Republic of Zambia

Ministry of Transport and Communications

Zambia Meteorological Department

Automatic Weather Stations Specifications

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Table of Contents

1. General

1.1 The Scope of the Specification

The functional and technical specifications described in this document give the requirements for the supply of 20 Automatic Weather Station (AWS) network project. 5 AWS shall be installed by the supplier and will be used for training ZMD technical Staff, whilst the remaining 15 will be installed by the ZMD staff under supervision of the engineers from the supplier.

This document is divided into sections where:

- Section 0 gives a general description of the station network to be supplied.
- Section 0 lists the minimum requirements for the supplier of the AWS systems.
- Section 3 details the minimum requirements for the electronics and data logger of the system.
- Section 4 describes the minimum requirements for the software.
- Section 5 lists the minimum performance requirements for the sensors to be supplied with the offered system.
- Section 6 sets the requirements for telemetry options.
- Section 7 sets the reliability and maintainability requirements.

1.2 General Description

The Automatic Weather Station (AWS) network consists of automatic observation stations, including electronics and data processing unit, sensors, telemetry and supporting structures further referred to as "stations", and a data collection system consisting of computer hardware and software and communication networks as later specified. The stations automatically

measure, log and send the observation data to a central data collection system. The central data collection system collects the data, stores, processes and forwards it further to desired users and systems as later specified. The system must be designed to operate in all environmental conditions, all year round and 24 hours a day. The expected life time of the system must be more than ten years.

2. REQUIREMENTS FOR AN ELIGIBLE BIDDER

2.1 General Information

2.1.1. This proposed project is a "Turnkey" project, where besides the supply of all components of Automatic Weather Stations (AWS), the integration, installation and training of all installed AWS systems are also considered. For such reasons, the selected Vendor shall provide in an integrated manner all components and constitute each AWS system and services described in this document, as no partial proposals will be accepted.

2.1.2. The Company shall have a long history and proven track record in design, manufacture and after sales support of hydrological and meteorological sensors and data collection systems. The company shall have sufficient and documented financial and technical resources to implement turnkey system deliveries. Together with its technical proposal, the company shall provide written detailed documents at least from ten (10) delivery projects of similar size, where the Bidder's equipment have been used as the standard equipment. In addition, the complete reference list of customers of the offered equipment shall be supplied.

2.1.3. The Company shall have the approved ISO 9001 Quality Assurance System certified by an accreted authority. The copy of this certificate must be attached to the technical proposal

2.1.4. As a manufacturer of products for environmental measurement, the Company shall have a process to minimize the environmental impacts of its operation, the prevention of pollution and the reduction of waste. This process shall conform to the requirements of the EN ISO 14001 standard. The conformance certificate shall be included with the tender proposal.

2.1.5. As a part of their Quality Assurance System, the Company shall operate the laboratory facilities for sensor testing and calibration. These facilities and the primary standards used shall be traceable to the international standards. Both the quality assurance system and the internationally traceable standards shall be documented in writing in the technical proposal.

2.1.6. The Company shall have a spare parts policy and sufficient financial resources for quarantining the availability of the spare parts for minimum of 10 years after finishing the deliveries of the tendered equipment. In order to show this

compliance, the financial statements of the last two (2) years must be included together with the price proposal.

2.1.7. The Company shall have sufficient technical and other resources for supporting the installed system locally. Description of these resources shall be included in the technical proposal or its appendixes.

2.1.8. The interested companies are required to submit detailed description of the proposed hardware and software implementation of the specification of this document.

3. DATA COLLECTION EQUIPMENT

3.1 General requirements

3.1.1. This section presents the AWS system's minimum functional requirements including hardware functions and operating environment.

3.1.2. The design of the system shall make maximum use of the commercial-off-the-shelf equipment with proven operating record and long expected lifetime. A primary characteristic of the system will be high availability and accuracy of the reported data.

3.1.3. The investment of the AWS network extends over many years. The life time of such a network shall be more than 10 years.

3.1.4. The design shall be modular enabling the change of the modules and system components without any special tools.

3.1.5. Easy-to-use DIN-rail mounting shall be used in mounting system components.

3.1.6. The following data processing capabilities shall be provided as minimum:

- Measure the sensors as specified in the section 3.3.
- Perform data quality check on the parameters as specified in the section 3.7.4.
- Process the data using calculation and statistical functions specified in the section 3.7.
- Offer to the user freedom to configure multiple output messages.
- Provide alarm functions based on a measured or calculated parameter exceeding its user set threshold value(s).
- Log the data at the user configurable formats and intervals.

3.1.7 The data logger shall have low power consumption due to solar power operation. The average current consumption of the data logger alone without optional modules shall not exceed 10 mA from 12 VDC supply.

3.1.8 The data logger shall have a modular design for supporting built-in pressure transducer module.

3.1.9 Provide maintenance terminal functions for maintenance technician to access the internal diagnostics including sensors data.

3.1.10 Provide the remote setup update function. Data logger shall allow automatically downloading setup from either FTP server. User shall be able to define of the startup time of the new setup.

3.1.11 Provide the automatic log files download function. Data logger shall allow downloading log files automatically according to a user-defined schedule.

3.1.12 System shall allow the user to view information, set site-specific parameters, and perform many maintenance functions in a graphical user interface format (GUI). By using the GUI, user must be able to check the internal system status and add SDI-12 sensors.

3.1.13 The equipment shall support various kind of communication equipment, including modems, satellite, wireless, radio and cellular 2G/3G.

