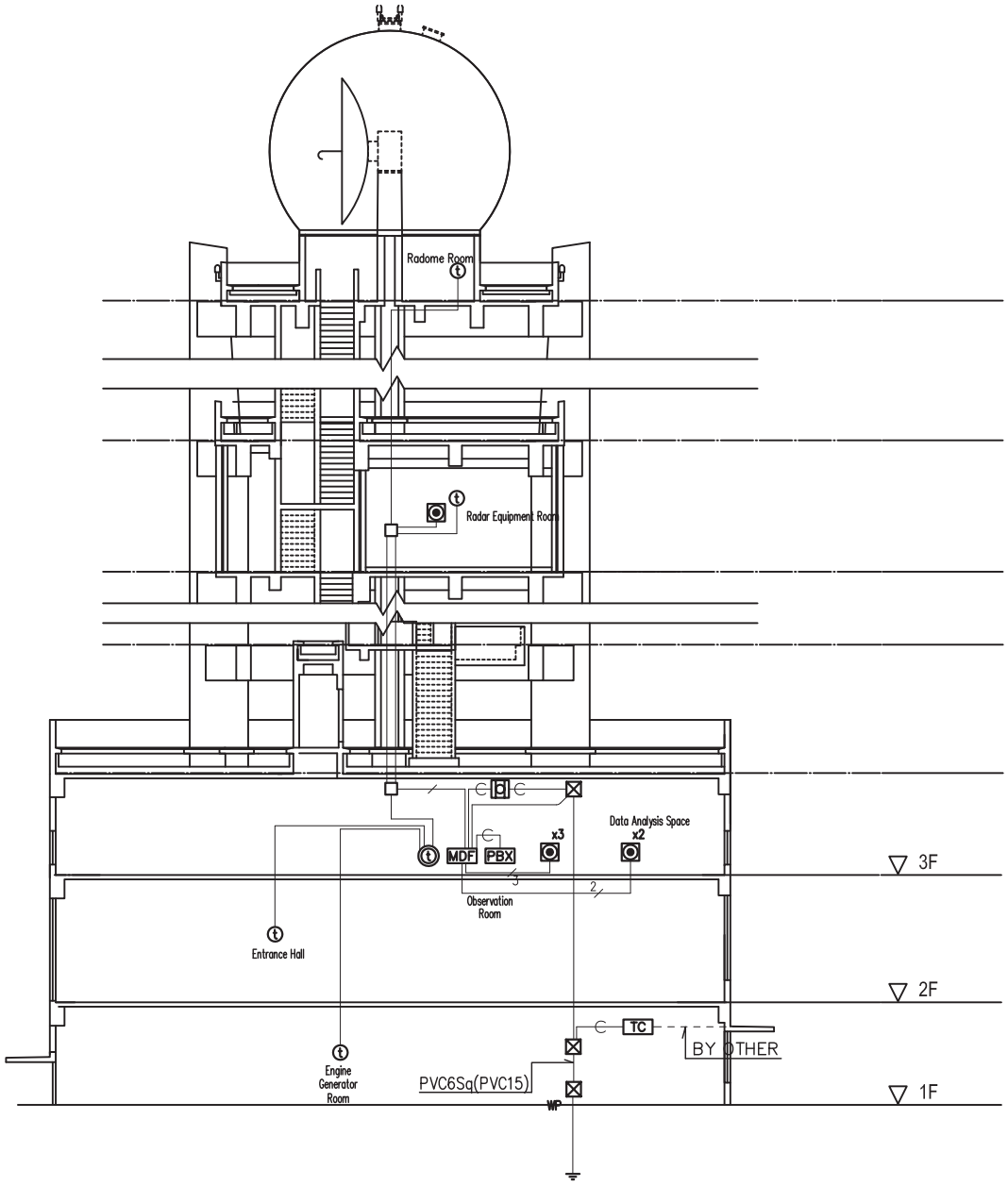
THE PROJECT FOR
ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM
IN THE REPUBLIC OF THE UNION OF MYANMAR

