FACT-FINDING AND NEEDS-ASSESSMENT MISSION
TO ASSESS THE CURRENT STATUS AND REQUIREMENTS
OF THE MALDIVES METEOROLOGICAL SERVICE
Ministry of Environment and Energy
Malé, Republic of Maldives
6 to 13 June 2013 & 23 June – 4 July 2013

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EXECUTIVE SUMMARY

The fact finding/needs assessment mission was conducted by the World Meteorological Organization (WMO) with a view to assess the state of the Maldives observing system and make recommendation for improvements.

The mission has found that the National Observing System needs to be upgraded to serve its purpose as planned: Approximately half of the network is not functioning; the availability of data is low; quality of data is in question; and a competency of the maintenance staff is low due to lack of specific technical training. In addition, the organizational structure of the Maldives Meteorological Service (MMS) needs to be reviewed with a view to support integrated management and operation of the National Observing System at the international standard. The current National Observing System of MMS raises the public liability concerns and could be a potential risk factor to the safety of aviation. Recommendations are proposed to improve the operations and maintenance of the Maldives national observing system and aviation met services.

With respect to the implementation of the Quality Management Systems (QMS), as required by ICAO for the provision of meteorological services to aviation, the short-term recommendations are directly linked to the provision of services to aviation and should receive the highest priority. The medium-term recommendations may be equally important as they are critical for the overall functioning of the Maldives national observing system, nevertheless, are regarded as lower priority.

Short-term recommendations

Operations:

1. For uninterrupted operations, spare and calibrated pressure and wind sensors are needed to be in stock ready for a replacement in case of a need at the major airports.
2. A new wind observing system with calibrated sensors has to be installed at the runway threshold area according to WMO/ICAO guidance for better provision of data representing take-off and landing areas.

Calibration and Maintenance:

3. MMS should arrange for a calibration of digital barometers and wind sensors used at major airports. This could be done at one of the Regional Instrument Centres (RIC Tsukuba or RIC Beijing).
4. Three rooms should be allocated to maintenance service staff: (1) for electronic equipment and sensors, (2) for non-electronic instruments, structures, supports, screens, etc, and (3) for storage of spare parts and consumables.

Capacity Development:

5. MMS should arrange for a training of technicians so that maintenance and calibration of the critical instruments for aviation can be done regularly. In addition to factory training, the mechanism of the Regional Meteorological Training Centres (RMTC) should also be used.
6. MMS should arrange for the training for already employed forecasters with BSc to become WMO meteorologists. WMO can coordinate a fellowship programme with neighboring countries (like India) with possibility of cost sharing. MMS should in future recruit BSc holders to shorten the time of training them to become meteorologists.

Implementation of QMS:

7. The ICAO deadline for the implementation of QMS in aeronautical meteorological services was 15th Nov 2012. MMS should consider hiring the services of an experienced consultant to guide the QMS implementation as soon as possible. This will ensure that the MMS becomes compliant within the next 9 to 12 months.

Medium-term recommendations

Operations:

1. Even if the existing internet connection to RTH New Delhi and RTH Melbourne seems to be quite reliable, consider re-installing VSAT link. Combination of the two will provide more sustainable communication solution for providing and receiving data from GTS.
2. As a first step to improve the availability and quality of data, MMS should implement a system for a semiautomatic production of WMO codes (SYNOP, CLIMAT, METAR, and SPECI) and an automatic quality control of data from both manual and automatic stations. For this purpose MMS should purchase observer workstations for major airports.
3. The Stevenson screen is placed close to the artificial sources of heat. MMS should look for an opportunity to move the whole meteorological station to a new position within the airport with more suitable environment so that data better represent airport region.

Calibration and Maintenance:

4. MMS should perform calibration and maintenance in regular intervals according to WMO practices (see WMO Guide to Meteorological Instruments and Methods of Observation, WMO-No.8). MMS should collaborate with the Regional Instrument Centres (RICs).
5. MMS should decide on a minimum configuration of manual and AWS stations that would allow MMS to fulfill its mandate.

Capacity Development:

6. MMS should continuously allow for training and re-training of its staff, especially observers and instrument technicians:
   - Use EEC visit to maintain and calibrate weather radar as the on-site training of all technicians. For remaining issues, MMS should arrange for factory training at EEC.
   - One more technician should be trained for seismic systems.
   - Arrange for a refresher course for trainers of observers at one of the WMO RMTC is advisable.
   - MMS should order detailed technical guidance material from manufacturers, some could be downloaded from their website, and document those available.
   - MMS should become familiar with the WMO Guide to Meteorological Instruments and Methods of Observation WMO-No.8; it should be used in training of observers and technicians.

Management:

7. MMS should consider a creation of an Observing Division with an integrated responsibility for operation, maintenance and repair of all observing stations (both manual and automatic) with a technician position at the major manual stations in remote islands.
8. MMS should also consider a creation of a Training Unit with a responsibility for education programmes, curricula, preparation of training material, conduction of training and preparation of Observers' Handbook.
9. The essential metadata of the national observing networks have to be included in the WMO Publication No. 9, Volume A.
10. MMS should nominate a national focal point (NFP) for Weather Radar Database, the Implementation Plan for the evolution of global observing systems (EGOS-IP) and the WMO Integrated Global Observing Systems (WIGOS).
11. A Change management process should be established for further automation of MMS National Observing Network.
12. MMS should develop a business case for operation and maintenance of AWS. In doing so use existing opportunities, such as collaboration with Mobile network providers and tourist resorts on remote islands.
13. The cost recovery for meteorological services to international air navigation can be considered using WMO Guidance, Doc 904 as a viable solution to resource the implementation and maintenance of QMS and Competency assessment. There is need for an Act of Parliament for MMS to become an independent or semi-autonomous entity, where they have permission to collect and use/retain revenue generated from aviation.

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1. REASONS FOR THE MISSION

1.1. The mission was undertaken following the request for the fact finding/needs assessment mission to the Maldives by Mr Abdullahi Majeed, the Permanent Representative of the Republic of Maldives with WMO, and the invitation of the Minister of Environment and Energy, Dr Mariyam Shakeela, during her visit to WMO on 28 February 2013. The objective of the mission was to assess the current status and requirements of the Maldives Meteorological Service (MMS).

2. SCOPE OF THE MISSION

a) Assess the state of the weather radar, automatic weather stations, wind systems and digital aviation barometers;
b) Identify ways and means how WMO could assist in instrument/equipment calibration and maintenance;
c) Assess the need for training of meteorological technicians;
d) Make recommendations for improvements of the national observing system.

3. INTRODUCTION

3.1. Geography and Climate

3.1.1. The Republic of the Maldives (Maldives) is an island nation in the Indian Ocean consisting of a double chain of twenty-six atolls oriented north-south of the length of about 900 km from the far north to the far south islands. The chains stand in the Laccadive Sea, about 700 kilometers south-west of Sri Lanka and 400 kilometers south-west of India. The Maldives atolls encompass a territory spread over roughly 90,000 square km, making the country one of the worlds's most geographically dispersed. Its population of 328,536 (2012) inhabits 192 of its 1,192 islands.

3.1.2. The Maldives is the smallest Asian country in both population and land area. With an average ground level of 1.5 m above mean sea level, it is the planet's lowest country. It is the country with the lowest natural highest point in the world at the level of 2.4 m. The Maldives is one of the most endangered nation due to flooding from climate change. Inundation and sea-level rise is therefore a great concern for the Maldivian people.

3.1.3. The Maldives is located at the equator and experiences monsoonal climate. It has two distinct seasons: (a) dry season (northeast monsoon) and (b) wet season (southwest monsoon). In these two seasons the temperature varies very little. Northeast monsoon extends from January to March, with the change over period in April then Southwest monsoon from May to November with December being the changeover to Northeast monsoon. Daily temperature ranges from around 31 degrees Celsius during the day to 23 ^{o}C at night. The mean daily maximum temperature for central

parts (Hulhulé) is 30.5 ^{o}C and minimum temperature is 25.7 ^{o}C. During the wet season (Southwest monsoon) from May to November, the Maldives experiences torrential rain.

