TECHNICAL SPECIFICATION

for the acquisition of

c-band weather radar system in The Norwegian Weather Radar Network

2024/263

Contents

1 SCOPE OF THIS TENDER

1.1 Background

This document specifies the requirements for a single weather radar system with the necessary software to be integrated into the Norwegian weather radar network. Tenderers are hereby invited to participate with their offer for one weather radar system, with the future option to extend the order with up to four similar systems. Tenderers must be able to deliver the first system within August 2025.

The Norwegian Meteorological Institute (hereafter MET Norway), which is the government agency responsible for providing meteorological and other related weather services in Norway, has been operating a digital radar system since 1988 and have over many years expanded the radar network. The radars are situated respectively in Hurum south of Oslo, Hafjell, North east of Oslo, in Hægebostad in the south of Norway, in Bømlo and Stad at the west coast, in Rissa west of Trondheim, at Sømna and the islands Røst, Andøy and at Hasvik in northern Norway, and Berlevåg and Kautokeino in the northeast. A draft plan for the Norwegian weather radar network includes 13 C-band Doppler weather radars. The exact locations of the optional last radar systems is being decided, but not yet official.

All radars are unattended and remotely controlled. They make several three-dimensional data-collection scans every five minutes. The complete data sets are transferred to a central computer at MET Norway in Oslo where various products are made for in-house and external use. The current C-band systems are Leonardo METEOR 600C, 635CDP and 735CDP weather radars.

Products and moment volume data from our present weather radars are integrated into ProRad, an in-house development software, which post-processes the data, generates products, creates mosaics/composites of radar products and exchanges weather radar data with our partners. Products and volume data from any new weather radar shall also be integrated into ProRad.

1.2 The Present Tender

This tender refers to the procurement, installation and bringing into operational service of one radar system at Hasvik. The tender must also include a proposal for the provision of service and support for the radar systems.

The tenderers must provide us with the option to extend the order with up to four more systems within sixc years. Tenderers are therefore required to clearly state unit prices, reductions for quantity ordered, and conditions relating to the prices offered.

MET Norway is aiming, as far as possible, to minimize costs, to purchase already available off-the-shelf hardware and software for the radar system with a minimum of modifications. Tenderers should approach the task of tendering with this in mind, indicating wherever necessary if a specified requirement cannot be met using a standard product. The tenderer is free to propose operational functions and technical solutions that are based on alternative approaches to those assumed or presented in this document. A detailed description and justification on cost/benefit reasons of such alternative solutions must be presented by the tenderer.

2 DEFINITIONS

2.1 Definition of Terms used in this ITT

The following terms are used throughout these specifications to denote the level of the individual requirements and the type of information requested from the tenderer:
MANDATORY: The requirements stated must be met by the tenderer and the system offered, and the tenderer must unequivocal state his compliance or inability to comply.We are obliged by law to refuse tenders which have a significant deviation from our mandatory requirements.
IMPORTANT: The requirements stated may be met by the tenderer and the system offered, and the tenderer must unequivocal state his compliance or inability to comply. The feature is highly desirable but not mandatory. It will be scored during the evaluation process.
INFORMATION: Additional information shall be provided by the tenderer in the tender itself. The provided information will be part of the evaluation process, and scored accordingly.
COST: The unit cost of this feature shall be given in the tender.

2.2 Definition of Acceptance Tests

Factory Acceptance Test (FAT)

MANDATORY: Prior to shipment the supplier shall arrange a FAT with MET Norway staff present. The FAT shall demonstrate MET Norway's own radar system, fully operational, at the tenderers factory. The FAT shall also include an inspection of all documentation to be supplied with the system. The documentation has to be approved by MET Norway. MET Norway representatives will also inspect all relevant quality control documentation. The FAT shall proceed according to a check plan, previously approved by the buyer no less than 21 days before the FAT. This document and the list of compliance shall be a part of the FAT. All requirements from this document shall be checked at the FAT. Eventual missing items or malfunctions will be recorded for further consideration and correction by the supplier. A satisfactory FAT will allow the supplier to proceed into the installation phase.

Site Acceptance Test (SAT)

MANDATORY: The SAT shall be arranged after the completed installation. The purpose of the SAT is to check that all required functions are installed as specified in the contract and that the reliability is good enough to start the operational test. The SAT will be conducted according to an agreed plan submitted by the supplier and approved by the buyer no less than 21 days before the SAT, following in general the procedures applied during the FAT.

Operational Test (OT)

MANDATORY: The reliability and functionality of the individual system items of hardware and software will be checked during an operational test. The OT will continue for a period of 30 consecutive days. During the OT, the various functional items shall achieve an availability figure specified in the contract to be signed. Furthermore, all functional requirements shall be checked to be working as specified. In principle, a failure of the OT shall result in the holding of a new OT after corrections by the supplier of the reasons for failure. This can be repeated three times before MET Norway will have the right to renegotiate/break the contract with the tenderer. If the OT is satisfactorily completed, the complete radar system will be accepted into operational service.

3 GENERAL TECHNICAL REQUIREMENTS

3.1 Introduction

Chapter 3 describes the general technical requirements for all equipment to be supplied by the tenderer. In general, if no standard is stated, ISO 9001 (EN 29001) shall be adopted.

3.2 Physical Construction

3.2.1 Materials

MANDATORY: Only material, components and workmanship of a high grade, shall be employed. The equipment shall be robustly designed and the manufacturer's ratings of all components, which it uses, shall not be exceeded under the conditions stated in this specification.
INFORMATION: The tenderer shall list all component manufacturers and second sources. The tenderer shall list all the major components that are not second sourced.

3.2.2 Environmental Protection

MANDATORY: Full attention must be paid to the effects of the wide outdoor temperature variations (-50°C to +40°C) experienced in Norway.
MANDATORY: All metal surfaces shall be treated against corrosion with a treatment appropriate for the metal.
INFORMATION: The tenderer shall state the standards used for the treatment of metal surfaces in the radome. E.g. radome/tower interface and pedestal.The tenderer may state the standards used for the treatment on other parts in the system.

3.2.3 Construction

MANDATORY: Modular construction shall be employed using connectors suitable for repeated changes without impairing their efficiency. The connections within the equipment where separation of parts may be required shall be by plug and socket adequately rated for the purpose. Plug and socket connections shall be keyed or polarised to prevent incorrect mating.
INFORMATION: The standards adopted for mechanical construction and for electric components shall be stated by the tenderer.
INFORMATION: The mechanical standards adopted in relation to the ability of equipment to withstand mechanical vibration and impact shall be stated by the tenderer.
COST: The tenderer shall suggest critical components, which could be replaced by higher grade parts with consequent improvement in reliability and shall state the cost of such changes.

3.3 Architecture

3.3.1 System Architecture

MANDATORY: Systems are to be designed to provide ease of maintenance.
INFORMATION: The tenderer shall describe the architecture of the complete system. This shall include description of interfaces between subsystems and state any modules that are common between subsystems.