DRAWING TITLE
METEOROLOGICAL RADAR TOWER BUILDING
POWER RISER SYSTEM

SCALE
NONE

DRAWING No.
SD - 02



REMARK

- —C— : —C— (G36)
- —/— : TIEV 0.65−4C (G20)
- —/2— : TIEV 0.65−4Cx2 (G20)
- —/3— : TIEV 0.65−4Cx3 (G25)
- —/— : TIEV 0.65−4C (UNDER THE ACCESS FLOOR)
- —/2— : TIEV 0.65−4Cx2 (UNDER THE ACCESS FLOOR)
- —/3— : TIEV 0.65−4Cx3 (UNDER THE ACCESS FLOOR)
- —— : AE 0.9−2C (G20)
- —— : AE 0.9−2C (UNDER THE ACCESS FLOOR)
- PBX : PBX COT. 5L , EXT. 15L
- MDF : MAIN DISTRIBUTION FRAME 30P
- : TELEPHONE OUTLET (MODULAR JACK)
- : TELEPHONE OUTLET SLAB MOUNT
- : ARRESTER
- : INTERCOM (POWER SUPPLY FOR INTERCOM)
- : INTERCOM
- : PULL BOX 200x200x200 (WATER PROOF TYPE)
- TC : INCOMING TERMINAL FRAME