3.1.4. This type of tropical maritime climate creates harsh environment for instruments' operations. Therefore, a careful selection of instruments and more importantly their regular preventive maintenance is a precondition for reliable operation of instruments and observing systems. The difficult weather and climate conditions require a careful design of the observing network.

3.2. Maldives Meteorological Service (MMS)

3.2.1. A meteorological service was established in Maldives in the early 1940s. The meteorological service underwent several breaks during these years and functioned under different government offices including Wireless Office, Customs, Prime Minister's Office and the Airport Office. The Meteorological Centre was created as a section of the Airport Office on 1 August 1974. On 1 July 1980 the Department of Meteorology was established as an independent office reporting to the President's Office. The Department of Meteorology remained functioning under the Head of State's Office until November 1993. After that, the Meteorological Department was brought under the Ministry of Planning, Human Resources and Environment and Physical oceanography and seismology was included into a responsibility of the Department. In November 1998, the Department became an office reporting to the newly formed Ministry of Home Affairs, Housing and Environment and currently it is under the Ministry of Environment and Energy.

3.2.2. Maldives Meteorological Service is headed by the Director General. Under his direct responsibility are the Management unit and the Weather Service Division (WSD). The Deputy Director General is the head of the WSD. Under WSD there are the National Meteorological Centre (NMC) and Regional Weather Service (RWS). Within the National Meteorological Centre Malé, located at Hulhulé Island with an international airport, there is a Climate section, an Observatory and a Meteorological Watch Office. The Observatory is the principal MMS manned observing station. It is named Malé even if it is not on Malé Island. Under RWS, there are four regional meteorological offices: (a) Haa Dhaal Hanimaadhoo Meteorological Office, (b) Laamu Kadhdhoo Meteorological Office, (c) Gaaf Dhaal Kaadedhdhoo Meteorological Office, and (d) Seenu Gan Meteorological Office. Regional meteorological offices are operating manned observing stations with the synoptic, aviation and climatological observing programme. Seenu Gan Meteorological Office performs also upper-air sounding programme. In total, MMS service has about 106 employees. Out of them, 18 observers in Malé (Hulhulé) station, 9 at Hanimaadhoo, 9 at Kadhdhoo, 8 at Kaadedhdhoo and 17 observers at Gan. Daily weather, aviation and marine forecasts and weather warnings are issued from National Meteorological Centre located at Hulhulé international airport.

3.2.3. A Support Service, under the Director of Management, is responsible for maintenance of all kind of equipment used in the whole MMS, including observing, communication, data processing and instruments and systems. The challenge of the five technicians employed in the Support Service is the maintenance of instruments spread around the vast territory of Maldives. The other challenge is to keep trained technicians in MMS. Currently, all technicians that received training for instruments installed at MMS have all left the services for private sector.

3.2.4. Several staff of MMS assisted in this Fact-finding and Need-assessment mission and their information was invaluable for the correct assessment. All staff members that were consulted showed a great deal of enthusiasm and dedication. The list of the staff that assisted a consultant is in Annex 1.

3.3. RESULTS OF THE FACT FINDING/NEEDS-ASSESSMENT AND RECOMMENDATIONS

3.3.1. Manned Observing Stations of the National Observing Network

3.3.1.1. Five manually operated stations registered in the WMO Weather Reporting Publication No. 9, Volume A (Observing Stations) are also recorded in the Regional Basic Synoptic Network (RBSN) and the Regional Basic Climatological Network (RBCN). Five stations recorded as surface, one as upper-air and two as climatological stations:

- 43533 HANIMAADHOO (06 44 47N/73 10 07E); RBSN
- 43555 MALE (04 11 30N/73 31 45E), GSN, RBCN, RBSN
- 43577 KADHDHOO (01 51 30N/73 31 11E); RBSN
- 43588 KAADEDHDHOO (00 29 18N/72 59 46E); RBSN
- 43599 GAN (00 41 36S/73 09 20E); GUAN, RBCN, RBSN(SYNOP/TEMP)

3.3.1.2. Observations are made hourly for the aviation purposes (METAR). Synoptic observations (SYNOPs) are done in the main and intermediate hours and are transmitted through GTS every 3 hours. Measured data are digitized and stored. Dissemination is done through the 10 Mbps Internet connection to RTH New Delhi (primary) and RTH Melbourne. Ingestion of reports into GTS is done manually through the MESSIR-COMM system from COROBOR. VSAT (256 kbps) was used as a back-up, however it is not working now. ***Recommendation 1:*** *Even if internet connection seems to be quite reliable, consider re-installing VSAT link. Combination of the two will provide more sustainable communication solution.*

3.3.1.3. The availability of SYNOP, TEMP and CLIMAT reports received at MTN Centres during the 6 year period from 2007 to 2012 is in the table below. The unavailability of TEMP report is due to lack of consumables that allows only for one sounding a day. Unavailability of CLIMAT is likely due to the insufficient training of observers. However, there has been a significant increase of SYNOP reports in the last three years. This is mostly due to better training of observers in making SYNOP reports and improved manual ingestion into the GTS through the MESSIR-COMM terminal. In many case reports are disseminated but RTH New Delhi is not receiving data. In some cases RTH Melbourne receives data while RTH New Delhi not. This shows that a problem may resist in MESSIR-COMM local communication system. Technicians do not have enough training to reinstall/update MESSIR-COMM software or routing catalogue and investigate this problem further. ***Recommendation 2:*** *Arrange for training of two technicians to master MESSIR-COM and integrated workstations MESSIR-AERO and MESSIR-VISION.* Internet connection is likely responsible for missing reports on the side of RTHs. The reduced availability of data is therefore most likely due to the problems inside as well as outside of MMS.

Year	Number of stations / Percentage of reports (%)					
	Surface / SYNOP		Upper-air / TEMP		Climatological / CLIMAT	
2007	05	76%	01	50%	02	00%
2008	05	46%	01	13%	02	50%
2009	05	07%	01	00%	02	00%
2010	05	18%	01	47%	02	00%
2011	05	13%	01	43%	02	50%
2012	05	86%	01	50%	02	50%

(Source: AGM-IWM-SMM – RBSN/RBCN)

3.3.1.4. There is no formal data quality control process in place, except of manual control by observers themselves and forecasters. Observers manually write WMO coding messages into a MESSIR-COMM system that has no possibility to check whether WMO codes are compiled according to agreed practice. In case of error within a code message, this may be successfully

sent by MESSIR-COM to RTH, however, such message may be rejected by RTH. ***Recommendation 3***[1]***:*** *Consider purchase of an observer workstation for a semiautomatic production of WMO codes (SYNOP, CLIMAT, METAR, and SPECI) and automatic quality control of data. This will assure that reports are compiled according to an agreed WMO standard practice. Automatic data quality control will eliminate errors in coding, thus increasing availability of reports in RTH.*

3.3.1.5. Malé observing site (located at Hulhulé Island) was the only one visited. Standard manual equipment are used (dry and wet-bulb Casella type liquid-in-glass thermometers and Casella simple rain gauge) supplemented by a digital wind system and digital barometer (described below). Casella simple rain gauge is a type used for schools with a very small orifice area. There are enough spare parts for sustained operation, except of barometers (see below).

3.3.1.6. The site of Malé observing station is on a flat horizontal land very close to artificial heating sources. According to the WMO Siting classifications for surface observing stations on land (Guide to Meteorological Instruments and Methods of Observation, WMO-No. 8, Annex 1.B, 2008 edition, updated in 2010), this site would be classified category 4 for temperature (with additional estimated uncertainty added by siting up to 2℃) and category 3 for rainfall (additional estimated uncertainty added by siting up to 15 per cent). Observers' room is modern but does not provide unobstructed view over the area. ***Recommendation 4:*** *As a short term solution relocate the Stevenson screen from its current position into the middle of the enclosure.* Artificially protect rain gauges against the wind. ***Recommendation 5:*** *Look for an opportunity to move the whole meteorological station to a new position within the airport with more suitable environment so that data better represent airport region.*

3.3.2. **Digital Barometers**

3.3.2.1. Five Vaisala digital barometers (PTB220 transmitter) are installed at each manned station connected to a local internet. Sensor and display are is in the observers' room. QNH and QFE readings are calculated by a formula provided by manufactures and are to be considered according to the WMO standard. All barometers are operational; however, in Male station only one of the three pressure cells is working.