3.3.2 Subsystem Architecture

INFORMATION: The tenderer shall describe the architecture of each subsystem. The following points shall be included:

- centralised or distributed
- type of processing and processors
- any bus standard used
- communications network
- redundancy, including changeover processes
- physical dimensions, and number of equipment racks at each site
- modules required

3.4 Labelling

MANDATORY: All labelling shall use alphanumeric English characters.

3.4.1 Plug, Socket and Cable Labelling

MANDATORY: All plugs, sockets and cabling shall be marked in such a way as to avoid ambiguity in locating the mating connector.

3.4.2 Module/subsystem Labelling

MANDATORY: All modules/subsystems designed as a replaceable unit shall be labelled with the name of module, manufacturer, serial number and a part number.

3.4.3 Equipment Labelling

MANDATORY: Equipment racks shall be labelled, and each module position in the racks shall be labelled with the name of the module to be inserted.

3.5 Environment

3.5.1 Operational Environment

MANDATORY: Systems other than radar antenna environment: temperature +15°C to +35°C, humidity 10% - 95%.

INFORMATION: Tenderers shall state the heat output from the complete radar system.

3.5.2 Environmental Conditions During Transport and Storage

MANDATORY: During transport the equipment shall withstand temperatures from -50°C to +40°C and relative humidity 20 - 100%. Suitable transport packing, which shall be dust-tight, shall be employed. During storage the equipment shall withstand temperatures from -50°C to +40°C, and relative humidity 30% to 90%. The maximum time for storage is two years. During installation the equipment will be stored outside without shelter.

3.5.3 Radiation

MANDATORY: The radar system must operate within the limits set by the current Norwegian / European regulations regarding non-ionising radiation for areas accessible to the general public (International Commission on Non-Ionising Radiation Protection).

3.5.4 Equipment Noise

INFORMATION: The expected noise sound level in dBA at a distance of one metre from each equipment rack, and each operating position.

3.6 Electrical and Transient Interference

3.6.1 Lightning Protection

MANDATORY: The radome shall be equipped with a lightning rod. The height of the lightning rod shall be calculated based on the “Rolling sphere” principle. Site specific details can be exchanged during purchase of each radar system. The down conductors from the lightning rod shall be connected to the basering.
MANDATORY: The tenderer shall provide adequate protection to be used on and between the various units, e.g. antenna and transceiver, and for external line interfaces.
INFORMATION: The implementation principles and practices regarding lightning protection shall be stated in the offer. Details can be agreed on during contract agreement.

3.6.2 Electrostatic Protection

MANDATORY: The tenderer shall implement the necessary antistatic standards, using material to ensure the equipment is not damaged by electrostatic discharge.
INFORMATION: The standards used for electrostatic protection.

3.6.3 Electrical Interference

MANDATORY: The equipment shall be protected from radiated or conducted electrical interference from surrounding equipment.
INFORMATION: The means and the extent to which the equipment offered will be protected against HF, VHF, UHF, SHF, microwave and radar transmissions from sources, which may be nearby. Relevant standards shall be quoted.
MANDATORY: No part of the equipment shall generate such radiated or conducted electrical interference that will affect the operation of any other part of the equipment or other on-site equipment.
INFORMATION: The tenderer shall state the measures taken to prevent the equipment offered from generating radiated or conducted electrical interference to the external power supply or other equipment which may be nearby. Relevant standards shall be quoted.

3.7 Electrical Wiring Regulations

3.7.1 Electrical Wiring Regulations

MANDATORY: All connections to the mains (230 VAC or 400 VAC), equipment connected to the main and any mains wiring shall conform to the Norwegian Regulations for Electrical Safety NEK 400:2022 or corresponding regulations.
MANDATORY: No voltage potential must be present anywhere inside the radar after the main power (and UPS) to the radar has been turned off.
IMPORTANT: 230 VAC and 400VAC circuit breakers that causes the radar system to stop being operational if operated or triggered should be equipped with an remote control auxiliary (e.g. Hager MZ911 or similar). This should make it possible to remote control open and close the circuit breaker with 24VDC from MET Norways own minitoring/control.
MANDATORY: All 230VAC and 400VAC circuit breakers delivered shall be equipped with an auxiliary contact. This will be used to check circuit breaker position by MET Norway's own infrastructure surveillance if not already monitored by the tenderers software and available to MET Norways operators..
MANDATORY: All overvoltage protections embedded in the system shall be fitted with an auxiliary contact for monitoring the status.
INFORMATION: State if overvoltage protection auxiliary contact are monitored by the system. If not, this can be done be MET Norways own monitoring/control hardware.

3.8 Power Supplies

3.8.1 Mains Supply

The mains power supplies available are single-phase 230 VAC (+/- 10%) 50 Hz (+/- 5%), and three-phase 400 V (+/- 10%). A 5-conductor system is used. The AC neutral and the protective ground shall be kept separated in the equipment.
MANDATORY: All power supplies shall have adequate internal protection and filtering against supply transients.

3.8.2 Power Consumption

INFORMATION: Tenderers shall state the total expected power consumption, both peak and average (kVA) of the completed installation at each site.

3.8.3 Power Distribution

INFORMATION: The tenderer shall describe the distribution of power supplies in the system and each subsystem. This shall include power distribution from the mains supply to the equipment racks, card-frames and modules, including contactor switch and fuse locations. Redundancy or backup components and methods shall be stated.

3.8.4 System Start after Complete Power Failure

MANDATORY: The complete system, antenna and radar hardware, must be able to start-up successfully without operator intervention after a power failure.

3.9 Grounding

MANDATORY: All equipment shall be grounded as required in the Regulations for Electrical Safety (NEK 400:2022).
INFORMATION: The tenderer shall state the recommended maximum earth resistance that the equipment should be connected to.

3.10 Reliability

MANDATORY: The basic design philosophy of the radar system shall be the requirement to function for a minimum of 15 years without other changes than those resulting from normal wear and tear. Correspondingly, mechanical (moving) parts shall be designed to withstand at least 132 000 hours of continual use without failure or significant degradation of performance.
INFORMATION: The tenderer shall provide descriptions and frequency of necessary maintenance tasks required to fulfil this requirement. The tenderer shall provide expected lifetime exceeding this requirement, and any additional maintenance tasks and frequency of these necessary to accomplish this.
MANDATORY: The radar and its ancillaries, considered as a whole system, shall be designed and constructed so that it shall not normally require any form of maintenance more frequently than every 9000 hours (one year).
INFORMATION: The tenderer shall provide descriptions and frequency of necessary maintenance tasks required to fulfil this requirement.
MANDATORY: The radar system shall attain an annual average availability of 98%. In calculating this figure, it is assumed that the necessary maintenance and repair staffs are already on-site with the necessary spare parts when required.
INFORMATION: The tenderer shall provide a description and frequency of necessary maintenance tasks required to fulfil this requirement.