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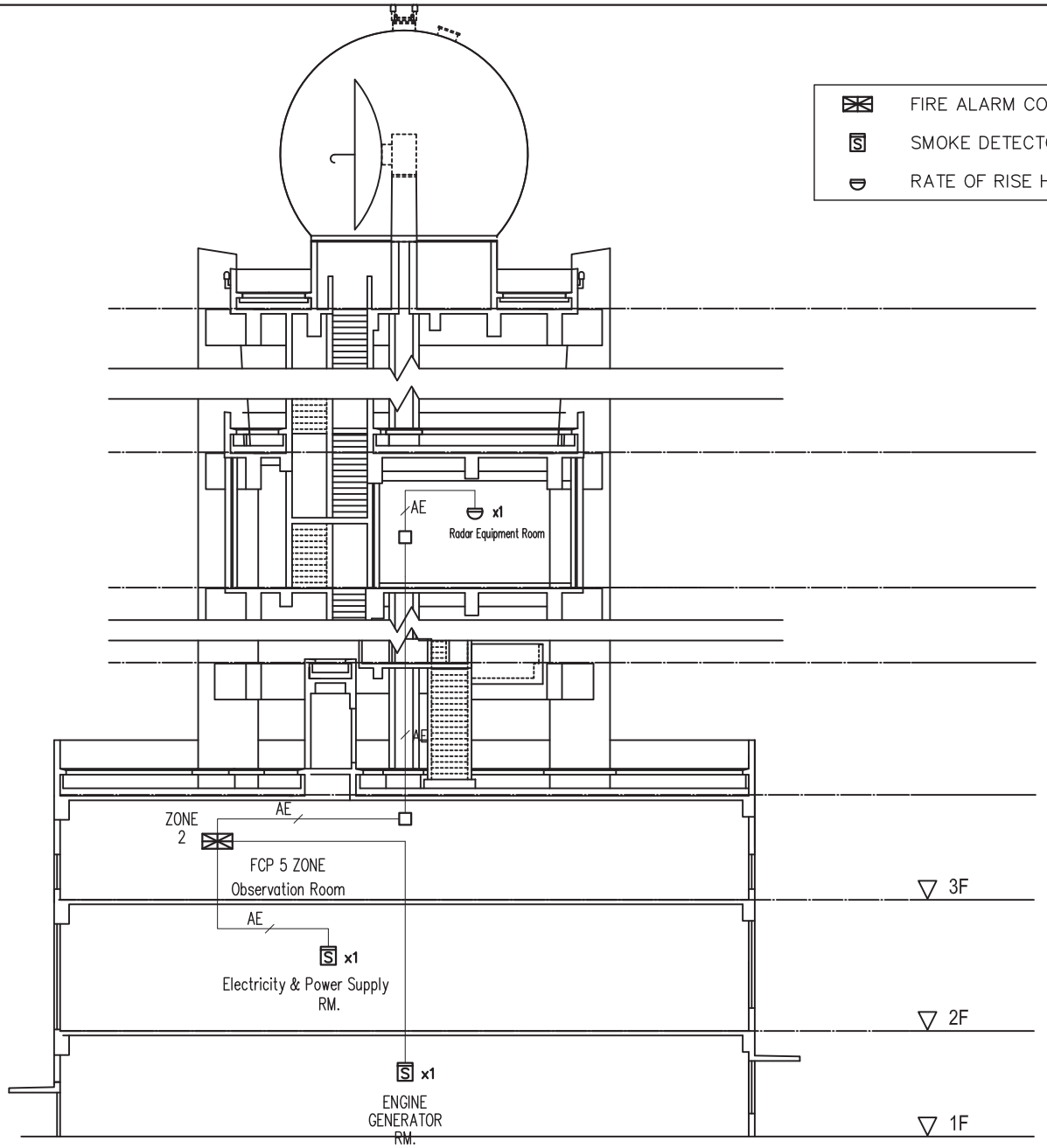