3.3.2.2. System operation is monitored manually by observers. Also quality control of data is done manually by observers. ***Recommendation 6:*** *Consider purchase of an observer workstation (see Recommendation 3) that can monitor data flow automatically and can quality control of data.* Data are provided also to aviation authority (through METARs also to AFTN) and are stored in the dedicated server at MMS.

3.3.2.3. No preventive maintenance is being done. ***Recommendation 7:*** *A portable standard*[2] *should be purchased to adjust barometers thus ensuring correct readings at the ambient values.* Note: temperature and pressure varies little throughout the year. There are no spare parts available. In an emergency, Vaisala PTU 330 Transmitter that is on the stock could be used, however it is also not calibrated. If spare parts would be available, repair could be done within a week. Taking into account that manual stations are located at islands with airports, the period needed for repair is unacceptable. ***Recommendation 8:*** *A back-up system is needed to allow for an uninterrupted operation, preferably using three pressure cells barometer for a redundancy and higher confidence. As a minimum, two spare barometers should be in kept in the stock to allow for a repair and/or calibration of the field instruments.*

3.3.2.4. Barometers were never calibrated since the installation in January 2008. If the barometers are not calibrated, it is unlikely that MMS can be certified as required by ICAO.

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[1] This action is generic, covering compilation of WMO codes, monitoring of data flow and quality control of data

[2] Portable standard should be used for T, H, P

Recommendation 9: *Arrange for a calibration of digital barometers at RIC Tsukuba or RIC Beijing. Request WMO to assist if needed.*

3.3.3. **Digital Wind Systems**

3.3.3.1. Five digital Vaisala wind systems installed at each manned station using WAT12 and WAC155 RS 485 transmitter. All five wind systems are operational.

3.3.3.2. System operation is monitored manually by observers. Also quality control of data is done manually by observers. ***Recommendation 10:*** *Consider purchase of an observer's workstation to monitor the flow of wind data and for the automatic data quality control (See Recommendation 3).* Data are provided also to aviation authority (through METARs and AFTN) and are stored in the dedicated server at MMS.

3.3.3.3. Preventive maintenance is done twice a year and there are spare parts available. A possible repair can be done within a week. ***Recommendation 11:*** *A redundant wind system is needed for an uninterrupted operation (see also recommendation 13 below).*

3.3.3.4. Wind sensors were never calibrated since the installation in January 2008. If the wind sensors are not calibrated, it is unlikely that MMS will be certified as required by ICAO. ***Recommendation 12:*** *Arrange for calibration of wind sensors at RIC Tsukuba or RIC Beijing.*

3.3.3.5. Wind system in Malé station is located on the top of 15 meter tall mast, some 10 meter above the top of the adjacent buildings. The correction of 10 % is applied to measurement of wind speed, however, there was no document available to explain how this correction was computed. The Hulhulé runway is located perpendicular to the prevailing wind thus take-off and landing may be extremely dangerous in situations of a strong cross wind. ***Recommendation 13:*** *Two wind systems would be needed for safe aviation operations (see also Recommendation 11)*. The current system may be kept for reference purposes and climatology, however another system should be installed at the runway threshold area according to joint WMO and ICAO guidance.

3.3.4. **Sunshine Duration Recorders**

3.3.4.1. Three Campbell-Stoke sunshine recorders were installed in three manual stations at (1) Hulhulé, (2) Hanimaadhoo and (3) Gan. Consumables (charts) are available; data are used for SYNOP and CLIMAT, they are digitized and stored at MMS. Note: the type installed uses curved cards. Recorders that are best suitable for tropical region use straight cards..

3.3.5. **Visibility System**

3.3.5.1. One Vaisala visibility meter (FD12) using a principle of a forward scatter measurement is installed near the runway at Hulhulé international airport (Malé station). Data are displayed in the observers' room and are used. However, RVR is never reported in METAR. ***Recommendation 14:*** *Even if the visibility only occasionally falls below 1 km, in such rare cases RVR should be included in METAR.* System was operational at the beginning of the consultant visit, however was out of order at the end. Field visit revealed that instrument works well and problem is in communication. Technicians are likely to fix this problem.

3.3.5.2. No preventive maintenance is done. Technicians are not in a position to make maintenance or repair due to lack of training. The calibration unit is available at MMS, however never used. ***Recommendation 15:*** *FD12 should be regularly calibrated.* ***Recommendation 16:*** *Arrange for a training of two technicians so maintenance and calibration of FD12 can be done regularly.*

3.3.6. **Automatic Weather Stations**

3.3.6.1. 22 VAISALA WXT 510/520 Automatic Weather Stations, with GEOPRESSION data-logger, ware install on major Maldives islands between 2007 and 2009 (see Annex 2). Two similar stations were installed by University of Hawaii AWSs in Hulhulé and Gan (together with the Sea Level Systems) and data are available at MMS. WXT 520 at Malé observing station is installed 1.5 meter above the ground. WXT 520 is a compact low-cost system designed for remote location that measures temperature and wind speed and direction at the same height, therefore, wind readings of this system have little value for observers at Malé station. ***Recommendation 17:*** *Consider relocation of this AWS (Hulhulé airport) on the other site of the runway on a 10-meter tall mast for a redundancy of a wind system at Malé (Hulhulé airport).* On the contrary the AWS Malé (at Malé Island) is located on the top of a building near the stadium at a height of about 25 meters. However, this may be one of the best possible places in the densely populated island with blocks of building adjacent to each other.

3.3.6.2. AWSs measure ambient air temperature and humidity, atmospheric pressure, wind speed and direction and rainfall. No siting metadata are available, except of coordinates of the sites. None of these stations are recorded in the WMO Weather Reporting Publication No. 9, Volume A (Observing Stations). ***Recommendation 18:*** *Register AWS stations in Pub. No. 9, Volume A.* Currently only eight AWSs stations are operational.

3.3.6.3. Data are transmitted every 10 minutes via GPRS into the dedicated central server at MMS where data are also stored. There is no back-up in case of server failure. Data are further disseminated to the Regional multi-hazard early warning system for Asia and Africa (RIMES), located in Thailand, through RIMES communication server at MMS. No data are distributed regionally or globally via GTS. Data are disseminated in the engineering format and WMO codes cannot be compiled. ***Recommendation 19:*** *Upgrade central server to allow for the compilation of SYNOPs and distribution of data from the selected AWSs via GTS, or request RIMES centre does it. If observer workstation is purchased (see Recommendation 3) than compilation of messages, quality control and distribution to GTS can be done by this workstation.*

3.3.6.4. Monitoring of stations is done through the web-based interface, see: http://202.21.178.202/iflex/portal/listview.php. Quality control is done manually by forecasters. In case of problem, technician is informed. Observing programme of AWSs can be remotely adapted to the weather situation, e.g. more frequent measurements in rainy season.

3.3.6.5. No preventive maintenance, calibration and repair were ever done due to the lack of funds for travel to remote islands and incentives to technicians. In fact, some allowances of technicians traveling to remote islands are reduced for the period of being outside Malé and Hulhulé. ***Recommendation 20:*** *Negotiate with government providing sufficient incentive for technicians while on mission.*

3.3.6.6. Spare parts for three complete AWSs are in the stock but never used. Neither preventive maintenance nor repairs of AWSs were done by current technicians. Trained technicians that installed AWSs had left MMS and the current technicians are yet to be trained. Many of the non-operational AWS should be repairable and could be done locally if technicians would be trained and incentive provided. ***Recommendation 21:*** *Provide factory training in Vaisala for two technicians.* ***Recommendation 22:*** *Technicians should visit AWSs to acquire information on spare parts needed for repairs and purchase needed spare parts.* ***Recommendation 23****: Develop a business case for operation and maintenance of AWS. There are several opportunities, such as collaboration with Mobile network providers and tourist resorts on remote islands that would appreciate local weather data.*

3.3.7. **Weather Radar**

3.3.7.1. EEC magnetron powered DW SR-850S S-band, doppler, dual polarization radar was installed at Hulhulé in 2007. It is remotely operated from MMS headquarters through a wireless

100 Mbps link. Low attenuation and the output power of 850 kW allow for long-range (up to 600 km) monitoring of weather phenomena. It allows for rather accurate estimates of rainfall and good discrimination between weather targets and no-weather signals, such as birds. Radar is currently out of service due to a problem with the processing software EDGE and lack of calibration. Its position in the centre of Maldives was a preferred solution in case of one system only. Nevertheless, due to altering monsoons (northeast and southwest monsoons) the most suitable arrangements would be for two systems, one in the north (e.g., Hanimaadhoo) and one in the south (e.g., Gan). This is however rather costly solution and at is unlikely to be considered at the near future.