3.10.1 MTBF, MTTR

INFORMATION: Since the system has to be available 24-hour/day, the tenderer shall provide worst-case mean time between failures (MTBF) and mean time to repair (MTTR) figures for the equipment listed below. MTTR is taken from the time a technician arrives on site (with a replacement part or module, and the appropriate tools) to the time the equipment is repaired. MTBF and MTTR calculations shall be made for the complete system, and for the following subunits:

- Pedestal
- Rotary joints
- Azimuth and Elevation Drives
- Transmitter
- Receiver
- Signal Processor
- Radar Control Processor
- Power Supplies

INFORMATION: The standards used for calculations of MTBF and MTTR shall be stated.

3.11 Support and Maintenance

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3.11.1 General Support

Lifetime technical support is recognised as a major cost factor in the continued operation of the radar system. The minimising of cost through efficient maintenance methods, but without compromising availability of service, is identified as a prime objective.

MANDATORY: Maintenance support shall be available all normal working-days during the work hours (8-16), Mondays to Fridays, from the tenderer for a period of at least 15 years from the date of commissioning. If an Initial contact with 1st level support doesn't resolve the reported issue, MET Norway technicians shall be given the possibility to discuss the issue with the specialist on the subsystem, either by mail or phone

MANDATORY: The tenderer must state if support can be made available after normal working hours when MET Norway's technicians are troubleshooting a given issue on a radar site.

COST: The tenderer shall describe how the price for support is calculated; e.g Hourly based, how the number of radars affects the total price, the use of expertise other than level 1 support and support outside regular office hours.

3.11.2 Software support

MANDATORY: The tenderer must provide up to date software and bug fixing for every relevant part of the radar system. If a security issue/vulnerability, at any system level, is detected MET Norway shall be notified as soon as possible with information of when new patched software will be available.

COST: The tenderer shall describe how the price for support is calculated. How the number of radars affects the total price, the use of expertise other than level 1 support and support outside regular office hours.

MANDATORY: Errors found in the software must be possible to report to the tenderer. Further the tenderer must have a system for handling these error reports, so that they are solved in an efficient way. Serious errors in the software that makes it impossible to obtain normal operation of the radar system, must be fixed by the tenderer as soon as possible, and no later than the figures for availability under chapter 3.10 demands. Minor bugs/errors must be corrected in the first planned update of the software, and no later than 3 months from the time the fault was reported.
data files.
MANDATORY: The tenderer shall ensure that, during the period of the project implementation and the warranty period following its final operational implementation, the application software shall always function with the latest published version of the radar and central server node operating systems, and whenever necessary, will issue without delay a new version of the application software to comply with this.
INFORMATION: The tenderer shall state his policy for future maintenance of software, both that offered and that to be developed.

3.11.3 Spare part availability

MANDATORY: A complete list of spare parts, down to lowest replaceable units, must be provided. The list shall indicate which parts are recommended to store locally, which parts are recommended to store centrally (Oslo) and which parts are available through the tenderer.
COST: The prices of each spare part on the complete spare part list shall be stated.
INFORMATION: If the tenderer supplies a spare part pool program, a detailed explanation of how the tenderers spare part pool program works..
COST: Cost of participating in the spare part pool program.
MANDATORY: Average expected delivery time and guaranteed maximum delivery time for each part should be indicated with and without participation in a spare part pool program. The delivery time is defined from the time the order is placed from MET Norway until the part is delivered in Oslo. Information regarding if the part can be second sourced should also be included.

COST: The tenderer shall supply as an option a full list of consumable spares, complete with prices to support operation for an initial period of 5 years. This list should contain any spares that the tenderer would advise us to have in stock locally.

MANDATORY: The cost of spare parts and labour service shall not increase with more than the price index per year.

3.11.4 Hardware support

INFORMATION: The tenderer shall describe their repair service and pricing system for repairs. The tenderer shall provide details of the factory service available for repair of lowest replaceable units, including typical costs and details of turnaround times.
INFORMATION: The tenderer shall state the period after the system has been commissioned for which it can be guaranteed that full support can be provided for all items of equipment covered by the offer, in terms of the availability of spare parts as well as a repair service.

3.11.5 Periodic maintenance

INFORMATION: Recommended regular maintenance will be performed by MET Norway's own technicians. The tenderer shall provide a list of tasks for suggested necessary preventive maintenance and estimated time consumption.

3.11.6 Test and Maintenance Equipment

INFORMATION: The tenderer shall list all test equipment and tools required for the proper maintenance and adjustment. The tenderer shall be prepared to provide full information and training for using this equipment

3.12 Installation

3.12.1 Site Preparation, Installation, and Other Work

MANDATORY: The tenderer must be willing to take full responsibility for the mounting, installation and commissioning of the radar system . The tenderer must also accept that it might not be possible to provide accommodation and a working environment that is up to normal standards during the installation period. The tenderer must accept that daily mountain hiking is necessary to access the site. Because of this, the tenderer must provide a time schedule where all efforts to make the installation period as short as possible has been taken. A detailed list of the work to be undertaken by MET Norway will be prepared and agreed upon during the contract negotiation phase.

INFORMATION: The tenderer shall propose a list of the work to be undertaken and its proposed division between the MET Norway and the tenderer. The list shall include a general timetable for delivering and erecting the proposed radar system. All demands the tenderer has regarding parts of the installation they expect MET Norway to be responsible for, has to be clearly specified in the tenderer's answer. Some examples of possible subjects are:

- Free space needed for the radar installation
- Demands for the supply of electric power
- Demands for the communication
- Demands for radiation-protection
- Demands for heating, cooling and dehumidifying
- Specifications for cranes, equipment needed during the system installation
- Specifications regarding the interface between the radar tower and the radar equipment/radome. Note that on existing sites the tenderer has to provide a solution to adapt their interface to existing basering.

3.12.2 Helicopter Installation

Most of the radar sites in Norway are not accessible by road, and a helicopter is necessary to install the radar system on these sites. For safety reasons a trained helicopter installation crew will be used for preliminary mounting the lifted units (ex. pedestal, antenna, radome). Helicopter and helicopter installation crew is not part of this tender and will be booked and coordinated by MET Norway.
MANDATORY: The tenderer shall give necessary training to the helicopter installation crew for securely mounting units on top of the radar tower. The tenderer accepts that the helicopter installation crew will only do mounting necessary to securely attach the units, and the tenderer itself will do the precision installation when the helicopter lifting is complete.

MANDATORY: The tenderer shall assist where needed during the helicopter lifting, ex. coordinating the lifting order, consulting during mounting.
MANDATORY: The tenderer shall bring all necessary equipment needed for the helicopter lifting (lifting straps, shackles, etc) and prepare all the units ready for lifting before the helicopter arrives.
MANDATORY: Each subunit prepared for helicopter lifting must be less than 1250kg
COST: The tenderer shall supply additional cost for prospective helicopter installation, and specify what this cost includes.