3.1.14 The data logger shall be able to control communication equipment without additional processor.

3.2 Environmental Specifications

In order to minimize the effects of the environmental and electrical conditions into the quality of the data and reliability of the equipment, the system shall be designed and manufactured to operate within the minimal range of the environmental conditions listed below:

- Operational temperature limits - 40° … + 60°C
- Storage temperature limits - 60° … + 70°C
- Operational relative humidity limits 0 … 100 % RH
- Tolerant to wind speeds up to 60 m/s
- Ingress protection class at least IP66

In order to withstand electrical disturbances and prevent interference with other electronic equipment, the equipment shall fulfill the EN55022 standard for emissions and IEC61000-4 standards for electrostatic discharge immunity, radiated, radio-frequency, electromagnetic field immunity, electrical fast transient/burst

immunity, surge immunity and immunity to conducted disturbances, induced by radio-frequency fields.

EMI and ESD Compliance	**Standard**
Environmental tests: Operating	
Dry heat IEC 60068-2-2	IEC 60068-2-2
Cold IEC	IEC 60068-2-1
Damp heat	IEC 60068-2-30
Environmental tests: Storage	
Dry heat	IEC 60068-2-2
Cold	IEC 60068-2-1
Damp heat	IEC 60068-2-30
Environmental tests: Transport	
Vibration (random)	ETSI EN 300 019-2-2v2.3.1
Rough handling (free fall etc.)	ETSI EN 300 019-2-2v2.3.1
EMC tests	IEC 61326-1- Industrial Standard
Electrostatic discharge	EN 61000-4-2
Fast transient burst	EN 61000-4-4
RF field immunity (80MHz ... 18GHz)	EN 61000-4-3
Transient surge	EN 61000-4-5
Conducted RF immunity	EN 61000-4-6
RF field emission	EN 55022
Emission to DC/I/O ports	EN 55022
Harmonic current emissions	IEC 61000-3-2
Magnetic field immunity	IEC 61000-4-8
Immunity to Voltage Dips and Short	IEC 61000-4-11
Safety tests	
Electrical safety	IEC 60950-1
Enclosure protection & IP-class	IP66 acc. IEC 60529. Sand & dust test acc. MIL-STD 810 G Method 506.5 Procedure 1

The copy of each certificate must be attached to the technical proposal.

The system must be compliant with all the applicable CE directives and standards.

The system shall be designed to operate in those conditions 24 hours a day, 365 days a year.

3.3 Device Interfaces

The system must have built-in the support of different sensor and device interfaces listed below.

3.3.1. Analog Interfaces

In order to be able to measure several parameters with analog sensors, the system shall have at least ten (10) analog inputs, which are individually and freely configurable by the user. The inputs must be differential type for increased accuracy and avoiding grounding caused errors.

The analog interfaces shall have the following features:

- at least 24 bit A/D conversion
- voltage measurement uncertainty less than 0.06 % of FS (Full Scale) over the full temperature range -50 ... +60 °C
- accuracy of resistance measurements (e.g. Pt-100) better than 0.05 % of FS over the full temperature range of -50 ... +60 °C
- measurement interval freely configurable from one (1) second to twenty-four (24) hours in one (1) second intervals independently and separately for each measurement channel
- each sensor input should have independently configurable gain, scaling factors, calibration coefficients and data quality validation parameters
- each sensor interface should have internal over voltage and ESD protection, minimum 5 kV per pin

The data logger shall include automatic calibration of A/D converter and the measuring electronics. This calibration shall be based on an onboard temperature measurement: self-calibration shall be initiated automatically whenever there is a change of more than 1 □ C of the onboard temperature or at every 30-minute interval.

The system shall have minimum two frequency inputs with minimum accuracy of 0.005 % of F.S. for sensors such as anemometer or tipping bucket type precipitation sensor.

3.3.2. Digital Interfaces

For enabling the use of sensors with digital interface and device control, an interface for digital I/O channels must be available. The interface shall have at least eight (8) digital input and output channels.

The digital interface shall have the following features:

- have LED indicators for activity; in order to reduce the current consumption, it shall be easily possible to disable the LED if seen necessary
- accept any positive DC voltage from 2V to 25 V
- tolerate negative voltages down to -25 VDC

- the inputs shall have switch debounce and hysteris circuitry for reliable operation

The data processing unit shall have at least eight (8) serial input and output channels; or at least five (5) digital input and output channels when the data logger has built-in Ethernet interface:

- RS232 ports: 3/2
- RS485 ports: 3/2
- SDI-12 ports: 2/1
- Ethernet ports: 0/1

The data processing unit shall be able to communicate with smart sensors having a serial communication interface. These communication functions include retrieving data, retrieving self-diagnostic information (if available) and controlling the sensor operation.

The system must have a serial-pass-through-mode, which allows direct communication via maintenance line with any smart sensor connected to the system via serial interface.

3.3.3. Network Interfaces

The system must be able to have a 10Base-T Ethernet interface with native TCP/IP support.

3.3.4. Maintenance Connection

- The system must have a connection port to which a PC can be connected in order to perform system initialization, device software update, and configurations, download stored data and monitor the unit operation. Once connected there shall be full access to all programming features. Maintenance connection shall also be remotely accessible as later described.
- Operations made via the maintenance port must not interfere with the automatic operation of the data acquisition, registering or transmissions except when this is the user's intention.
- In order to prevent moisture or dust to enter the electronics enclosure, the access to the maintenance port shall be available without having to open the enclosure using an external connector. A cable for the service connection shall be included in the delivery.

3.4 Equipment Enclosure

- All parts of the electronic and data processing unit must be enclosed in a sealed robust enclosure with easy access to all components with

mounting options at least to a mast or a wall. The enclosure shall have the following features:

- The enclosure complies with the standards of NEMA-4X or IP-66 as minimum.