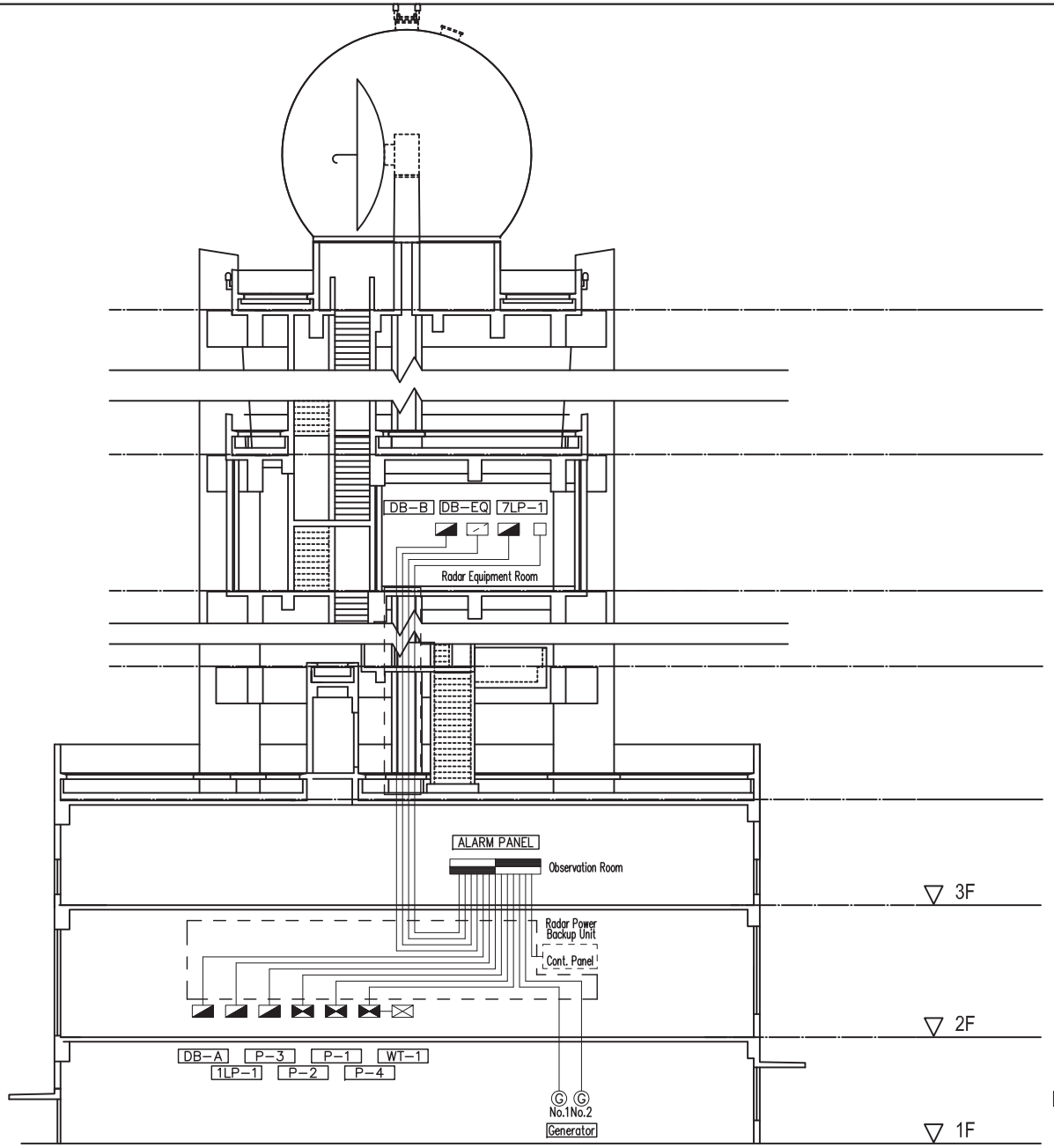
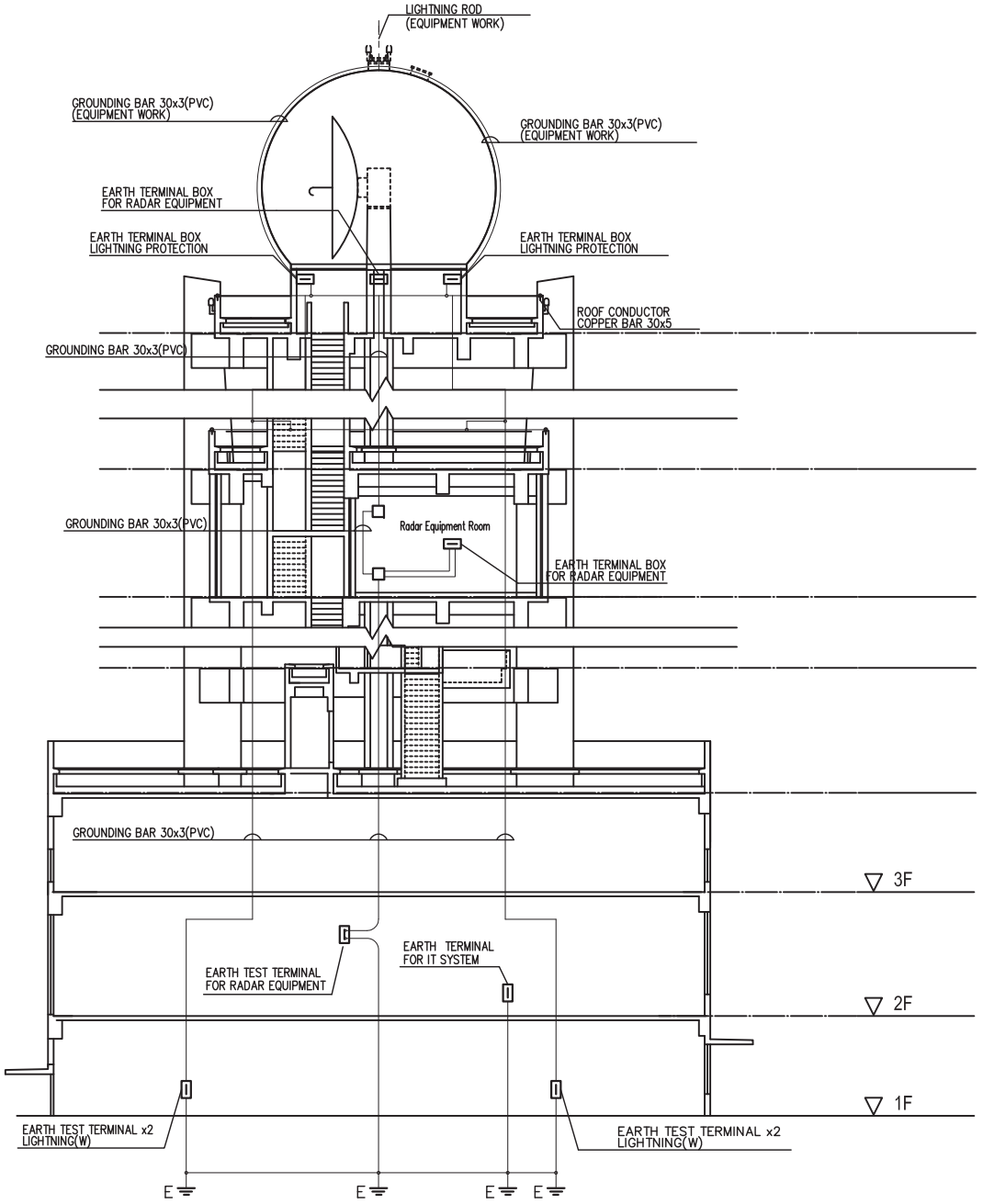