4 RADAR SYSTEM REQUIREMENTS

4.1 Introduction

Each radar site shall comprise of a radar together with its related processor hardware and software, allowing complete remote control and surveillance of the radar from authorised computer terminals at MET Norway central office in Oslo.

This chapter specifies the characteristics of the radar transceiver and its immediate ancillaries, while chapter 5 specifies the requirements for the computer and processor facilities at the radar site and at the central site. In addition to radar control and surveillance facilities, the system shall also contain facilities for testing the radar, and for carrying out certain computational tasks on the collected data

In recent years new transmitter technology has emerged in the c-band weather radar space. However, the adaptation of these transmitter technologies in operational use are still sparse throughout European meteorological services. MET Norways' c-band weather radar network is used purely as an operational network. We focus on high availability and a homogeneous network. The sites run the same type of scans, with local adaption for minimising clutter, etc. Single site C-bands systems are not used for research campaigns and MET Norway does not have the resources needed to study how to fully take advantage of a new transmitter technology. It is therefore concluded that this tender will require a magnetron transmitter.

4.2 General Requirements

MANDATORY: The design of software and hardware shall be "fail safe" in any partial or total power failure situation.
MANDATORY: It shall be possible, under certain safeguards, for the radar station to automatically recover from a power failure situation and resume normal operation.
MANDATORY: The design of software and hardware shall be "fail safe" in any partial or total system fault situation. E.g. the system must withstand and automatically take necessary precaution measures if any part in the system fails.
MANDATORY: The system must monitor all system parameters of importance and if beyond rated limits, necessary precaution measures must be carried out automatically.
MANDATORY: The system shall monitor the status of every power supply in the system.
MANDATORY: To ensure that the radar network functions properly, the radar transceiver and associated equipment shall be designed to:

- Be capable of modular expansion to enable system expansions and modifications
- Use industry standard communication protocols/buses for maximum compatibility and expandability

4.2.1 Site

MANDATORY: Tenderers shall provide details on the following for the equipment to be installed at the radar site:

- number and size of equipment racks
- recommended minimum equipment room size, including, necessary infrastructure, space for the installation of the system and normal maintenance work, testing instruments, equipment and spare parts
- recommended equipment room layout, including the electrical layout
- any other aspects relevant to building design
- air conditioning / dehumidifier requirements

MANDATORY: Suitable equipment shall be provided at the radar site for maintenance purposes.

4.2.2 Antenna Drive Replacement

MANDATORY: All parts of the antenna drive shall be replaceable. This includes motors, gearbox, belts, planetary gears, bearings, etc.
MANDATORY: Repair/replacement of any part of the drive shall not require the removal of the radome.
INFORMATION: Tenderers shall provide information regarding these replacements.
MANDATORY: The tenderer shall give a three year warranty on the antenna moving parts.

4.2.3 Radome

MANDATORY: The radar antenna system and radome shall be capable of continuous operation in outside temperatures ranging from -50°C to + 40°C and in relative humidity up to 100%. Maximum wind figures are: continuous steady winds 60 m/s with 80 m/s gusts. The radome and radome/tower interface shall also be dust and waterproof and withstand the extra stress caused by problems like icing and snow.
MANDATORY: The radar antenna shall be housed in a radome. A radome shall be included in the tenderer`s offer. The radome shall create minimum beam distortion, polarisation and side lobe degradation properties. The radome shall be included in the estimation of overall system performance.
MANDATORY: The radome shall have a one way dry attenuation of maximum 0.3 dB.
MANDATORY: The radome shall have a cross polarisation degradation less than 0.8°.
MANDATORY: The radomes shall not introduce a bore sight error greater than 0.003°.
MANDATORY: The tenderer shall be able to deliver the interface between the radome and concrete tower (or existing basering on existing sites), upon MET Norway's request, separate from the rest of the radar system delivery. On new sites this may be one year prior to the radar system installation.
MANDATORY: The radome must be optimised for use with a dual polarisation radar system.
MANDATORY: The radome shall have a durable hydrophobic coating and keep its water repellent properties over prolonged time. It shall be completely weather sealed, with no ventilation openings.
MANDATORY: The effect of solar radiation on the radome surfaces shall be negligible.
INFORMATION: The tenderer shall provide the aforementioned properties (preferably measured) of the radome, together with expected ageing performance in Norwegian climatic conditions.
INFORMATION: Procedures for cleaning and maintenance of the radome.
INFORMATION: The tenderer shall provide information about the radome performance in worst case weather conditions. This shall include information on loading from a steady wind speed, and from wind gusts. Loads transferred to the tower shall be calculated.
MANDATORY: The radome shall be delivered with a lather
MANDATORY: The radome shall be delivered with a hatch on top. The hatch is for accessing the outside of the radome for maintenance purposes.
MANDATORY: The tenderer shall give a three year warranty on the radome parts, including weather sealant and panel bolts tightening torque.

4.3 On-site man machine interface

MANDATORY: The radar system shall be equipped with an on-site man-machine interface (MMI) capable of reporting system status and basic control of the system. When the radar system is started the MMI shall be available and ready to use without additional user actions.

4.3.1 System status and diagnostics

MANDATORY: The radar shall include a capability for equipment monitoring and reporting the status of radar functions to a man-machine interface (MMI) at site.
MANDATORY: It shall be possible to monitor the performance of selected functions on a non-interfering basis concurrent with the processing of online data and to perform sufficient tests to ascertain that no degradation in operation has occurred.
MANDATORY: The following (but not limited to) shall be monitored from the local MMI:

- Antenna speed
- Antenna position
- Antenna motors voltages and currents
- Horizontal transmitter output power
- Vertical transmitter output power
- Horizontal transmitter reflected power
- Vertical transmitter reflected power
- Calculated VSWR
- Selected pulse width
- Selected PRF
- Status of all system power supplies
- Oil levels

- Transmitter high voltage/current
- Filament voltage/current
- Temperatures at critical positions
- Waveguide pressure status

MANDATORY: All built-in self-tests that can cause the radar system to deviate from normal operation when a FAULT or WARNING is detected shall be monitored from the MMI.
MANDATORY: The software shall be designed in such a way that the technician can see the "health" (OK/Warning/Fault) of the radar subsystems instantly when using the software.
MANDATORY: Tenderers must deliver documentation with technical data and exact position (physical and in a circuit diagram) for all system sensors responsible for providing information on the actual system status A complete list of sensors and measurements used for monitoring the radar system shall be provided, together with information regarding:

- The parameters each sensor measures
- Where in the system the sensor is placed
- Which fault indications the sensor is involved in and will trigger
- High and low limits, and the normal values for the sensors output