3.3.7.2. As the trained technicians had left, the radar is not maintained properly. It is documented by the fact that the radar was in operation only less than 50 % of the overall time. Local meteorologist claim the range of radar is only about 250 km. This may be due to attenuation in waveguides and radome. Dehydrator/Compressor is likely not used according the manufacture's instructions, thus resulting in excessive humidity in waveguides. Radome may need hydrophobic painting. This should be checked by EEC (see below opportunity).

3.3.7.3. Quite many spare parts are available in the original boxes in the technicians' workshop but there is no list of what spares are available. Technicians seem to have necessary testing gauges to perform calibration, except of the External Test Signal Generator, but lack the knowledge. One year contract with EEC was signed early this year to reinstall software, to maintain the system and to perform needed calibration. ***Recommendation 24:*** *Use EEC visit to maintain and calibrate weather radar as the on-site training of all technicians.* ***Recommendation 25:*** *Arrange for factory training at EEC for two technicians.*

3.3.8. Sea Level Systems

3.3.8.1. Three sea level measurement systems were installed at Hanimaadhoo, Hulhulé and Gan by University of Hawaii (USA) using SUTRON components. Stations were installed in 1989 and upgraded after Tsunami by UNESCO/IOC. The last upgrade was done in July 2012. Communication is done through SUTRON SAT link to the University of Hawaii. Actual data and metadata are available at University of Hawaii public website. Data are stored also by the University.

3.3.8.2. Systems are fully automatic and monitored by the University who has service contract for preventive maintenance and repair. This also covers calibration that has been regularly performed. Basic maintenance is done locally.

3.3.9. Seismic Systems

3.3.9.1. Two seismic broadband systems model "Streckeisen STS2" were installed by GFZ Potsdam, Germany, in 2007 at Hanimadhoo and Kaadhehdhoo islands. Both systems are operational. Details are in Annex 3.

3.3.9.2. 1-minute data are transmitted in real-time to the Meteorological Service of Indonesia (BMKG) through VSAT link. A backup communication is also installed in both stations. Monitoring systems "SeisComp3" is installed in Maldives Meteorological Service. Data are stored at BMKG. Quality control of data is done by BMKG and the manufacturer. Manufacturer claims that no calibration of sensor is needed. This has to be verified.

3.3.9.3. There is no service contract with the manufacturer, however, it monitors data remotely and inform MMS to fix the problem. Spare parts are available and maintenance is done by the trained technician. Station at Hanimadhoo has currently power problems and the station in Kaadhehdhoo has communication problems. ***Recommendation 26:*** *A battery should to be replaced at Hanimadhoo and new modem, receiving and transmission modules should be replaced at Kaadhehdhoo seismic stations.* ***Recommendation 27:*** *One more technician should be trained for seismic systems.*

3.3.10. **Satellite Receiver**

3.3.10.1. Currently used satellite receiver “CMA-Cast” was installed by Chinese Meteorological Administration (CMA) in 2012. It allows receiving all three channels of Fengyun-2C satellite. MMS also receives SYNOPs through CMA-Cast.

3.3.10.2. No training was provided to technicians, however, CMA is ready to help in case of serious problems. Spare parts are available and maintenance is done locally.

3.3.11. **Training of Personnel and Training Material**

3.3.11.1. Meteorological observers are trained locally. One senior forecaster and one senior observer serve as trainers of Class IV staff - observers. One received Class II and the other one Class III training in RMTC Pune, India. One or two observers are trained yearly. The length of the Class IV training course is 2-month theory and practice plus 1-month on-the-job training. Refresher courses for observer are very sporadic. The only training material available is the Compendium of lecture notes for training Class IV meteorological personnel, Volume II – Meteorology (WMO-No. 266) and the WMO Manual on Codes (WMO-No. 306). There is no “Observers’ Handbook” available for routine operations. ***Recommendation 28:*** *Arrange for a refresher course for trainers at one of the WMO RMTC is advisable.* ***Recommendation 29:*** *Complete set of training material for meteorological observers should be ordered, many are available from WMO.* ***Recommendation 30:*** *Observers’ Handbook should be developed by trainers.* ***Recommendation 31:*** *One full staff post should be included in the organization structure for training of observers with a responsibility for education programme, curricula, preparation of training material, conduction of training and preparation of Observers’ Handbook.*

3.3.11.2. (1) The Chief technician has B.Sc in information technology, certificate in basic computing and information and communication technology. (2) The electrician has a certificate in the electrical engineering, a certificate in communication and telephone skills and training for installation, operation and maintenance of the seismic systems; (3) One technician has a certificate in PC trouble shooting and configuration, Certificate in PC networking and hardware, certificate communication and telephone skills and has also received training on installation of the seismic system. (4) The assistant technician has diploma in information technology, certificate in telephone skills and attended JMA/WMO training workshop on calibration and maintenance of meteorological instruments in Japan in February 2013; (5) The last staff is new and received no training. None of the current staff has specialized training related to operation and maintenance of the automatic systems currently in use, except of the seismic systems. ***Recommendation 31:*** *Arrange for factory training of two staff at Vaisala and other two staff at EEC, send staff to attend regular AWS/Radar/instrument training at RMTC in India or other centers. See also Recommendations 22 and 26.*

3.3.11.3. There are no training materials available for technicians, except of the basic documentation supplied by manufactures and those available are not documented. Technicians contact manufactures for information, as appropriate. ***Recommendation 33:*** *Order detailed technical guidance material from manufacturers, some could be downloaded from their website, and document those available.*

3.3.11.4. There are many WMO publications in the library. The WMO Guide to Meteorological Instruments and Methods of Observation, WMO-No.8 (CIMO Guide) was not readily available and there was no knowledge on its existence and a possibility of its free download from the WMO website. Link to CIMO Guide was provided to MMS staff during the presentations made by a consultant. ***Recommendation 34:*** *Study the CIMO Guide and use the existing Regional Instrument Centres (RICs) in RA II to get assistance if needed.*

3.4. GENERAL CONSIDERATIONS IN VIEW OF SUSTAINABILITY OF OBSERVATIONS AND QUALITY OF DATA

3.4.1. On 27 June and 1 July afternoon presentations were organized by a consultant followed by a discussion with the MMS staff on topics relevant to design and operation of the national observing system and WMO priorities, namely: GFCS, WIGOS and WIS, and capacity development (see Annex 4). Basics on the WMO regulatory material were presented with indication where to find source information. Presentation relevant to instruments and methods of observation covered also the areas relevant to sustainability of observations and quality of data: (a) User requirements, (b)Functional and technical specifications, (c) Selection of instruments, (d) Acceptance tests, (d) Compatibility, (e) Siting and exposure, (f) Instrumental errors, (g) Data acquisition, (h) Data processing, (i) Real-time and non-real time quality control, (j) Performance monitoring, (k) Testing and calibration and responsibilities of RICs, (l) Maintenance, (m) Metadata, and (n) Training and education. References were provided for detailed information on the above topics. Discussions revealed insufficient knowledge of the above aspects. ***Recommendation 35:*** *The CIMO Guide should be studied by trainers and used in training of observers and technicians (see also Recommendation 35).*

3.4.2. On 2 July a discussion with the top management was organized on the future management structure to allow MMS to better respond to requirements for services. Currently, operation of the five major manual stations (also called regional stations) and the maintenance service is under three different organizational entities (directors) which is not regarded as optimal solution from the point of view of harmonized development, operation and maintenance of the national observing system. At present, there is a no training unit to take care after education and training of the staff, development of national manuals and guides, such as the Observer handbook, guidance on improvement of the data quality, development of training material and conducting basic training courses for the staff. ***Recommendation 36:*** *Consider creation of an Observing Division with an integrated responsibility for operation, maintenance and repair of all observing stations (both manual and automatic) and creating a technician position at the major manual stations in remote islands. Also consider creation of a training unit.*