- The sensor and device connections shall be installed at the bottom side of enclosure to reduce the risks of water or humidity penetration.
- Sensor and device connections to the enclosure shall be through cable flange or cable glands. A cable cover shall be provided to protect the cable connections from splashes of water or deep snow cover. Sensors that use serial connections shall be routed through surge protection units, which are mounted on a DIN rail inside the enclosure.

- To connect to telemetry antenna cables, the corrosion resistant N type connectors shall be used.

- The enclosure shall be properly vented with a device, which will not allow humidity to enter in the enclosure.

- The enclosure design and material shall be such that it reduces condensation caused by large daily temperature differences inside the enclosure. The use of regularly changeable desiccant material is not allowed.

- The enclosure shall be made of corrosion resistant material with high resistance to UV radiation and chemicals.

- All wiring inside the enclosure shall be bundled so that no loose wires or cables exist inside the enclosure.

- Whenever a pressure sensor is used there shall be a provision to install a static pressure head for minimizing the error cause by the wind turbulence at the pressure outlet.

3.5 Powering

3.5.1. General

It must be possible to power the system from mains network or with solar panels. In both cases the system should include rechargeable, sealed and maintenance free backup batteries sufficient for keeping the station running at least for seven days without recharging. The backup batteries must have a charge regulator with

protection against battery overcharge or deep discharge. The charger must have an indication of the battery condition and charging state.

3.5.2. Batteries

The station must work on batteries. The station shall include only rechargeable, sealed and lithium ion batteries. The capacity of the batteries shall be at least 52Ah. The battery life cycle shall be at least 10 years.

3.5.3. Solar Panel

Solar panel must have a maximum power of 30 W. It shall be design, with tempered glass, EVA resin, weatherproof film, and an aluminum frame, in order to be weatherproof and suitable for extended outdoor use. The solar panel shall be manufactured in a facility certified to ISO 9001 quality management system standards. The solar panel package shall include angle adjustable mast-mounting accessories and a 10-meter cable for fast and easy installation to a pole mast. In built protected solar panels for less attraction to vandalism shall be encouraged.

3.5.4. Battery Regulator

The battery regulator shall include temperature compensation function for charge/recharge, and a deep discharge protection of the battery.

The battery regulator shall allow simultaneous input from both AC (mains) power and solar panel.

The battery regulator shall include LED lamps for indicating the Battery OK/Low and Charge/Recharge conditions. To maximize autonomy time, the lamps are activated only when pressing a TEST push button. Battery regulator shall be a rail mountable unit for allowing easy maintenance.

The battery regulator shall have the following characteristics:

- Maximum input voltage: 30 VDC or less(less attractive to vandalism)
- Maximum input current: 6 A
- Solar panel input: 12 V panels only, lesser voltage are encouraged or inbuilt solar system design for less attraction to vandalism in remote areas.
- Max. load current (backup output) 3.5 A
- Battery charge current limit 0.5/1.0/1.5/2.0/2.5 A (jumper selectable)
- Max. battery discharge current 3.5 A
- Max self-consumption from battery 0.3 mA
- Battery charge voltage selection (with external resistor)
- Housing Anodized aluminum, gray
- Operating temperature range -50 ... +60 °C

- MTBF: > 150 000 hours

3.5.5. Grounding and Transient Protection

The station must have a common and secure grounding point for static and safety grounding. The station must be protected against electrical disruptions and lightning induced surges on all input lines. Transient protection of the most vulnerable lines, such as power lines, long communication and sensor lines must be separate and modular so that the protection device can easily be changed.

3.6 Pole Mast

- The pole mast shall be sufficient to securely mount the wind sensor(s) 10 meters □ 0.1 meter in height. The structural integrity shall also withstand the load of an optional flight warning light when necessary.
- The mast material shall be anodized aluminum and galvanized steel.
- The mast shall have minimum one set of guy wires.
- The mast shall include lightning protection (rod) and electrical grounding. The lightning shall be insulated from the mast and separately grounded.
- The mast shall be fully and easily tiltable for sensor maintenance such that the sensor is not more than 1.5 meters above the ground for maintenance.
- The mast shall withstand wind speed up to 60 meters/second.
- The mast delivery shall include all parts and material, except concrete, for easy installation.

3.7 System Functionalities

3.7.1. Data Acquisition

- The AWS system must support various data acquisition modes including at least: Scheduled acquisition, On-demand acquisition, Alarm based acquisition.
- The data acquisition rate shall be individually configurable for each sensor. The rate shall be adjustable from 1 second to 24 hours in steps of 1 second.
- Data messages shall be sent automatically by the system at the user set intervals. There shall be possibility to configure several data messages to serve different purposes and/or users.
- It shall be possible to trig any measurement on-demand basis, i.e. whenever the user wants to have the latest data to be made available.
- Regardless of when the data logger samples, the user shall be able to set a threshold(s) for any measured or calculated parameter to detect whether a threshold has been exceeded. Once a threshold has been crossed the

AWS system shall automatically start using a new user set sampling interval until the value returns below the threshold level.

3.7.2. Data Transmission

- The AWS system shall have capability to be equipped with several different telemetry modules such as serial lines, Ethernet line, radio modems, wireless telemetry, and satellite transmitters.

- To increase the reliability and redundancy, the AWS system shall have capacity to interface with minimum of two different telemetry devices at the same time. As a preferred choice for communications, the system shall support bi-directional TCP/IPv4 based connections with 3G modem.