4.3.2 Control

MANDATORY: It shall be possible to block any external control of the system from the MMI, allowing only local control from the MMI itself.
MANDATORY: The following (but not limited to) shall be controllable from the local MMI:

- Antenna elevation (position or speed)
- Antenna azimuth (position or speed)
- Radiation on/off
- Pulse width
- PRF
- Transmitter power on/off
- Receiver power on/off
- Antenna/pedestal power on/off

4.4 Diagnostic interface for status monitoring, control and calibration

MANDATORY: Software/interfaces must be provided which can be installed/opened on the technician's maintenance laptops. The software shall be used for fully controlling the radar system, diagnostics, various display tasks and radar system calibration.
MANDATORY: The software should be able to run on any MET Norway purchased off-the shelf computer. The computer itself is not part of the delivery from the tenderer.
MANDATORY: The software shall have help menus explaining calibration routines, meaning of status indicators, etc.
MANDATORY: The menu language shall be English.
MANDATORY: The software shall be able to connect to the radar system and perform the task specified in 4.4.1, 4.4.2, 4.4.3 and 4.4.4 using TCP/IP both on-site, and off-site (from another TCP/IP subnet).
MANDATORY: Results from the software, e.g. parameters set, status, etc., should be possible to save/export to file for future reference.
INFORMATION: The tenderer shall give detailed information on the software used, licence information and which operating system and/or runtimes are required.

4.4.1 System status and diagnostics

MANDATORY: The software shall be able to monitor everything monitored by the MMI. This includes everything specified in 4.3.1.
MANDOTORY: The software shall also be able to monitor the following (but not limited to):

- Noise levels
- Other signal processing parameters

MANDATORY: The software shall be designed in such a way that the technician can see the "health" (OK/Warning/Fault) of the radar sub-systems instantly when using the software.
MANDATORY: The software shall be able to display log-files showing historical radar system status.

MANDATORY: The software shall be able to graph selectable historical parameters. All parameters shall be logged for a period of minimum 6 months.
MANDATORY: The reporting of the radar status has to be so detailed and accurate, that in case of a fault situation it is possible with great certainty, for an experienced technician to troubleshoot remotely and travel with the right spare parts on the first trip to the radar site.
MANDATORY: Tenderers must deliver documentation with technical data and exact position (physical and in a circuit diagram) for all system sensors responsible for providing information on the actual system status.

4.4.2 Control

MANDATORY: The software shall be able to control everything controlled by the MMI. This includes everything specified in 4.3.2.
MANDATORY: The software shall also be able to control the following (but not limited to):

- Processing parameters such as filters, thresholds, etc.
- Soft-reset computer based subunit
- Hard-reset (power on/off) for each system subunit (via a network power switch or similar).
- Sector blanking settings

IMPORTANT: It shall be possible to control the AFC (if equipped) from the radar control software in order to make it possible to disable AFC during manual operations.
MANDATORY: It shall not be possible to perform actions that can damage the system in any way. When such actions are detected the software shall display an error warning notifying the end user.
MANDATORY: If the end user tries to set invalid or conflicting process parameters, the system shall notify the user and clearly show witch parameters that are invalid/conflicting

4.4.3 Display

MANDATORY: The software shall be able to display the following (but not limited to):

- PPI-scope for viewing radar data (e.g. reflectivity, radial velocity, spectral width)
- A-scope for viewing radar data
- B-scope for viewing radar data

IMPORTANT: The software should allow examination of the transmitter pulse in real time while running in normal operation. The resolution has to be good enough to tell if the transmitter is operating as expected. E.g. should be able to detect a failing magnetron with a collapsing tail.
IMPORTANT: The software should be able to display the following (but not limited to):

- RHI-scope for viewing radar data
- Allow viewing of I/Q-data
- Examination of the radar triggers

4.4.4 Calibration and test

IMPORTANT: The software should be able run the following calibration (but not limited to):

- Sun tracking/antenna position
- Radar trigger calibration/adjustments
- Transmitter calibrations
- Receiver calibrations (power/phase)
- Noise calibrations
- Noise Figure
- Single Point calibration
- Bird bath calibrations
- Receiver linearity check (with external signal generator)
- Dynamic range check
- Sun raster scan for antenna measurements and receiver dual polarisation offsets.
- Antenna parameters check (positioning, speed, acceleration)

IMPORTANT: It shall be possible to run calibrations remotely (when additional instrumentation is not needed).

4.5 Integrated test equipment

4.5.1 Signal Generator

MANDATORY: The system shall be fitted with a built in test signal generator, CW and/or pulsed, used for calibrations mentioned in 4.4.4 and calibrations run alongside data acquisition (online calibrations).

4.5.2 Noise Source

MANDATORY: The system shall be fitted with a RF noise source, used for calibrations mentioned in 4.4.4.and calibrations run alongside data acquisition (online calibrations).

4.5.3 Power Sensors

MANDATORY: The system shall be fitted with external power sensors on waveguide couplers for measuring forward and reverse power on the horizontal and vertical channel, used for calibrations mentioned in 4.4.4.and calibrations run alongside data acquisition (online calibrations).

4.6 Transmitter/Receiver

MANDATORY: The radar system must be a simultaneous transmit and receive dual polarization radar system.
MANDATORY: The transmitter shall be a magnetron system.

4.6.1 Frequency

MANDATORY: The radar transceiver shall operate in the C-band in a frequency range of 5600 - 5650MHz.
IMPORTANT: The transmitter should have countermeasures to prevent frequency drift caused by temperature drift in the magnetron.
INFORMATION: The countermeasures taken should be explained.
MANDATORY: The transceiver stability shall give a phase stability at near ranges (<50 km) better than 0,5°, and a satisfactory performance with weather echoes out to a range of 250 km.
INFORMATION: The tenderer shall provide evidence (e.g. a theoretical breakdown of the degradation of the phase stability by various known factors in the transceiver construction and parameters) that the transceiver has the required stability and other characteristics required for satisfactory operation out to the given range.

4.6.2 Power

MANDATORY: The peak pulse power shall be in excess of 400 kW for all pulse widths, PRFs, and transmitter mode, and shall not vary more than ± 5% from one measurement to the next. The power should be measured on a waveguide coupler before the signal is split to its horizontal and vertical components.

4.6.3 Dual Polarisation

MANDATORY: The radar transceiver shall be a dual polarisation radar system.

4.6.4 Static pulse widths

MANDATORY: The pulse width shall be adjustable with a span from 0,50µs or narrower to 2.00µs or wider. At least two pulse widths shall be provided on delivery; one at 2.00µs, the other at 0.83µs.
IMPORTANT: It shall be possible to configure different pulse widths than the ones configured upon delivery.
INFORMATION: The tenderer shall specify the procedure for accomplishing this, e.g. tools/instruments needed.