3.4.3. Most of the staff is working in a modern building with the reasonable space allocated to the individual units. However, maintenance section (called Support Service) has only two small rooms in the old building without any storage space for spare parts and consumables. In this limited space the “clean” and “dirty” work is done in both rooms and spare parts are spread around in several places. There is no list of existing spare parts and consumables. ***Recommendation 37:*** *As a minimum, three rooms should be allocated to Maintenance service staff, i.e., a “clean” room for work with the electronic equipment and sensors, a “dirty” room for work with non-electronic instruments, structures, supports, screens, etc, and a room for storage of spare parts and consumables. List of spare parts should be created and regularly updated. List of technical documentation supplied with instruments and instrument systems should be documented and stored separately.*

3.4.4. For any longer-term repair or calibration of instruments/sensors outside the county (in either RIC Tsukuba or RIC Beijing) spare instruments/sensors should be available. Currently this is not the case and, for example, pressure sensor cannot be sent for calibration unless a new system is purchased or redundant system installed. ***Recommendation 38:*** *Make sure there are spare sensors/units/instruments available for every system used operationally. Purchase those that are missing.* ***Recommendation 39:*** *Instruments used for critical applications, such as for aviation, should have redundancy in case of failure. As a minimum, redundant digital barometers should be installed at five manual stations where airports exist. Note: There is and existing mercury barometer in the observers’ room in Malé, however its calibration abroad is unlikely to happen due air transport restrictions.*

3.4.5. The WMO requested nominations of several National Focal Points (NFP) that are needed for direct communication on issued related to design, sustainability and metadata of national observing systems and quality of observations. While NFP exist for (a) Volume A/RBSN,

(b) GCOS/RBCN, no NFP were so far nominated for (c) Weather Radar Database, (d) the Implementation Plan for the Evolution of global observing systems (EGOS-IP), and (e) the WMO Integrated Global Observing System (WIGOS). All the information was provided to the management of MMS, including the nomination forms. ***Recommendation 40:*** *Nominate NFP for Weather Radar Database, EGOS-IP and WIGOS.*

3.4.6. The automation of observations in Maldives was not carefully managed or certain principles were not taken into account. The management of automation must include network planning, operations and service provision staff. The following are some of the critical aspects to be taken into account in further automation: (a) Management of Network Change (Assessment of the extent to which a proposed automation could influence the outputs of the observing network. User requirements should be established by all network users. The change management process should include representatives from network planning, engineering, observations, data processing and communications, data services and archiving.); (b) Resource requirements (Costing of automated observations systems can be simplistic when they do not include all costs such as training, expertise development, asset life cycle costs and dependence on commercial technology.); (c) Gains and Losses (Automated observing systems are able to provide some attractive benefits that include remote operations, high frequency of objective measurements needed for severe weather forecasting and warnings. Automated observations are not able to fully replace manual observations, particularly visual observations.); (d) Management of system change (The manner in which observations are managed changes when the high volume automated data becomes part of the system. Instead of local quality control by an observer, this must be programmed into computer algorithms with the ability to detect and respond to warnings. Electronic storage and archive facilities must be expanded. Fault detection and response systems need to be monitored with staffs that have the appropriate competencies. Asset replacement funds need to be available to replace the equipment when necessary.). ***Recommendation 41:*** *Establish a Change management process for further automation of MMS National Observing Network.*

3.4.7. Several guidance material on automation was developed by the Commission of Basic Systems (CBS) and the Commission for Instruments and Methods of Observation (CIMO) and is available on the WMO website, e.g. Final Reports from the CBS Expert Team on Requirements for Data from Automatic Weather Stations (see: https://www.wmo.int/pages/prog/www/CBS-Reports/IOS-index.html), such as the Final Report of the Expert Team on Requirements for Data from Automatic Weather Stations, Geneva, Switzerland, 5 - 9 May 2008, and the CIMO IOM Report Series available at: https://www.wmo.int/pages/prog/www/IMOP/publications-IOM-series.html. ***Recommendation 42:*** *Study the existing WMO guidance material and request advice from the respective technical commissions, as appropriate.*

3.5. SUMMARY OF RECOMMENDATIONS

1. Recommendation 1: Even if internet connection seems to be quite reliable, consider re-installing VSAT link. Combination of the two will provide more sustainable communication solution.

2. Recommendation 2: Arrange for training of two technicians to master MESSIR-COM and integrated workstations MESSIR-AERO and MESSIR-VISION

3. Recommendation 3[3]: Consider purchase of an observer workstation for a semiautomatic production of WMO codes (SYNOP, CLIMAT, METAR, and SPECI) and automatic quality control of data. This will assure that reports are compiled according to an agreed WMO standard practice. Automatic data quality control will eliminate errors in coding, thus increasing availability of reports in RTH.

[3] This action is generic, covering compilation of WMO codes, monitoring of data flow and quality control of data

4. Recommendation 4: As a short term solution relocate the Stevenson screen from its current position into the middle of the enclosure. Artificially protect rain gauges against the wind.

5. Recommendation 5: Look for an opportunity to move the whole meteorological station to a new position within the airport with more suitable environment so that data better represent airport region.

6. Recommendation 6: Consider purchase of an observer workstation (see Recommendation 3) that can monitor data flow automatically and can quality control of data.

7. Recommendation 7: A portable standard[4] should be purchased to adjust barometers thus ensuring correct readings at the ambient values.

8. Recommendation 8: A back-up system is needed to allow for an uninterrupted operation, preferably using three pressure cells barometer for a redundancy and higher confidence. As a minimum, two spare barometers should be in kept in the stock to allow for a repair and/or calibration of the field instruments.

9. Recommendation 9: Arrange for a calibration of digital barometers at RIC Tsukuba or RIC Beijing. Request WMO to assist if needed.

10. Recommendation 10: Consider purchase of an observer's workstation to monitor the flow of wind data and for the automatic data quality control (See Recommendation 3).

11. Recommendation 11: A redundant wind system is needed for an uninterrupted operation (see also recommendation 13 below).

12. Recommendation 12: Arrange for calibration of wind sensors at RIC Tsukuba or RIC Beijing.

13. Recommendation 13: Two wind systems would be needed for safe aviation operations (see also Recommendation 11). The current system may be kept for reference purposes and climatology, however another system should be installed at the runway threshold area according to joint WMO and ICAO guidance.

14. Recommendation 14: Even if the visibility only occasionally falls below 1 km, in such rare cases RVR should be included in METAR.

15. Recommendation 15: FD12 should be regularly calibrated.

16. Recommendation 16: Arrange for a training of two technicians so maintenance and calibration of FD12 can be done regularly.

17. Recommendation 17: Consider relocation of this AWS (Hulhulé airport) on the other site of the runway on a 10-meter tall mast for a redundancy of a wind system at Malé (Hulhulé airport).

18. Recommendation 18: Register AWS stations in Pub. No. 9, Volume A.

19. Recommendation 19: Upgrade central server to allow for the compilation of SYNOPs and distribution of data from the selected AWSs via GTS, or request RIMES centre does it. If observer workstation is purchased (see Recommendation 3) than compilation of messages, quality control and distribution to GTS can be done by this workstation.

20. Recommendation 20: Negotiate with government providing incentive for technicians to compensate for the reduced salary during travels.

[4] Portable standard should be used for T, H, P

21. Recommendation 21: Provide factory training in Vaisala for two technicians.

22. Recommendation 22: Technicians should visit AWSs to acquire information on spare parts needed for repairs and purchase needed spare parts.

23. Recommendation 23: Develop a business case for operation and maintenance of AWS. There are several opportunities, such as collaboration with Mobile network providers and tourist resorts on remote islands that would appreciate local weather data.

24. Recommendation 24: Use EEC visit to maintain and calibrate weather radar as the on-site training of all technicians.

25. Recommendation 25: Arrange for factory training at EEC for two technicians.

26. Recommendation 26: A battery should to be replaced at Hanimadhoo and new modem, receiving and transmission modules should be replaced at Kaadhehdhoo seismic stations.