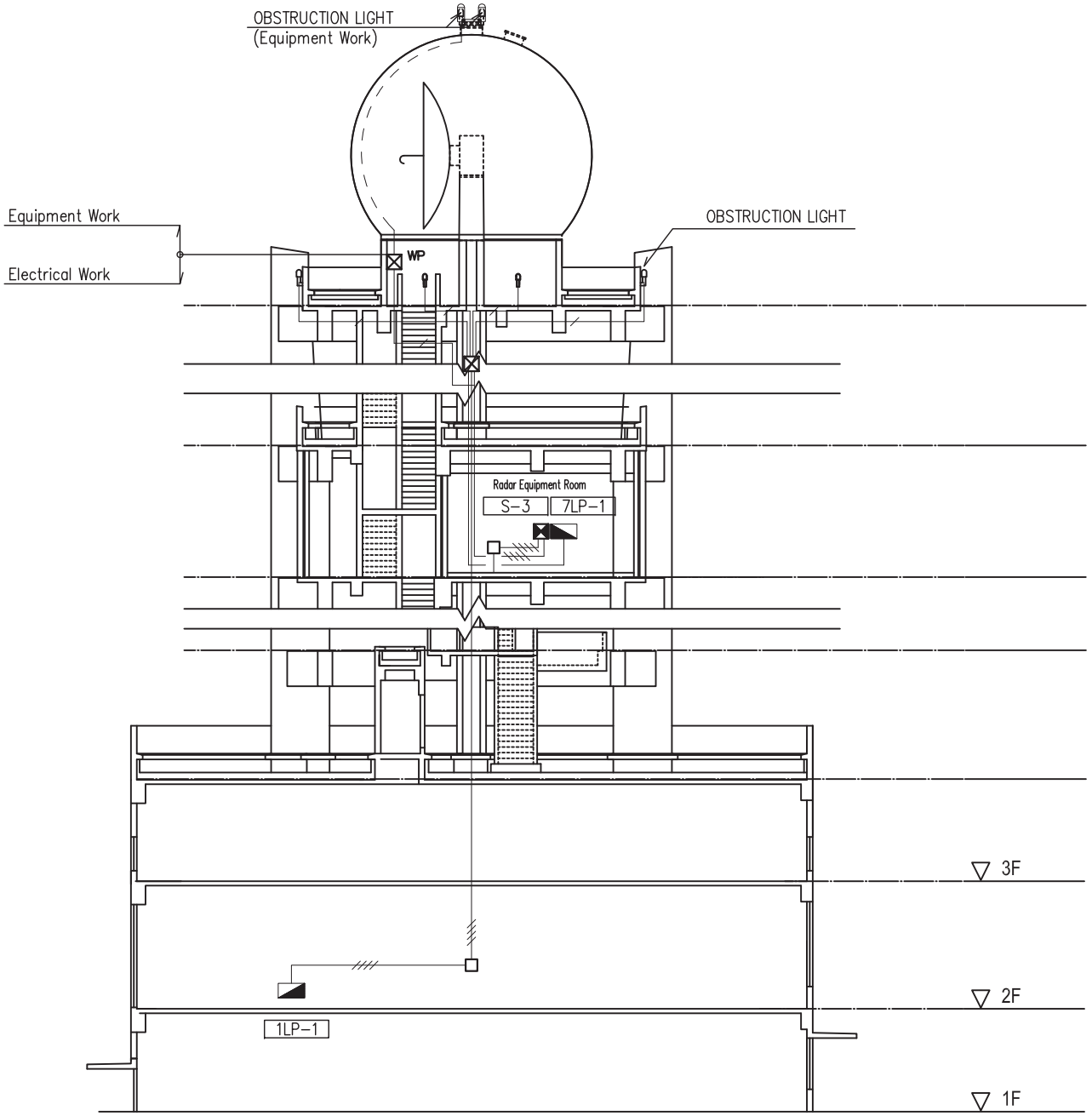
Joint Venture of Japan Weather Association and International Meteorological Consultant Inc.	THE PROJECT FOR ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR	DRAWING TITLE METEOROLOGICAL RADAR TOWER BUILDING RISER FIRE ALARM SYSTEM	SCALE NONE	DRAWING No. SD - 04