4.6.5 Dynamic pulse widths

IMPORTANT: During normal operation, the system should be able to run in a dynamic pulse width mode, where the system calculates the maximum possible pulse width, in regards to maximum duty cycle, for a given PRF and chooses this pulse width.

INFORMATION: The tenderer shall specify the principles behind the mode, e.g. how this works in regards to matched filters in the receiver.

4.6.6 PRF

MANDATORY: The pulse repetition frequency shall extend (for one or the other pulse width) from 250 Hz to at least 2200 Hz (determined by the magnetron duty cycle).
MANDATORY: A dual PRF mode with selectable stagger ratio to increase the measurable velocity range shall be available.

4.6.7 Filtering

MANDATORY: The radar transceiver shall include the means to minimise both the production and reception of frequencies other than that of main radar signal, i.e. spurious and harmonic out-of-band emissions.
INFORMATION: The tenderer shall provide performance figures for the methods employed to reduce the spurious emission and reception mentioned above.
INFORMATION: An estimate of the frequency difference required, between two adjacent radars equipped as described above, to give no detectable interference (above MDS) with antennae directly facing each other at a separation of 150 km. No earth curvature may be assumed.

4.6.8 RLAN Interference Rejection

The extent of Radio Local Area Networks (RLANs) in the 5GHz range is increasing. This represents a serious potential threat for C-band weather radars. Measures have to be made in C-Band meteorological radar design to ensure long-term coexistence with 5 GHz RLAN.
MANDATORY: The radar system shall follow “Recommendation on C-Band Meteorological radars design to ensure global and long-term coexistence with 5 GHz RLAN”.
https://www.eumetnet.eu/wp-content/uploads/2017/01/OPERA_2008_12_Recommendation_RLAN.pdf
IMPORTANT: The tenderer shall provide information of the methods employed to reduce RLAN interference, for both emission and reception. This includes out-of-band and spurious frequency rejection.

4.6.9 Digital Receiver

MANDATORY: The linear dynamic range of the digital receiver shall be at least 115 dB, and the MDS shall not be worse than -110 dbm for 0.5µs pulse length operation in both horizontal and vertical channels.
MANDATORY: The linear dynamic range of the digital receiver shall be at least 121 dB, and the MDS shall not be worse than -117 dbm for 2.0µs pulse length operation in both horizontal and vertical channels.
INFORMATION: The tenderer shall provide full technical details of the receiver, including typical measured receiver response curves.
MANDATORY: The observation range of the radar shall be divisible into at least 4096 range gates, which shall be groupable into larger units for range averaging purposes.
MANDATORY: Azimuth averaging shall be selectable in the range 1 - 1024 or more pulse samples, which shall be equally weighted (boxcar). Also an angle sync mode should be available, where all samples that fall into a selectable degree sector are averaged. The selection should be at least 0,5 degree.
MANDATORY: The A/D conversion shall be at least 16 bits. Sampling rate shall be such as to maximise S/N performance.
INFORMATION: The performance of the digitizer options offered shall be explained in detail, particularly where their performance exceeds or falls short of the above requirement.

4.7 Antenna, reflector and Waveguide Characteristics

All requirements in the following chapter shall be met in the whole frequency range from 5600 MHz to 5650 MHz.
INFORMATION: The tenderer shall state the temperature range needed to meet the requirements in this chapter.

MANDATORY: The antenna, reflector and waveguide situeded in the radome shall be capable of continuous operation in temperatures ranging from -15°C to + 40°C and in relative humidity up to 55%.

4.7.1 Beam Width

MANDATORY: The -3dB antenna beam width shall be less than 1º in E-plane and H-plane for both horizontal and vertical polarisation.
MANDATORY: The -3dB antenna beam width shall have less than 0.1º difference between E-planes and H-planes in horizontal and vertical polarisation.
MANDATORY: Over 2º off axis from to the centre the main lobe shall be suppressed at least 30 dB in E-plane and H-plane for both horizontal and vertical polarisation.
INFORMATION: Full measured beam parameters in E-planes and H-planes in horizontal and vertical polarisation

4.7.2 Side Lobes

MANDATORY: Side lobes shall be suppressed at least 30 dB referred to the main beam power in E-plane and H-plane for both horizontal and vertical polarisation.
MANDATORY: Over 20º off axis from to the centre of main lobe, side lobes shall be suppressed at least 45 dB in E-plane and H-plane for both horizontal and vertical polarisation.

4.7.3 Cross polar isolation

MANDATORY: The cross‑polar isolation shall be at least 32 dB for both horizontal and vertical polarisation..
MANDATORY: Over 2º off axis from the centre of the main lobe, the cross‑polar isolation shall be at least 45 dB for both horizontal and vertical polarisation.

4.7.4 Elevation and Azimuth Angles

MANDATORY: The antenna shall be capable of operation between elevations of -2° to 92°.
MANDATORY: Azimuth and elevation pointing error shall be less than +/- 0,1°.
INFORMATION: The tenderer shall state the position accuracy of the antenna in both azimuth and elevation in pointing and rotational modes.

4.7.5 Antenna Elevation Movement

MANDATORY: The antenna elevation Acceleration shall be minimum 18°/s² when travelling between 0° and 90° and vice versa.
MANDATORY: The radar transceiver shall be able to carry out vertically nodding scans on any azimuth bearing under remote control.
INFORMATION: Tenderer shall supply information of the dynamic response (i.e. overshoot characteristics) of the antenna drive in elevation.

4.7.6 Antenna Azimuthal Rotation

MANDATORY: The antenna shall rotate with a constant speed which is adjustable between 0 - 36 °/s with an accuracy and variability of less than 0.2°/s. Acceleration shall be minimum 18°/s².
INFORMATION: Tenderer shall supply information of the dynamic response (i.e. overshoot characteristics) of the antenna drive in azimuth.

4.7.7 Antenna Drive monitoring

MANDATORY: The tenderer should provide the software, hardware and documentation necessary to remotely monitor and adjust the servo drive parameters.

4.7.8 Waveguide

MANDATORY: Measuring couplers shall be provided for facilitating direct measurements of waveguide losses between transmitter/receiver and antenna dish.
MANDATORY: A measuring couplers shall be provided for facilitating direct measurements of transmitted power before it is split to its horizontal and vertical portions.
MANDATORY: A waveguide switch shall not be installed.'
MANDATORY: The waveguide loss shall be less or equal to 0.05 dB/m.
MANDATORY: The Rotary joint shall be robust and not degrade the transferred signals more than 0.02 dB.

4.7.9 Waveguide pressurisation

MANDATORY: The waveguide shall be provided with overpressure with dried air for condensation and arcing prevention.
MANDATORY: Remote readout off pressure, running duty cycle, temperature, etc shall be provided.
INFORMATION: The tenderer shall provide details on waveguide pressurisation as well as any other aspects, including dry air feed.
IMPORTANT: The tenderer shall provide a solution with a redundant pressurisation system to automatically take over if the primary system fails.
INFORMATION: The tenderer shall provide details on the functioning of the redundancy and failover system.
COST: The tenderer shall provide the additional cost for such failover.