- The 3G modem shall be housed inside AWS enclosure. It uses an external antenna that is attached to the AWS mast to improve connectivity to cellular network. The modem shall be connected to the data logger over an RS232 connection. The 3G modem shall comply with the following specifications:

- The system shall have functionality for detecting and automatically recovering from any non-permanent connection malfunction. During temporary communication failures, the system shall buffer outgoing messages up to user-defined limit so that when communications are restored, the buffered messages are transmitted to the destination system. The system shall allow configuring backup servers and/or media, which are taken into use when user configurable number of sequential communication failures has occurred.

3.7.3. Data Logging

- The system must be able to log measured and calculated data into a non-volatile flash memory.

- The logging interval for each variable must be freely configurable.

- In case the memory should run out of free space, the system must automatically clear more free memory by deleting the oldest data first, so that the most recent data will always be saved.

- Primary media for data logging must be an exchangeable external memory card to allow fast local data recovery. The capacity of the

memory card must be at least two gigabytes (2 GB). Compact Flash type cards are preferred for being more robust in outdoor use.

- The filesystem on the memory card must be readable with any PC and commercial card reader.

- The system must also have internal logging capacity at least for seven days of hourly measurements if the memory card should fail.

3.7.4. Data Quality Control

- The system must be able to check the measurement data quality to ensure accurate and complete data collection. It must be possible to automatically flag incorrect or missing data with a user-configurable symbol or text.

- The system must be possible to automatically perform at least the following quality checks for every measurement:

  a) For each measured parameter there shall be upper and lower climatological limits that corresponds to the normal operating limits of the sensor in order to prevent the reporting of possibly false values. These parameters must be user configurable to adjust them to the local climatological conditions.

  b) For each parameter there shall be a 'step change' validation. If the sensor output value changes more that the set maximum value between two consecutive measurements, the value shall be set 'invalid' (e.g. erroneous). This parameter must be user configurable to adjust it to the local climatological conditions.

  c) For each statistical calculation, there shall be the user configurable parameter for minimum number of the samples available for computing statistical values. If the number of samples is less that the user set value, the value shall be set 'invalid' (e.g. erroneous).

- The system must be able to indicate the status of the connected sensors. This indication shall include both analog sensors as well as sensor with digital serial interface. For each sensors, there shall be value in the

variable status, which can be included in the report(s) and/or monitored in order to produce an alarm e.g. for maintenance purposes.

3.7.5. Calculations

Statistical calculations

The station must be able to perform statistical calculations for any of the variables. The period over which the calculations are made must be adjustable from 1 second to 24 hours. At least the following operations must be supported:

- Average
- Minimum
- Maximum
- Standard deviation
- Cumulative sum
- Arithmetic operations

Other calculations

The system must have built-in operations for calculating various weather parameters following WMO recommendations, including at least:

- Dew Point Temperature
- Frost Point temperature
- Wet Bulb Temperature
- Effective temperature sum
- QNH, QFE and QFF pressure
- Pressure tendency and pressure trend
- Wind calculation: it shall be possible to make the calculation in scalar and vector formats.
- Evapotranspiration
- Calculation of Sunshine Duration based on data from the global solar radiation sensor (pyranometer).

- The AWS system shall include unit conversion module with multiple scale unit selection (e.g. m/s to knots or m/s to km/h). Unit selection shall be selectable/configurable by the user.

- The AWS system shall support customer specific calculation formulas

- Ability to perform crop disease models and
- Evaporation rate calculations

3.7.6. ALARM Function

- In order to enable early warnings for severe weather or system malfunction, the station must support the alarm functions described here.

- The system shall be possible for the user to freely set threshold limits for any of the measured or calculated parameters. It must be possible to configure an alarm to be launched whenever a parameter:

  a) exceeds a set upper limit (e.g. when the precipitation intensity exceeds 30mm/h),
  b) goes below a set lower limit (e.g. water level goes below 2.4 m),
  c) is between a set range (e.g. wind direction is between 90 and 180 degrees),
  d) is out of a user set reference range (e.g. 10 minute precipitation rate is 7 mm over the average hourly rate),
  e) changes faster than a user set rate, selectable both descending and/ or ascending value.

- The possible actions to be taken automatically when an alarm is launched shall include:

  a) sending a message to the user configured destination
  b) storing the alarm event together with the measured value
  c) triggering the logging of user defined data group
  d) Triggering an external signal e.g. a relay contact, light switch etc.

- The user shall be able to configure the alarm action to be taken:

  a) only once on the first occasion an alarm is detected,
  b) always when the alarm condition stays effective
  c) when the alarm condition disappears, i.e. the parameter return to its normal value

3.7.7. System Clock

- The station must have a Real Time Clock (RTC) protected against power losses.
- The system must be able to operate in UTC or local time.
- Daylight saving time must be enabled to be adjusted automatically.
- For supporting real-time messaging and alarm generation, the internal real-time clock's accuracy must be better than twenty (20) seconds per month.
- In addition, it must be possible to adjust RTC using at least the following methods:

  a) locally via terminal commands
  b) remote commands over a network
  c) automatically from a central data collections system or an NTP server
  d) using a GPS (Global Positioning System) signal if such a receiver is connected to the system

3.7.8. Power Saving Mode

When there is a power failure at a remote station, this shall enter into low power mode. When in low power mode, the AWS system shall switch off the communication module (modem, satellite transmitter etc) for most of the time, and will switch it on at user defined time(s) for narrow time window. Example: Communication module is switched off. It is switched on for 5 minutes at the beginning of the full hour.

After the user set period in low power mode, the AWS system shall be capable to switch off the communication device to save the battery. The AWS system shall continue to work as data logging station only.