27. Recommendation 27: One more technician should be trained for seismic systems.

28. Recommendation 28: Arrange for a refresher course for trainers at one of the WMO RMTC is advisable.

29. Recommendation 29: Complete set of training material for meteorological observers should be ordered, many are available from WMO.

30. Recommendation 30: Observers' Handbook should be developed by trainers.

31. Recommendation 31: One full staff post should be included in the organization structure for training of observers with a responsibility for education programme, curricula, preparation of training material, conduction of training and preparation of Observers' Handbook.

32. Recommendation 32: Arrange for factory training of two staff at Vaisala and other two staff at EEC, send staff to attend regular AWS/Radar/instrument training at RMTC in India or other centers. See also recommendations 22 and 26.

33. Recommendation 33: Order detailed technical guidance material from manufacturers, some could be downloaded from their website, and document those available.

34. Recommendation 34: Study the CIMO Guide and use the existing Regional Instrument Centres (RICs) in RA II to get assistance if needed.

35. Recommendation 35: The CIMO Guide should be studied by trainers and used in training of observers and technicians (see also Recommendation 34).

36. Recommendation 36: Consider creation of an Observing Division with an integrated responsibility for operation, maintenance and repair of all observing stations (both manual and automatic) and creating a technician position at the major manual stations in remote islands. Also consider creation of a training unit.

37. Recommendation 37: As a minimum, three rooms should be allocated to Maintenance service staff, i.e., a "clean" room for work with the electronic equipment and sensors, a "dirty" room for work with non-electronic instruments, structures, supports, screens, etc, and a room for storage of spare parts and consumables. List of spare parts should be created and regularly updated. List of technical documentation supplied with instruments and instrument systems should be documented and stored separately.

38. Recommendation 38: Make sure there are spare sensors/units/instruments available for every system used operationally. Purchase those that are missing.

39. Recommendation 39: Instruments used for critical applications, such as for aviation, should have redundancy in case of failure. As a minimum, redundant digital barometers should be installed at five manual stations where airports exist. Note: There is and existing mercury barometer in the observers' room in Malé, however its calibration abroad is unlikely to happen due air transport restrictions.

40. Recommendation 40: Nominate NFP for Weather Radar Database, EGOS-IP and WIGOS.

41. Recommendation 41: Establish a Change management process for further automation of MMS National Observing Network.

42. Recommendation 42: Study the existing WMO guidance material and request advice from the respective technical commissions, as appropriate.

3.6 CONCLUSIONS

3.6.1 While the design of the National Observing System seems reasonable, it is not serving its purpose as planned. Approximately half of the network is not functioning, the availability of data is low, quality of data is in question and a competency of the maintenance staff is low due to lack of specific technical training. In addition, the current organizational structure of MMS does not support integrated approach to management and operation of the National Observing System, which may raise the public liability concerns and could be a potential risk factor to the aviation safety. The reasons for these findings are discussed in the sections 3.3 and 3.4 above and a set of recommendations is provided in the section 3.5 for the consideration by Maldives Meteorological Service.

3.6.2 A sustainable solution should be based on a business case for the design, operation and maintenance of the National Observing System, otherwise good intentions may not work in practice.

3.6.3 Staff required traveling to outstations for servicing the observing instruments and systems should be given incentives, however, current systems disadvantages technicians through lowering some of their allowances when traveling outside the duty station. The other critical aspect is training of technicians to be able to maintain the existing instruments and systems. This should be not a one-time process as the already trained staff may migrate to other jobs thus leaving a gap if training is not recurrent.

Annex 1

List of persons assisted in the Fact-finding and the Needs-assessment Mission

1. Mr Abdullah Majeed, Permanent Representative of Maldives with WMO and Deputy Minister of Environment and Energy,
2. Mr Abdulla Wahid, the Director General of MMS
3. Mr Ali Shareef, Deputy Director General of MMS
4. Dr Zahid, Director Climatology
5. Mt Abdul Muhusin, Director, Management
6. Mr Ahmed Rasheed, Senior Meteorologist, Meteorological Watch Office
7. Mr Moosa Saeed, Electrician, Support Service
8. Mr Abdul Azeez, Assistant Technician, Support Service
9. Abdulla Hafiz, Forecaster
10. Ibrahim Waheed, Observer, trainer Class IV

Annex 2

Automatic Weather Stations Vaisala WXT 510 & WXT 520 ooerated by Maldives Meteorological Service

No.	Island Name	Sensor Type	GPS Location	Installation	Operational
1	V.Fulidhoo	WXT 510	N3°41'48.41 E73°24'56.75	2008	Yes
2	Th.Hirilandhoo	WXT 510	N2°16'13.27 E72°55'56.68	2008	No
3	Dh. Hulhudheli	WXT 510	N2°51'30.88 E72°50'53.03	2008	No
4	Hd. Makunudhoo	WXT 520	N6°24'40.71 E72°42'15.89	2008	No
5	K. Male	WXT 510	N4°10'24.12 E72°30'48.16	2008	Yes
6	Ha. Uligam	WXT 510	N7°05'10.70 E72°55'29.41	2008	No
7	R. Vaadhoo	WXT 510	N5°51'29.38 E72°59'29.00	2008	No
8	Aa. Rasdhoo	Not installed. Data logger and sensor was sent for repair. Now ready for installation			No
9	Ad. Rangali	WXT 520	N3°37'02.46 E72°43'24.52	2009	No
10	Th. Vilufushi	WXT 520	N2°30'11.98 E73°18'29.07	2009	No
11	L. Isdhoo	WXT 510	N2°30'11.98 E73°18'29.07	2009	No
12	Ga. Villingili	WXT 520	N0°45.088 E73°26.045	2009	Yes
13	Gd. Gadhdhoo	WXT 520	N0°17.401 E73°27.311	2009	No
14	Gn. Foammulah	WXT 520	S0°17'44.09 E73°25'25.56	2009	Yes
15	S. Hulhumeedhoo	WXT 520	S0°35'30.56 E73°13'39.30	2009	Yes
16	S. Hithadhoo	WXT 520	S0°35'57.70 E73°05'03.63	2009	Yes
17	K. Kaashidhoo	WXT 520	N4°57.546 E73°27.814	2009	Yes
18	Lh. Naifaru	WXT 520	N5°26'36.30 E73°22'03.56	2009	No
19	Ari.Atoll Banyan Tree	WXT 520	N4°18'35.58 E73°25'26.72	2009	Yes
20	N.Nilandhoo	WXT 510		2007	No
21	B.dharavandhoo	WXT 510		2007	No
22	Sh. Feevah	WXT 520		2007	No

Automatic Weather Stations Vaisala WXT 520 AWSs operated by RIMES, data available at MMS:

No.	Island Name	Sensor Type	GPS Location	Installation	Operational
23	Hulhulé	WXT 520		???	Yes
24	Gan	WXT 520		???	Yes

Annex 3

Seismic Network of Maldives Meteorological Services

There are two Broadband seismometers installed in Maldives. One in HA. Hanimadhoo (North of Maldives) and one in GD. Kaadhedhoo (South of Maldives). Details of the stations are below:

HD. Hanimadhoo Seismic Station	
Station Name	Hanimadhoo , Maldives
Station ID	HMDM
Network	GE (GEOFON Global Seismic Network)
Latitude	6^{o} 77' 31'' N
Longitude	73^{o} 18' 22'' E
Primary Sensor	Streckeisen STS2
Secondary Sensor	Kinemetrics Force Balance Accelerometer
Digitizer	Kinemetrics Q330
GD. Kaadhehdhoo Seismic Station	
Station Name	Kaadhehdhoo , Maldives
Station ID	KAAM
Network	GE (GEOFONE Global Seismic Network)
Latitude	0^{o} 49' 26'' N
Longitude	72^{o} 99' 49'' E
Primary Sensor	Streckeisen STS2
Secondary Sensor	Kinemetrics Force Balance Accelerometer
Digitizer	Kinemetrics Q330

Annex 4

Presentations by the Consultant to the staff of the Maldives Meteorological Service