5 RADAR DATA PROCESSING, COMMUNICATION, SOFTWARE AND DISPLAY REQUIREMENTS

5.1 Introduction

This chapter covers requirements specific to the conversion of radar echo signals, logging system data, production of data in digital form, and dispatch of the data to a central server node over a computer network.

The analogue signals must be converted to digital signals. The signal processor is assumed to be fully programmable regarding e.g. time-space resolution of the measurements, averaging, range dependent corrections, clutter filtering and various modes of thresholding.

Further data processing is performed by a radar control/signal processor(s), which formats the radar data (moment data) slices for onward transmission over limited bandwidth to the central server node of the MET Norway radar data network.

The communication must be running over a TCP/IP network, thus allowing almost all functions of the radar systems to be remotely controlled. The connection to MET Norway's main computer network is typically through a VPN tunnel with speeds up to 2Mb/s up/down.

The dissemination and display of radar data in various forms is today sent over the existing computer network. The radar data slices are received and further processed at the central server node. Software in the radar control processor and the central server node shall be mutually compatible to allow full networking.

Products from our present weather radars are integrated into ProRad, an in-house developed software, which is post processing raw volume data, generating products, generating mosaics/composites from self-made products or radar system generated products and exchanges weather radar products/composites with MET Norway's partners. Products from any new weather radar shall also be integrated into ProRad. ProRad uses a XML based file format for single site radar products and for composites/mosaics.

5.2 Scan definition and scheduling

MANDATORY: Software for defining scan definitions and schedules, and uploading this to the radar system.
MANDATORY: The radar system shall store the installed schedule(s) locally and continue running the schedule even if the communication lines to the radar site goes down.
MANDATORY: The radar system shall use the last installed schedule(s) when starting up from a complete power down even though the communication lines to the radar site are down.

5.2.1 2D scan definitions

MANDATORY: It shall be possible to create and run 2D scans for both azimuth and elevation.
IMPORTANT: It shall be possible to make a sector mode scan, in which the antenna moves to and from between two given azimuths at a given maximum rotation speed

5.2.2 3D scan definitions

MANDATORY: It shall be possible to create 3D scans consisting of a series of consecutive operations in rotation mode.
MANDATORY: The absolute positioning accuracy shall be the same as that attained in movement of the antenna under manual control, and the whole range of rotation speeds mechanically permitted shall also be available through the software.
MANDATORY: The set of elevation angels used shall be user defined.
MANDATORY: There shall be no restrictions on the number of different elevation angles used or in which order the elevations angels shall be scanned. Both decreasing and increasing angles are to be permitted. It should be possible to use the same angel multiple times in the 3D scan.

MANDATORY: It shall be possible to set rotation speed, PRF, pulse width, range steps, angle steps, doppler filter, threshold filters, speckle filter, etc. individually for each elevation angle.
MANDATORY: No data may be collected during periods of elevation angle change.
IMPORTANT: It shall be possible to make a 3D sector mode scan, in which the antenna moves to and from between two given azimuths at a given maximum rotation speed successively at a series of elevation angles.
MANDATORY: It must be possible to set up one single volume scan that consists of different elevations, which are optimised for different types of radar data (e.g. reflectivity). When generating products from these volumes it must be possible to select which elevation that shall be taken into consideration for each product.

- Further process radar data (raw data) into formatted polar files
- Compress polar files for efficient communication to other computers, for disk storage and for archiving

5.2.3 Schedules

MANDATORY: It shall be possible to create a schedule consisting of one or multiple 2D or 3D scans.
MANDATORY: It shall be possible to set the start time and a repetition time for a schedule.
IMPORTANT: It should be possible to include a noise check (zero check) at any given time between scans in a schedule.
IMPORTANT: It should be possible to start a noise check (zero check) after a given number of repeated schedules.
MANDATORY: The software shall automatically check whether it can fulfil the given schedule, and issue a warning in impossible cases.
IMPORTANT: It should be possible to define multiple schedules with different priority, different repetition time and/or different start time. If a lower priority schedule is running when a higher priority schedule is starting, the lower priority schedule should abort/pause (either should be selectable) and the higher priority schedule begin. If a higher priority schedule is running when a lower priority schedule is starting, the lower priority schedule should abort/postpone (either should be selectable) and the higher priority schedule continue.
MANDATORY: It shall be possible to select which products (see 5.4.3) that shall be generated from each volume in the schedule.

5.2.4 Online calibrations

MANDATORY: It shall be possible to schedule online(calibrations alongside data acquisition), and offline calibration (calibrations requiring no other scans to be running simultaneously).
IMPORTANT: It shall be possible to run bird bath, noise sounding, solar raster scan, single/multi point calibration and noise figure as scheduled offline calibration.
IMPORTANT: It shall be possible to run bird bath, noise sounding, single/multi point calibration and noise figure as online calibrations (given a scan that meets calibration requirements).
INFORMATION: The tenderer shall inform what kind of calibration can be scheduled as online and offline.

5.3 Signal processing

MANDATORY: The signal processing shall be handled either by a radar Signal Processor (RSP) on site or (partly) handed over to the centralised server specified in 5.4.
INFORMATION: The tenderer shall inform what kind of signal processing solution he can deliver, and inform about all possibilities, options and (if any) additional costs for such options.

5.3.1 Range and Other Corrections to Reflectivity Signal

MANDATORY: The digitised and averaged reflectivity signals shall be corrected for the following effects:

- normal range attenuation ($1/R^2$)
- gaseous attenuation due to oxygen

MANDATORY: The calibrated echo reflectivity (radar reflectivity factor) in scaled dBZ units shall be obtained from the corrected echo signal using a user-definable radar constant, together with a calibration table derived directly from a calibration procedure.

MANDATORY: Receiver noise shall be removed from the data in such a way that the maximum possible sensitivity to weather echo signals shall be automatically maintained.
INFORMATION: The method of maintaining maximum sensitivity during noise thresholding must be stated.
MANDATORY: Attenuation correction due to intervening hydrometeors based on dual polarization data.
IMPORTANT: Attenuation by hydrometeors (cumulative effect with range) in which there shall be a selectable maximum dBZ value, above which the correction is zero. Parameters in the attenuation formula shall also be freely selectable by the user. The attenuation correction shall take into account the true phase of the hydrometeors in the beam, i.e. correction for water shall only be made in that part of the beam containing liquid water droplets.
IMPORTANT: It shall be possible to correct for azimuth and elevation dependent attenuation due to beam blocking.