Joint Venture of Japan Weather Association and International Meteorological Consultant Inc.	THE PROJECT FOR ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR	DRAWING TITLE METEOROLOGICAL RADAR TOWER BUILDING ALARM SYSTEM DIAGRAM	SCALE NONE	DRAWING No. SD - 05



Joint Venture of Japan Weather Association and International Meteorological Consultant Inc.	THE PROJECT FOR ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR	DRAWING TITLE METEOROLOGICAL RADAR TOWER BUILDING RISER DIAGRAM LIGHTNING PROTECTION AND GROUNDING SYSTEM	SCALE NONE	DRAWING No. SD - 06



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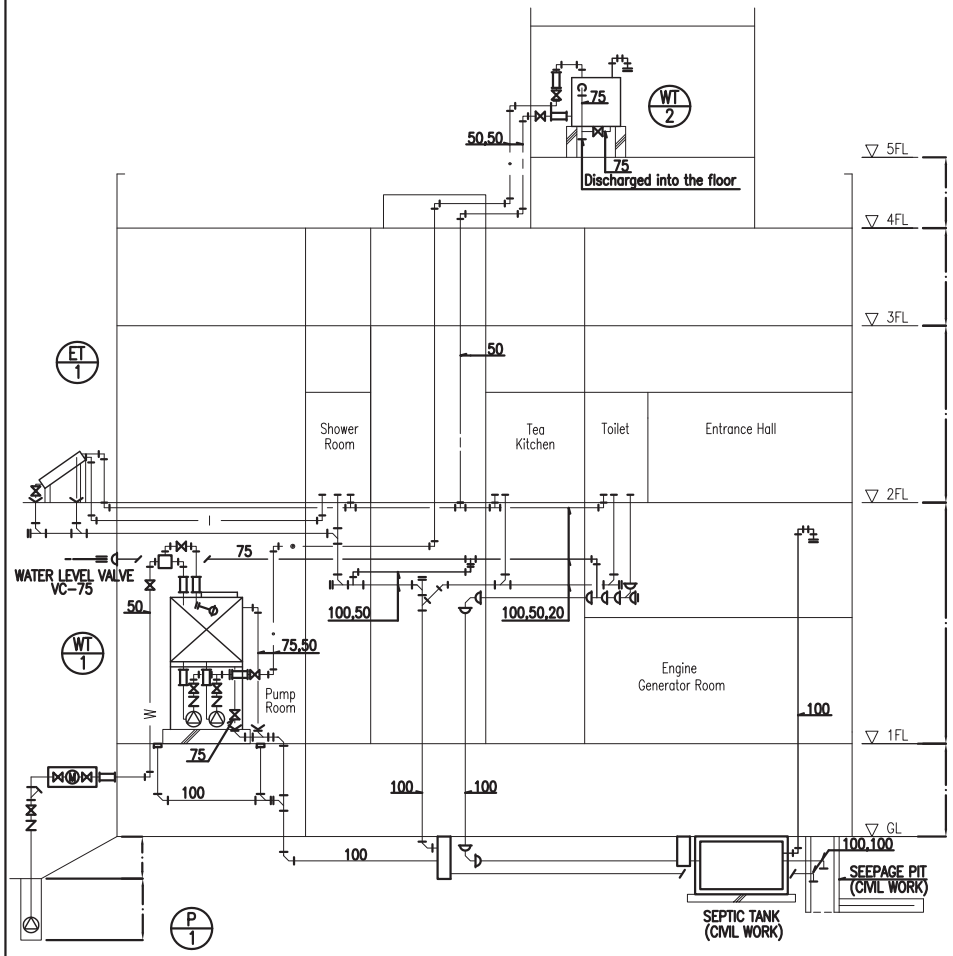