1. 27 June, 14:00 - 15:30 hours:
   - About WMO
   - WMO Integrated Global Observing Systems (WIGOS)
   - WMO Information System (WIS)
   - Global Framework for Climate Services (GFCS)
   - Siting Classification

2. 1 July, 14:00 - 15:30 hours
   - Regional Instrument Centres (RICs)
   - WMO Regulatory Material
   - WMO Manual on Global Data-Processing and Forecasting System (GDPFS): Quality Control of Data in real and non-real time
   - WMO Guide to Meteorological Instruments and Methods of Observation (CIMO Guide): uncertainty of measurements; QM of observing systems; Factors affecting Data Quality

**FACT-FINDING AND NEEDS-ASSESSMENT MISSION
TO ASSESS THE CURRENT STATUS AND REQUIREMENTS
OF THE MALDIVES METEOROLOGICAL SERVICE
Ministry of Environment and Energy
Malé, Republic of Maldives
6-13 June 2013**

Mr Scylla M. Sillayo
Scientific Officer, Aeronautical Meteorology Division
Weather and Disaster Risk Reduction Services Department
World Meteorological Organization

1. REASONS FOR THE MISSION

The visit was undertaken on the invitation of the Minister of Environment and Energy, Dr Mariyam Shakeela to World Meteorological Organization (WMO) Secretariat requesting for a fact-finding/needs assessment mission to the Republic of Maldives to assess the current status and requirements of the Maldives Meteorological Service (MMS), in particular as far as compliance with the World Meteorological Organization (WMO) and the International Civil Aviation Organization (ICAO) regulations are concerned.

2. SCOPE OF THE VISIT

SO/AEM was to carry out the following distinct activities during the visit to the meteorological service for civil aviation in Maldives:

- Assess the state of the quality of the services provided to aviation sector with a view of establishing its cost recovery methods. This could be done together with the Quality Manager by performing a gap analysis to establish how much has been done on Quality Management System (QMS) since April 2012 when one of their staff members attended a WMO QMS Workshop in Colombo, Sri Lanka;

- Check the functionality, infrastructure available, staffing level and competence assigned to the Meteorological Watch Office (MWO) responsible for the preparation and issuance and dissemination of Significant Meteorological Information (SIGMET). Check on how the MWO cooperates with the relevant Tropical Cyclone Advisory Center (New Delhi, India) and its Volcanic Ash Advisory Center (Toulouse, France);

- Determine the readiness of the service to ensure and assess the qualification and competence of personnel serving international air navigation;

- Provide a set of recommendations to be discussed with management and the parent ministry on priorities for addressing any deficiencies identified such as on the organizational setup, distribution of responsibilities and potential for improvement.

3. RESULTS OF THE FACT FINDING MISSION AND GAP ANALYSIS AT MALE'S INTERNATIONAL AIRPORT

3.1 Introduction

Maldives archipelago is located on top of the Chagos-Maldives-Laccadive Ridge, a vast submarine mountain range in the Indian Ocean. The Maldives atolls encompass a territory spread over roughly 90,000 square km, making the country one of the world's most geographically dispersed. Its population of 328,536 (2012) inhabits 192 of its 1,192 islands.

The Maldives is the smallest Asian country in both population and land area. With an average ground level of 1.5 m (4 ft 11 in) above mean sea level, it is the planet's lowest country. It is also the country with the lowest natural highest point in the world, at 2.4 m (7 ft 10 in).Forecasts of Maldives' inundation are a great concern for the Maldivian people.

The Maldives is located at the equator and experiences monsoonal climate. The Maldives has two distinct seasons; dry season (northeast monsoon) and wet season (southwest monsoon). In these two seasons the temperature varies very little. Northeast monsoon extends from January to March, with the change over period in April then Southwest monsoon from May to November with December being the changeover to Northeast monsoon. Daily temperature ranges from around 31c during the day to 23C at night. The mean daily maximum temperature for central parts (Hulhule) is 30.5Cand minimum temperature is 25.7C.

The wet season (Southwest monsoon) runs from May to November. In this season the Maldives experiences torrential rain.

3.2 Meteorological Stations

Maldives has 5 major manned stations with Hulhule as its Meteorological Watch Office (MWO). The four others are regional weather offices namely Gan which is also an international airport, Kaadehdoo, Kadhdhoo and Hanimaadhoo. Hanimaadhoo is already operating like an international airport. In total, the service has about 100 employees and has deployed 20 automatic weather stations in different atolls but only 10 are operational. The only Doppler weather radar (covers 250km radius) in the country is not operational due to maintenance issues. Furthermore, the only upper air observation station in Gan is not in operation due to unavailability of consumables. They have a modern spacious forecast office and observatory co-located at the MWO. The MWO is semi-automated with briefing services done from a MESSIR AERO workstation. Flight folders are e-mailed to respective airline and/or Flight operations offices.

3.3 Organizational aspects

The organizational chart has a Director General as the head of Maldives Meteorological Service (MMS) just below the Permanent Representative of Maldives with WMO (PR) and also Deputy Minister, Ministry of Environment and Energy (MEE).

The Weather Service Division is headed by the Deputy Director General and the National Meteorological Center (NMC) is under the Director of Climatology. There are two sections below the Director of Climatology, Observatory and MWO. The later is headed by a Senior Meteorologist.

The four other stations (offices) are under Regional Weather Services (RWS) headed by a Director with Assistant Directors for each airport.

TAFs and SIGMETs for Gan and Hanimaadhoo and the other regional airports are done at the MWO which is run by four senior technicians (former Class II meteorologists) and two observers/technicians (former Class III meteorologists).

3.4 Other services offered my MMS

The NMC/MWO is responsible for all forecasts which include public weather services (TV, newspapers, radio), seismology monitoring, marine and aeronautical services. In addition to weather related advisories/warnings for marine, earthquake and tsunami advisories, they use hotlines established with 5 focal organizations, namely national TV station (TVM), Voice of Maldives (VOM), Maldives Police Service (MPS), Maldives National Defense Force (MNDF) and Disaster Management Centre (DMC). The warnings are also disseminated through Short Message Service (SMS) to designated disaster related 83 focal points. The forecast office has also got an

automatic dial weather service. Daily weather advisories/forecasts are done in their studio and sent out to the TV station.

3.5 Training of personnel

MMS provides the initial basic training in meteorology to its staff. It comprises of two months of theory and one month of practical couching and on the job training. This leads to the qualification of the former Class IV certificate. The upgrading of this course to previous Class III is done in the Regional Center in India. Senior Technicians are usually trained in India and Pakistan and some in Australia. Three were exceptionally trained in the Nairobi Institute of Meteorological Training and Research (IMTR).

It is clear from this most of the officers are under-trained. Over the decade, the MMS has trained about 12 staff under Human Resource Development Project (from WMO and other donor funding). Currently only four graduate meteorological staffs are working at MMS with different background including Geology, Climatology, Astrophysics and Meteorology. All other well trained graduates have left the service for greener pastures. For those who remain or are going to join the service in the future, the management will have to come up with elaborate plans of motivating and creating a proper work environment to retain them. The government may need to consider the MMS as a scientific body with rare-professionals and provide special incentives for the staffs.

3.6 Availability of ICAO/WMO Guidance Documentation

A spot-check revealed the unavailability of recent ICAO documents in hard copy form. Remedial action was immediately taken and a soft copy of at least the current ICAO/Annex 3 was made available to the forecast office and placed on the desk top of the operational forecaster's computer. The management was encouraged to perform a thorough review of all ICAO/WMO guidance documents and request the provision of current documentation at the airport offices from the head office, CAA and/or the ICAO Regional Office.

4. IMPLEMENTATION OF QMS

ICAO requirement for Quality Management System (ICAO Annex 3) states that:

> *In order to meet the objective of meteorological service for international air navigation, the Contracting State should ensure that the designated meteorological authority establishes and implements a properly organised quality management system.*

Following the training of one staff member from the MMS at the WMO QMS Implementation Workshop held in Sri Lanka in March 2012, little progress was achieved as the single staff member was overwhelmed by this and a tight roster of normal duties as a forecaster. When we performed a gap analysis, it became apparent that little could be done under such circumstances. The management has not even appointed a quality manager to date. This puts the MMS in the RED category *(Member has not taken significant steps towards implementation of QMS and hence no compliance)*.