Similarly, in low power mode the AWS system will start using a new time schedule for data transmission. After the power failure, the AWS system shall automatically revert to its original time schedule.

4 SOFTWARE

4.1. Terminal software

The AWS system shall be delivered with easy to use terminal software. The software shall be Windows 7 compatible.

It shall be menu-driven and automate everyday functions such as read, recovery, archive and display observation data, and monitor the AWS system through communication port, remotely via modem or TCP/IP connection.

Terminal software shall support AWS system software update and parameter settings.

4.2. PC based setup program

The system shall be shipped with a PC based setup software to allow an easy configuration and modification of all the system parameters and operation. This software shall be Windows7 compatible.

The software must have a graphical user interface. The software must be able to configure at least the following features and functions:

- Sensors to be connected into the system with measurement parameters
- Measurement intervals freely for each sensor
- Sensor powering
- Sensor measurement validation parameters
- Statistical calculation
- User defined calculation formulas
- Data logging
- Message format and content
- Message sending
- Communications
- Alarms

4.3. Network management and data collection system

- The AWS system shall be delivered with a stand-alone network management and data collection system installed in customer premises. The network management

and data collection system shall be an integrated system software application for efficient management and automation of weather observation network able to connect with existing automated surface weather stations as well as the new AWS systems as specified in this document. The capabilities to manage weather radar, lightning detection and upper-air sounding system networks shall be provided by the network management and data collection system as future system upgrade options.

- The system software application shall include perpetual software license (permanent license with no expiration date) with an annual software update service contract for at least five (5) years.

- The system software application shall include the capability to receive data from the AWS weather stations and perform real-time data quality control services including range, step and persistence checks at minimum.

- The AWS systems shall be able to send the data in auto-send mode to the system application in accordance with the pre-configured schedule, for instance, every one minute. The weather stations shall send the data using a text-based message format. The communication to/from weather stations shall be through TCP/IP socket.

- The system software application shall support data post-collection: the system must be able to request the missing data from the new AWS systems.

- The system software application shall be also able to receive the observations and other calculated parameters from the weather stations via FTP using the text based message report.

- The system software application shall support the capability to receive successfully up to 100 observations in one message. A weather station time service shall be provided as an option to synchronize weather station clocks in UTC time for those sites not provided with GPS receivers or direct connection to NTP server.

- The system software application shall include a browser-based IO terminal application used for viewing the weather station and other field device data, and for sending commands to the new AWS systems and other field devices once allowed by the used communication method.

- The system software application must provide a browser-based user interface for viewing the observation data and for monitoring the data quality and the status of the network and its components. The software shall be accessible by concurrent authorized users at any local area network connected computer. No software shall be loaded on any client PCs. The access to the browser-based user interface is provided using HTTPS and restricted by username and password. To ensure data security the front-

end application of the web user interface shall be primarily based on JavaScript and HTML technologies not using Java applets.

- The web user interface shall be available in English languages.

- The web user interface must include wind, chart component and generic text user interface widgets for displaying detailed view of the weather stations and status in graphical and text/table formats.

- The web user interface must allow users to create data quality and observation reports in table and graphical formats as well as export the data accordingly in CSV and image file formats for further use. When creating observation graph report the user shall be able to compare the observations from the two selected observations sites in the same graph.

- The web user interface shall include an events list view where users can see the last 1000 system events categorized to three different types: info, warning and error.

- The system software application shall support different user rights. The web user interface must provide an administrator view for user management and system settings purposes. Administrator must be able to add and modify pages and page components for all users, add and edit users and organizations, change passwords and password requirements for all users in all organizations and modify the system settings. Organization-level administrator must be able to add and modify pages and page components available for all users inside their organization as well as add and edit users inside their organization. User is able to access the available pages and select the displayed parameters as well as change their own password and edit their own personal information. Guest is authorized to only view the pages and data as configured by the administrator. The system settings shall be available in the administrator view of the web user interface for root-level administrators.

- The system software application shall provide a geographic information system (GIS) map server to generate the map images using data from a GIS database. Standard interface protocol Web Map Service (WMS) shall be used for geo-referenced map images generated by the map server. GIS maps provided as a part of the stand-alone software media installation package shall support zoom levels 1:6759K or better.

- The system software application shall provide alarm icons and sounds to indicate the most critical unacknowledged alerts in the system application and observation network to the operator. The user must be able to acknowledge the alarm sound by clicking a system alarm icon, and if the related alert is still active 12 hours after the

acknowledging the sound, the sound alarm and system alarm icon will be reactivated again.

- The system software application shall automatically store text file logs of daily alarms and other events. The log files must be opened with a text editor or other suitable application for the purpose.

- The system software application must include a notification service where a customer-hosted email server is used for sending email alerts. The configurable parameters shall include at least the email alert sending interval and list of required email addresses. The title of the email alert message shall be configurable.

- The system software application must store all the system events, state changes, observations and message reports received from the observation sites to a scalable database management system.

- The system software application shall use automatic database housekeeping to remove old observations from the database.

- The system software application must store observation data from the new AWS systems in raw data files in character separated text format.

- The system software application shall allow automatically generating a text file from the relational database for each connected surface weather observation station in character separated CSV format and sending these files to external applications and systems via SFTP with the frequency configured by the user. The text files shall contain observation data optionally processed by the data quality control checks when available. The automatic housekeeping settings shall be provided for the user to define how long the generated CSV files are stored in the system.

- The system software application shall allow accessing the data stored into the database via Standard OGC (Open Geospatial Consortium) Web Feature Service (WFS) interface via HTTPS.