ITEM	1F	2F					TOTAL	REMARK
	PUMP ROOM	TOILET(M)	TOILET(F)	SHOWER ROOM	TEA KITCHEN	SERVICE		
WATER CLOSET		1	1				2	
LAVATORY		1	1				2	
PAPER HOLDER		1	1				2	
FAUCET	1	1	1		1	1	5	
MIRROR		1	1				2	
SHOWER HEAD				1			1	
KITCHEN SINK					1		1	
URINAL		1					1	
SERVICE SINK						1	1	

NO.	NAME	SPECIFICATION	Q'TY	POWER SUPPLY					LOCATION	REMARKS
				PHASE	VOLT (V)	FREQUENCY (Hz)	MOTOR (KW)	EMERGENCY POWER SUPPLY		
P-1	PUMP	Model : Deep Well Submersible Pump	1	3	440	50	7.5		Out door	
		Product made in stainless steel 150mm								
		40ϕ x 100 l/min x 1800 kpa								
		Accessories : Panel,Ball valve,								
		Check valve								
WT-1	POTABLE WATER	FPR Tank	1					O	Pump Room	RC FOUNDATION
	TANK / PUMP	Rated capacity 2.5 m^3								(CIVIL WORK)
		Dimension 1,000 x 1,500 x 2,000H								1.8x1.8x0.3mH
		Accessories Manhole 600ϕ Breather								
		Ball tap 25A , overflow and drain pipe 40A								
		Electrode 4P								
		Constant pressure type pump	2	3	440	50	1.5			
		40 ϕ x 100 l/min x 270 kpa x 2 pcs (1 spare)								
		Accessories Flexible connector for suction 40A								
WT-2	POTABLE WATER	FRP tank	1						5FL Roof	RC FOUNDATION
	GRAVITY TANK	Rated capacity 1.5 m^3								(CIVIL WORK)
		Dimension 1,000 x 1,500 x 1,500H								0.4x1.4x0.5mH
		Earth quake proof 2.0G(Wind –Proof type)								
		Accessories Flat frame 150H,manhole 600 ϕ								
		Electrode 4P								
ET-1	Solar heat water	Model : Natural circulation method type	1						2F Out door	
	heater	Dimension: Collector 1002x2002x60 (Two pieces)								
		Water storage tank 465x2008x505								
		Heat to collect Area : 4.02m^2								
		Water storage volume : 200 LIT								
ABC	FIRE EXTINGUISHER	ABC Dry chemical, wall hang	2						Each room	
		10 Lbs Discharge time 14 sec								
C02	FIRE EXTINGUISHER	Carbon dioxicide, wall hang	9						Each room	
		10 Lbs Discharge time 14 sec								
	SEPTIC TANK	Septic tank & Seepage pit (RC type, Civil work)	1						Out door	
	(CIVIL WORK)	Blower pump (Civil work)								