The following areas of QMS remained undeveloped:

- Leadership and creation of awareness: Visible and strong support from executive management needs to be increased to signal to all staff that this project is seriously considered as a matter of survival for the organization and that if not implemented will have serious consequences nationally;

- The lack of communication between MMS and its aviation user community requires a very strong effort in designing effective and efficient MET processes to strengthen customer focus;

- The management needs to form a small QMS team to initiate QMS activities using the only trained forecaster. It should start with the creation of awareness and involvement of the people working for MMS;

- MWO has already a few procedures for reporting and issuing several types of advisories/warnings. Such a situation clearly requires a strong effort in streamlining in order to create an effective and efficient system that can be managed for quality successfully;

- As in many Small Island Developing States (SIDSs) and Developing Countries (DCs) Met Services, there is need for capacity building and coordination of the sometimes disjointed activities;

- Competency assessment of the personnel has not yet started and needs to be planned as a fundamental element of the QMS.

5. FUNDING AND COST RECOVERY

5.1 Implementation of QMS requires stable and sustainable funding. Currently, the MMS is underfunded and was not able to calibrate equipments and maintain crucial equipments to provide services. Cost recovery is seen to be a possible way, thus reducing dependence on regular budget allocated by the government. ICAO and indeed all signatories of the Chicago convention have agreed that costs for met services to civil aviation should be met by the users, **user pays principle**.

5.2 SO/AEM, together with Mr Ali Shareef (Deputy Director General, MMS) and Mr Ahmed Rasheed (Senior Meteorologist, NMC), met with Mr Ibrahim Thoha, General Manager, Air Traffic Services and his team (Annex 5) to discuss the issue of cost recovery for MMS.

In principle, it was agreed that they support the move and feel it will become even easier when they become an autonomous entity in the near future. A presentation giving the main steps as listed in WMO-No. 904, *Guide to Aeronautical Meteorological Services Cost Recovery-Principles and Guidance* was used in the roadmap agreed to by the group. The need for transparency and use of consultative meetings with the users was emphasized. Both parties were given the links to the WMO AEM website for further reading and usage.

5.3 SO/AEM, together with Mr Ali Shareef and Mr Ahmed Rasheed had also met with the Chief Executive of the Maldives Civil Aviation Authority, Mr Hussain Jaleel and his team (Annex 6) to discuss issues of cost recovery for aeronautical meteorological services to international air navigation. The discussions were also facilitated using WMO-No. 904 in the form of a power point presentation. Again, there was a general consensus on the rationale and need for cost recovery as a way to meet the challenges that the MMS is facing with the implementation of QMS and maintenance and repairs of meteorological instruments and equipment.

5.4 On the last day of the mission, SO/AEM briefed the two ministers dealing with international civil aviation and meteorology (Annex 7) on the findings and both promised to assist MMS by bringing to the attention of cabinet their predicament. They promised to look into ways that would ultimately transform MMS into a semi autonomous entity as a way of easing its financial situation and assisting them with training and capacity building. It is believed this would also enhance their capacity of retention of professional staff.

6. COMPETENCY AND QUALIFICATION OF PERSONNEL

A spot-check on the competency of Observers revealed that they were not competent and needed some refresher training on instrumentation and to some extent basic underpinning knowledge showing that the work attitude was not meeting with the criteria. Most did not know the required standard procedures and even when there were not being followed. The implementation

of QMS will definitely improve the situation but remedial action was in the meantime necessary. Aeronautical forecasters were much better but also needed some refresher training or on-the-job-training especially on writing SIGMETs. There was also need for forecasters to familiarize with ATS (both approach and area controls), AIS and Search and Rescue section at the Airport.

7. RECOMMENDATIONS

Based on the findings and gap analyses described above, a series of recommendations have been developed for the MMS. Further discussions on the details could continue through exchange of correspondence between the WMO Secretariat and the MMS.

QMS implementation

7.1 QMS implementation is a management decision. It is only when there is full management commitment that it will succeed. Awareness of what it is, how it will be done and for what reason can start immediately with minimal resources.

7.2 After the appointment of the Quality Manager/Management representative, initially, he/she should be relieved of other duties so that 80% of time is spent on building the QMS blocks.

7.3 Deadline for QMS implementation was November 2012. The only way to expedite implementation is to solicit for the services of an experienced consultant to guide the implementation. This will ensure that the MMS becomes compliant within the next 9 to 12 months.

7.4 Ensure that all relevant regulatory and guidance documents coming from WMO and ICAO are:

- Up to date, signed and authorized;
- Available at the point-of-use; If there is no hard copy, soft copy on desk top of an operational computer;
- Familiar, in their use and interpretation, to all relevant staff.

- This means that the country would not yet be considered fully compliant with the relevant ICAO regulations in paragraph 2.2.3 ff of the ICAO Annex 3, and should be advised to inform ICAO (through the appropriate regional office or directly to the MET section at ICAO Headquarters in Montreal, Canada) of this fact using the standard procedure of filing a difference, stating also when and by what means the service provider MMS, expects to become compliant in the future.

Training and Competency of personnel

7.5 ICAO Annex 3, Para 2.1.5 states: *"Each Contracting State shall ensure that the designated MET authority complies with the requirements of the WMO in respect of qualifications and training of MET personnel providing services for international air navigation"*.

To address the issue of shortage of qualified professionals for aeronautical services to international air navigation, the MMS must have a training programme. It is recommended that the programme should:

- Arrange further training for forecasters with BSc (it will only take 9 months for post graduating in Meteorology to become WMO meteorologists);

- Recruit recently science graduates who have majored in Mathematics and Physics. Again, it will only take 9 months for them to become WMO meteorologists

Cost Recovery

7.6 The following areas on the implementation of cost recovery remain undeveloped:

- There is no institutional or legal setup to permit the collection and retention of external revenue. There is need for an Act of Parliament for MMS to become an independent agency or a semi-autonomous entity, where they have permission to collect and use/retain revenue generated from the services provided to users. In the mean time, the government needs to allocate adequate budget to MMS so that it can conduct necessary training workshops for the staff, repair, calibrate and maintain all operational equipment;

- Services to aviation are provided under a “Letter of Agreement” (LoA) between the MMS and the Civil Aviation Authority and the Air Traffic Services in accordance with ICAO Doc. 9377, their bill is still in draft form (not yet passed by Ministry/Parliament);

- Need for the establishment of regular, open and interactive meetings with user representatives. To ensure relevance and transparency in costs (at least once a year);

- Agreement with users on inventory of facilities and services relevant to meet aviation requirements (should involve Civil Aviation Authority (CAA));

- Determination of general costs of basic items plus maintenance and support services as given in various ICAO Doc. 9161(Para 3.2);

- Allocation of costs for core services between all user groups (Public Weather Services (PWS), seismological, marine, aeronautical, etc.);

- Additional services as agreed with CAA and users like low level forecasts for general aviation may also be charged by the MMS.

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Annex 5

Mr Ibrahim Thoha	General Manager, Air Traffic Services
Mr Ibrahim Khalid	Head of Safety & Standards
Mr Ibrahim Hameed	SATCO
Ms Haseena Hadi	Senior AISO
Mr Ishaq Abdulla	Senior Engineer ATE
Mr Ibrahim Imran	Engineer ATE

Annex 6

Mr Hussain Jaleel	Chief Executive
Ms Fathimana Ramiza	Director, ANS and Aerodromes
Mr Ibrahim Mohamed	Senior Airworthiness Engineer
Mr Ibrahim Rasheed	Director Flight Operations
Mr Mohamed Samnoon Fuad	Aerodrome Officer
Mr Ahmed Naseem	ANS Officer
Mr Ahmed Faseel	Associate Manager

Annex 7

Dr Mariyam Shakeela	Minister of Environment and Energy
Colonel (Rtd) Mohamed Nazim	Minister of Defense and National Security
Mr Abdul Matheen Mohamed	Minister of State for Environment and Energy
Mr Abdullah Majeed	Permanent Representative of Maldives with WMO and Deputy Minister of Environment and Energy
Mr Ahmed Saleem	Principal Secretary, Ministry of Environment and Energy