- The system software application shall provide the capability to edit the synoptic observation data manually via the web user interface.

- The system software application shall run on Microsoft Windows 64bit and Linux CentOS 7.3 operating systems or the stand-alone system application shall run in Microsoft Windows Server 2012 R2 environment.

- The system software application shall be delivered as a stand-alone installation on customer premises using suitable computer hardware for the purpose.

- The system application shall be delivered as a stand-alone installation on customer premises using suitable computer hardware for the purpose. Alternatively, the application shall be able to run on VMware vSphere 5.0 (or later) virtual environment. The bidder shall provide the specifications to run the system applicationmeeting the

requirements regarding number and type of observation sites connected, amount of data collected, data acquisition interval(s), data storage time, maximum number of concurrent web clients connected and features specified.

- The system shall also have terminals/PC to visualize data at the 41 locations were manual stations are located

5 SENSORS

5.2 General Requirements

All the sensors must be interchangeable. All sensors shall be independently operated by the electronics and data processing unit so that a possible failure of any of the sensors shall not affect the performance of the remaining sensors. The sensors must be tested to correctly operate in the system. All sensors must be able to operate in environmental conditions as specified in 3.2 and the required performance must be reached over the whole measurement and operational temperature range.

5.3 Air Temperature

Air temperature must be measured using an IEC 751 standard Pt-100 resistance temperature detector (RTD) or a better sensor. To minimize the effect of sensor line resistance, the Pt-100 element shall be measured using the 4-wire resistance measurement technique.

The air temperature sensor shall comply with the following specifications:

Feature	**Specification**
Sensing element	Platinum resistance element Pt-100
Accuracy	± (0.176 - 0.0028 x temperature) °C between [-80 … +20°C] ± (0.07 + 0.0025 x temperature) °C between [+20… +60°C]
Resolution	0.1 °C
Operating temperature	-80...+60 °C

5.4 Relative Humidity

Relative humidity shall be measured with a thin film type capacitance sensor. The sensor must be protected from pollution by an appropriate, exchangeable filter. The sensor shall be easy detachable to allow quick replacement in the field.

The relative humidity sensor shall comply with the following specifications:

Feature	Specification
Sensor type	Capacitive humidity sensing element
Measuring range	0..100 %
Accuracy	±2% between 0..90 % of RH ±3 % between 90..100 % of RH
Long term stability/year	±1 % or better
Operating temperature	-80...+60 °C

5.5 Radiation Shield for Temperature and Humidity Sensors

Temperature and humidity sensors shall be installed inside a naturally vented radiation shield at 1.5-2 m above the ground, protecting measurement result from effect of direct solar radiation.

The radiation shield (stacked plate structure) shall be made of a UV stabilized thermoplastic material with white outside finishing. Shields made of metal are not allowed. Underside of the shield plates shall be black colored to ensure that any heat is emitted off the radiation shield.

5.6 Atmospheric Pressure Sensor

Atmospheric pressure shall be measured by an intelligent digital silicon solid-state pressure sensor. The sensor shall have redundant pressure transducers. The sensor shall have a minimum drift and long term stability over the whole operating temperature range. The sensor shall have in-built temperature compensation to guarantee the required accuracy over the whole operating temperature range.

The pressure sensor shall comply with the following specifications:

Feature	Specification
Type	Silicon capacitive pressure sensor
Measuring range	500...1100 hPa
Resolution	0.01 hPa

Accuracy	± 0.15 hPa over the whole temperature range
Temperature dependence	± 0.1hPa
Long-term stability	± 0.1hPa/year
Maximum pressure limit	5000 hPa absolute
Operating temperature	-40...+60 °C

5.7 Ultrasonic Wind Sensor/ Rotating Anemometer & Wind Vane (less power consumption preferred)

The Ultrasonic Wind Sensor shall use ultrasound to determine horizontal speed and direction of the wind. To avoid the possible errors caused by orthogonal incidence angle, the sensor must use the three-transducer principle. The observation height shall be 10 meters.

The ultrasonic wind sensors shall comply with the following specifications:

Feature	**Specification**
Self-diagnostic	Separate supervisor message, unit/status fields to validate measurement stability
EMC compliance	IEC 61326-1 IEC 60945 IEC 55022:2010 Class B
Environmental	IEC 60068-2-1, 2, 6, 14, 30, 31, 52, 78 IEC60529 VDA 621-415
Wind Speed	**Specification**
Type	Ultrasonic 3-transducers
Range	0…60 m/s
Response time	0.25 s
Accuracy	± 3% at 10 m/s
Resolution	0.1 m/s
Wind Direction	**Specification**
Type	Ultrasonic 3-transducers
Range	0…360°
Response time	0.25 s
Accuracy	± 3° at 10 m/s

Resolution	1°

5.8 Precipitation (Tipping bucket)

The precipitation shall be measured by a tipping bucket type of sensor. The rain gauge shall be fabricated from UV resistant plastic and aerodynamically shaped for minimizing the wind-originated airflow from reducing precipitation catchment. The rain gauge shall be installed on a leveled metal platform whose height is such that the rim of the rain gauge is at 1 meter from the ground.