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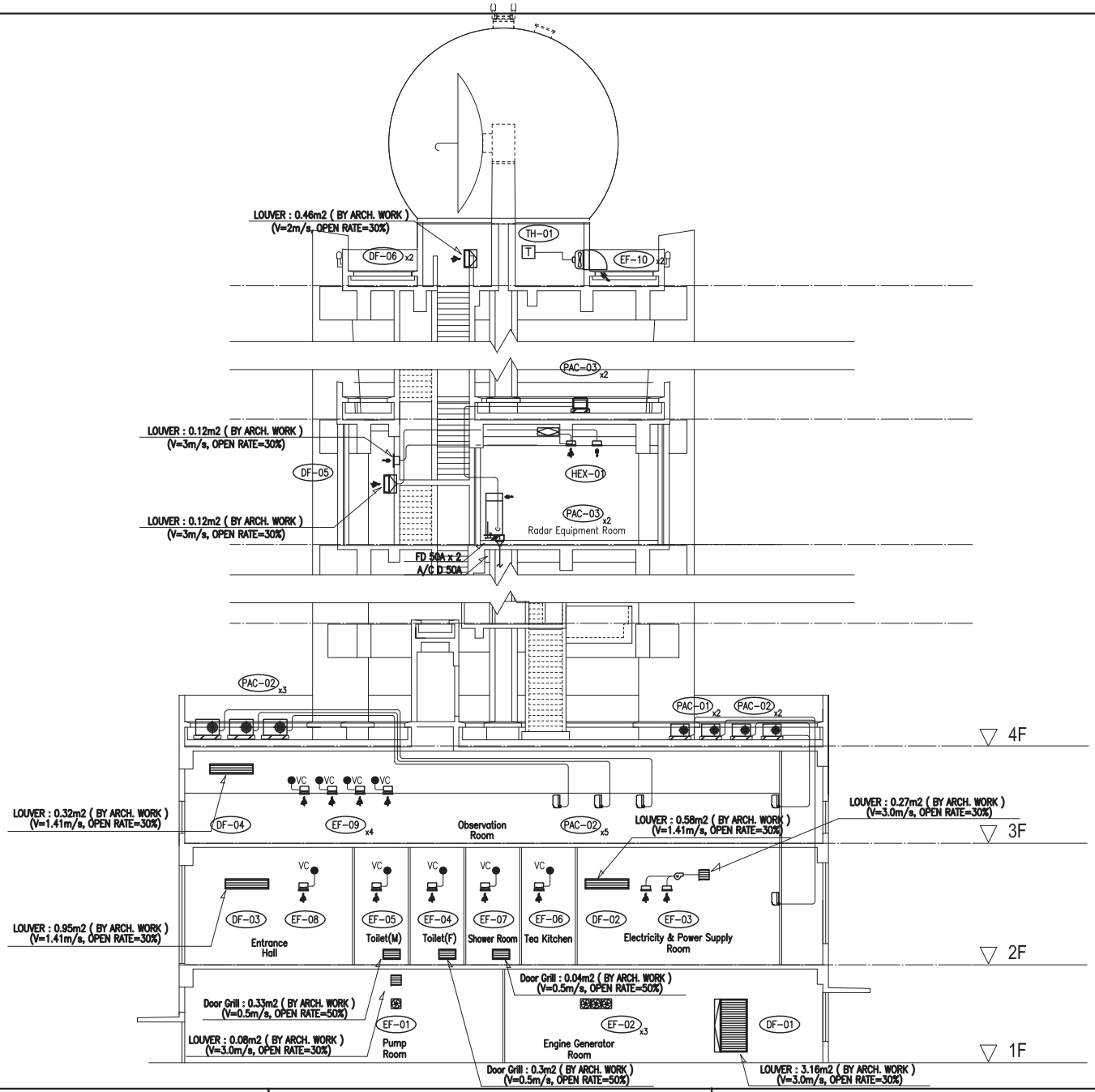
THE PROJECT FOR
ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM
IN THE REPUBLIC OF THE UNION OF MYANMAR

DRAWING TITLE
METEOROLOGICAL RADAR TOWER BUILDING
WATER SUPPLY & DRAINAGE SYSTEM

SCALE
NONE

DRAWING No.
SD - 08



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International Meteorological Consultant Inc.

THE PROJECT FOR

ESTABLISHMENT OF DISASTROUS WEATHER MONITORING SYSTEM

IN THE REPUBLIC OF THE UNION OF MYANMAR

DRAWING TITLE

METEOROLOGICAL RADAR TOWER BUILDING

AIR-CONDITIONING & VENTILATION SYSTEM DIAGRAM

SCALE

NONE

DRAWING No.

SD - 09