The sensor shall comply with the following specifications:

Feature	**Specification**
Type	Tipping bucket
Sensitivity	0.2 mm per tip
Accuracy	<± 1 % (weather-dependent) (<25 mm/h) <± 5 % (weather-dependent) (<120 mm/h)
Area of aperture	<= 400 cm^2
Capacity	120 mm/h

5.9 Soil surface Temperature Probe

Soil temperature must be measured with a water-tight and corrosion resistant Pt-100 sensor. It shall be used to measure the temperature at different levels beneath the surface. The housing of the platinum resistance (Pt-100) sensing element shall be made of stainless steel, located in the tip part of the assembly. To minimize the effect of sensor line resistance, the Pt-100 element shall be measured using the 4-wire resistance measurement technique. Temperature sensor shall be installed inside a naturally vented radiation shield above the ground, protecting measurement result from effect of direct solar radiation. The radiation shield (stacked plate structure) shall be made of a UV stabilized thermoplastic material with white outside finishing. Shields made of metal are not allowed. Underside of the shield plates shall be black colored to ensure that any heat is emitted off the radiation shield.

The sensor shall comply with the following specifications:

Feature	**Specification**
Sensing element	Platinum resistance element (Pt-100)
Accuracy	¼ DIN 43760 B; (±0.08 □C at 0 □C)
Sensitivity	0.385 ohm/□C

Measurement range	-50 □C...+60 □C

5.10 Solar Radiation Sensor

Solar radiation must be measured using an ISO-9060 certified First Class pyranometer. The sensor must have a double glass dome and a drying cartridge to avoid moisture and built-in level to ease the installation.

The sensor shall comply with the following specifications:

Feature	**Specification**
Spectral range	285...2800nm (50% points)
Spectral selectivity (350 to 1500nm)	< 1%
Response time	<12 s (95%)
Maximum solar irradiance	2000 W/m²
Directional error	< 15 W/m2 (0 ... 80° at 1000 W/m2)
Stability	<1 % per year
Non-linearity (100 to 1000W/m2)	< 1 %
Operating temperature	-40...+80 □C

5.11 Soil Moisture Sensor

The soil moisture must determine volumetric water content (VWC) from 0 to 100 % by measuring the dielectric constant of the media using capacitance/frequency domain technology. Sensor must be easy to install, and its robust design makes it easy to push it directly into undisturbed soil to ensure good accuracy. The sensor must include a 5-meter cable.

The sensor shall comply with the following specifications:

Feature	**Specification**
Measurement time	10 ms
Accuracy	At least 0.03 m3/m3 all soils, up to 8 dS/m With soil-specific calibration: ±.02 m3/m3 (±2%)
Resolution	0.001 m3/m3 VWC in mineral soils 0.25% in growing media
Operating temperature	-40...+60°C
Operating voltage	2.5…5 VDC at 10mA

Output	10...40% of excitation voltage (250...1000 mV at2500 mV excitation)

5.12 Leaf Wetness Sensor

The Leaf Wetness (LW) as in soil moisture sensor must determine volumetric water content (VWC) of a leaf from 0 to 10 or 0 to 100 % (depending on the Scale Factor Unit SFU used by manufacturer) by measuring the dielectric constant of the media using capacitance/frequency domain technology. Sensor must be easy to install, the sensor must include a 5-meter cable.

The sensor shall comply with the following specifications:

Leaf wetness sensor	
	Capacitor-based sensor or better
Operating Temperature	0°C to 60°C
Measurement range	0 to 10 or 0 (dry) to 100% (wet) or any other Scale Factor Unit (SFU)

5.13 Evaporation Rate Sensor

The Evaporation rate sensor must determine evaporation rate by measuring the change of water level in the evaporation pan or of the media using capacitance/frequency domain technology or any other alternative technology. Sensor must be easy to install, the sensor must include a 10-meter cable.

The sensor shall comply with the following specifications:

Evaporation sensor	
	Capacitor-based sensor or better
Operating Temperature	0°C to 60°C
Measurement range	0 to 10mm or any other Scale Factor Unit (SFU)

6 TELEMETRY SYSTEMS

6.1 General Requirements

The AWS shall be capable to interface with a wide range of modern telemetry systems, including:

- Wired Ethernet adapter, with the following specifications:

Feature	Specification
Speed	10 Mbs supports autonegotiation
Operating mode	10Base-T

- Direct serial (RS-232/RS-485) connection, with the following specifications:

Feature	Specification
Isolation	Galvanic
Operating modes	2-wire RS-485/Modbus, RS-232, SDI-12
Connection distance (max.)	1500 m (0.93 mi)

- 3G/4G modem, with the following specifications:

Feature	Specification
Modem installation	Inside AWS enclosure
Antenna installation	External
Frequency bands	Quad-band 850/900/1800/1900 MHz
SIM card	1.8 V and 3.0 V
Operating temperature	-30 … +85 °C
Acceptance	FCC (USA), IC (Canada), CE (Europe)

- Radio modems, with the following specifications:

Feature	Specification

Modem installation	Inside AWS enclosure
Antenna installation	External
Frequency range	403 ... 473 MHz
Channel spacing	12.5/25 kHz
Number of channels	160/80
Frequency stability	< +/- 1 kHz
Type of emission	F1D
Communication mode	Half-duplex
Carrier power	100, 200, 500, 1000 mW
Carrier power stability	<-/+1.5 dB
Adjacent channel power	According to EN 300 113
Sensitivity	-114 dBm (BER < 10 E-3)
Co-channel rejection	>-12 dB
Adjacent channel selectivity	>47 dB / >67 dB
Intermodulation attenuation	>60 dB
Interface	RS-232 or RS-485
Data formats	Asynchronous data
Operating voltage	3 ... 9 VDC / 6 ... 30 VDC
Power consumption	1.2 W (receive) / 7 W (transmit)
Temperature range	-25 ... +55 °C (-13 ... +131 °F)
Antenna connector	TNC, 50 Ω, female

- GOES Satellite transmitters, with the following specifications:

Feature	**Specification**
Transmitter installation	Inside AWS enclosure
Antenna installation	External

Output frequency	GOES: 401.701000 to 402.099250 MHz (x532 300-bps channels and x177 1200-bps channels)
Frequency stability	Long-term TCXO maintained to <±125 Hz Short-term stability <±1 Hz/s
Output	50 Ω impedance, short and open circuit protected
RF power output	Nominal output power of the transmitter 27 ... 370160 dBm in 0.5-dB steps Nominal effective Isotropic Radiated Power (EIRP) with approved 11 dB gain antenna assuming 1 dB cable loss 37 ... 470160 dBm in 0.5-dB steps
Harmonics	Suppressed > 60 dBc
Spurious	Meets NESDIS spurious signal spectral mask for all data rates
Phase noise	Meets NESDIS Carrier Phase Noise, Phase Modulation Bias and RMS Phase Error requirements specified in 300 and 1200 GOES DCPRS Certification Standard V2.0
Modulation message format	8-ary phase shift keying (PSK) with Square Root Raised Cosine Filtering Rate 2/3 trellis coding and data scrambling
Data rate/symbol rate	300 bps (150 SPS ±0.025 %) and 1200 bps (600 SPS ±0.025 %)
Time-of-day clock	Accurate to 20 milliseconds
Diagnostics available to the DCP, storage, and transmission	Forward power Reflected power Internal temperature Before and during transmission Voltage reading Before and during transmission Latitude and longitude Altitude Time of last GPS acquisition Time of last GPS acquisition missed GPS status Failsafe status VSWR
Certification	NESDIS Certification Number 12142012; December 20, 2012
Operating temperature	-40 … +55 °C

- Iridium Satellite transmitters, with the following specifications

Feature	Specification
Transmitter installation	External
Antenna installation	External
Transmit frequency	1616...1626.5 MHz
Transmit power	32 dBm (typical)
Packet size	Tx 340 bytes Rx 270 bytes
Latency	20 sec (typical)
Power consumption	1 amp maximum transmit
Protection class	IP66
Operating temperature	-40 ... +85 °C
Certifications	FCC-certified RoHS-compliant

6.2 Communication Protocol Specifications

The AWS shall support at least the following protocols: MODBUS, ARP, UDP/IP, TCP/IP, FTP, SMTP, PPP(with PAP or CHAP authentication), HTTP(get), Telnet, ICMP Echo, DHCP, NTP,DNS, serial port tunneling over TCP/IP.

6.3 Error Recovery and Connection Redundancy

The system shall have functionality for detecting and automatically recovering from any non-permanent connection malfunction. During temporary communication failures, the system shall buffer outgoing messages up to user defined limit so that when communications are restored, the buffered messages are transmitted to the destination system. The system shall allow configuring backup servers and/or media, which are taken into use when user configurable number of sequential communication failures has occurred.

7 RELIABILITY AND MAINTAINABILITY REQUIREMENTS

7.1 Reliability

7.1.1 The system shall have a demonstrated operational data availability of over 95 % for correct, complete and error-free reporting of data. This requirement is exclusive of any third party equipment supplied by the Purchaser.

7.1.2 The systems shall be designed and fabricated so that the Mean Time Between Failures (MTBF) shall not be less than 20,000 hours for the entire system. The MTBF value (reliability prediction) shall be calculated using the MIL-HNDB-217F standard and shall assume 'ground fixed' glass of operation.The documented calculation of the MTBF shall be included as a part of the technical proposal.

7.2 Maintainability

7.2.1 The Mean Time To Repair (MTTR) of a system failure shall not exceed 1 hour. It is preferable that the MTTR is less than 30 minutes. MTTR shall include failure detection time, remove and replace the faulty FRU and perform a checkout and any necessary calibration, once the parts, tools and manuals are available. The repairs shall be accomplished by a single person.

7.2.2 In order to accomplish the ease of maintenance at the field:

- The system shall have the equipment enclosure with hinged door

- All Field Replaceable Units (FRU) shall be easily accessible and exchangeable without any special tools. Mounting on the DIN- rails is preferred over parts and printed board held in place by screws.

- The technician shall not have to perform preventive maintenance more than once annually.

7.3 Remote Maintenance

7.3.1 In addition to the local maintenance port, the AWS system shall have capability to access the terminal and diagnostics mode remotely via a modem line or wirelessly using GPRS/3G/4G network.

7.3.2 The system shall be capable to produce, at the user set interval, a maintenance message containing as minimum the following information:

- Internal temperature

- Battery voltage
- Voltage of the DC supply
- Status of the mains power supply voltage (ON/OFF), when the mains power is used

7.4. Calibration and Preventive Maintenance

1. The system shall be designed to eliminate or minimize the need for equipment adjustment, alignments, calibrations and preventive maintenance.
    i. A pair of site calibration equipment (travelling standard) shall be part of the package.
    ii. Maintenance tools

7.5. Services

1. Supplier shall carry out training for technicians at ZMD HQ on AWS/software integration of the station, including administrators training.
2. The system shall have the capabilities of integrating with existing sensors and similar systems. The current system is hosting 68 AWS with GPRS/GSM data loggers with SDI/ and IO sensor ports also allowing sending of text messages.
    1. Connection protocols/ capabilities: TCP-IP socket, FTP, SFTP, Ethernet, LAN/WAN
    2. Data storage: PostgreSQL / Relational Database
    3. Windows 10 operating system
3. All provided components and services, shall be guaranteed for a 2 years period beginning at the acceptance date of the equipment.
4. Factory Acceptance and Testing (FAT) shall be conducted by ZMD to ensure the system required confirm to the ZMD requirements by the vendor.