5.3.2 Processing of Digitised Signals

MANDATORY: Staggered PRF velocity unfolding (with at least 3 selectable ratios) shall be provided. The velocity resolution/maximum values shall be automatically indicated with PRF change in the set-up interface specified in 5.2.
IMPORTANT: A staggered PRF multi trip method to identify and recover signals beyond unambiguous range should be included.

5.3.3 Time and Angle Marking

MANDATORY: Each angular sector of data values shall be provided with a time and angle tag, from which the actual (i.e. computer maintained) time and elevation and azimuth angles of the individual observation can be obtained. These tags shall accompany the polar data.

5.3.4 Clutter Removal

MANDATORY: A ground clutter removal algorithm (or algorithms) for all data types shall be included in the signal processing.
MANDATORY: A dual polarisation based sea clutter removal algorithm (or algorithms) for all data types shall be included in the signal processing.
INFORMATION: Sea and ground clutter removal methods and algorithms that are offered by the tenderer shall be described in detail, including estimates of the performance in precipitation conditions.

5.3.5 Signal Thresholding

MANDATORY: Signal thresholding (for all radar data types) on a bin-to-bin basis based on Signal/Noise, unfiltered signal/clutter and coherency shall be provided
MANDATORY: Removal of single-bin spike echoes shall also be provided.
IMPORTANT: Signal thresholding (for all radar data types) on a bin-to-bin basis based on non-trip recovered signal/multiple trip recovered signal should be provided

5.3.6 Processing of interference from wind turbine parks

IMPORTANT: Methods/algorithms for minimizing interference from nearby wind turbine parks should be included.
INFORMATION: Methods and algorithms for minimizing interference from wind mill parks that are offered by the tenderer shall be described in detail, including estimates of the performance.

5.3.7 Customer algorithms

IMPORTANT: It should be possible to run customers' own developed algorithms on the signal processor.
INFORMATION: The tenderer should describe the functionality and where in the processing chain it's possible to run the algorithms.

5.3.8 I/Q data

IMPORTANT: It should be possible to store IQ data for customer offline use.
INFORMATION: The tenderer should describe the functionality.

5.4 Centralised server

MANDATORY: The radar system(s) shall communicate with a centralized server located at MET Norway's headquarter in Oslo. The server shall be responsible for gathering radar status information, gathering radar data slices, assembling slices into volumes, generating products from volumes or single slices and converting native file formats to other radar data formats.
IMPORTANT: The centralised server software should be able to run on a Linux operating system.

5.4.1 Radar status information

MANDATORY: System performance and malfunctions shall be recorded continuously in log files, which shall be easily accessible for off-line analysis in human readable format e.g. XML, json or easily parsed text files.
MANDATORY: The status signals logged shall be configurable.
MANDATORY: It shall be possible to log all signals specified (but not limited to) in 4.3.1 and 4.4.1.
MANDATORY: Software for displaying and filtering the log files.
INFORMATION: Tenderers shall give an overview of what kind of status reportins that can be generated in their offered system.

5.4.2 Radar volume data/moment data

MANDATORY: The radar volume data shall be compressed at site to limit bandwidth usage.
MANDATORY: The centralised server shall receive the compressed radar data, slice by slice, from the radar system as soon as they are completed.
MANDATORY: The centralised server shall be able to create volumes from a user specified subset of slices (or singular slice) before the whole 3D scan has completed.
MANDATORY: The centralised server shall be able to forward single slices as soon as they arrive to converters or 3rd party software e.g. ProRad. The slices shall contain metadata identifying which scan it originated from, how many elevation the original scan contains, and its own order in the number of slices.
MANDATORY: The centralised server shall assemble the slices into one or more volume files.
MANDATORY: The following radar volume data types shall be available:

- Reflectivity (corrected and uncorrected)
- Radial velocity
- Spectrum width
- Differential reflectivity
- Differential phase shift
- Specific differential phase shift
- Polarimetric correlation coefficient
- Ratio between the unfiltered signal power and the clutter filtered signal power
- Signal to noise ratio

IMPORTANT: Both corrected and uncorrected data for the above radar data types.
IMPORTANT: Both horizontal and vertical data for the above radar data types (not applicable to dual polarisation data).
MANDATORY: Radar volume files shall be able to store in 8 bit binary form (not applicable to phase data).
MANDATORY: Radar volume files shall be able to store in 16 bit binary form.
MANDATORY: Radar volume files shall be stored as polar data files.
MANDATORY: It shall be possible to use uncorrected radar volume files in the same way as corrected radar volume files.
IMPORTANT: It should be possible to enable flagging in the corrected radar volume files, which instead of removing data only hides it using "flags". The flag should show which filtering method removed the corresponding data (e.g. threshold filter or clutter filter).
MANDATORY: All radar volume files shall contain human readable metadata containing sufficient information relating to the time and place of data collection and other parameters relevant to archiving and further processing
IMPORTANT: All radar volume files should contain human readable metadata containing the time stamp for when the first elevation of the particular scan started.
IMPORTANT: Noise level should be part of the metadata stored in radar data files.
IMPORTANT: The radar constant for the system should be part of the metadata stored in radar

IMPORTANT: Naming of radar volume files should be set to the time when the first elevation of the particular scan started.
INFORMATION: The tenderer must supply documentation on software file formats used. This includes explanation of radar volume files to the degree that the customer is able to create its own converter.
INFORMATION: The tenderer must supply information on how the conversion of polar grid data to Cartesian grid data is done.

5.4.3 Radar products

MANDATORY: The centralised computer shall do the computation of radar products from the radar volume data according to schedule. The available product list shall at least include:

- PPI, Plan Position Indicator, at any selected elevation angle
- RHI, Range Height Indicator
- CAPPI, Constant Altitude PPI, any selected height, with optional filling with lowest elevation (PSEUDO CAPPI)
- Echo Height (including height of max echo and echo top height)
- MAX, maximum
- SRI, Surface Rain Intensity
- Rainfall accumulation for selectable periods of 1 - 24 hours
- HWIND, Horizontal Wind
- VVP, Velocity Volume Processing (available wind field parameters should be specified)
- Vertical Cut

MANDATORY: The tenderer shall supply software able to display products generated by the server.
IMPORTANT: The vertical wind profile product should have the possibility to show the development over time using wind-barbs, displaying wind profiles in a XY-diagram with X=time and Y=height above sea level.
INFORMATION: Tenderer should supply documentation on what radar data input the different products supports.
INFORMATION: Tenderer should supply documentation on what additional radar products that is available.
INFORMATION: The tenderer must supply documentation on radar product parameters and product algorithms.
INFORMATION: The tenderer must supply documentation on software file formats used. This includes explanation of radar volume files, radar product files and radar log files.

5.4.4 Converters

MANDATORY: A solution for starting converters (scripts or applications) for converting radar volume data or radar product data from the native file format used to another radar file format.
MANDATORY: It shall be possible to define filter rules for which products or volumes the converter shall be triggered to run. The filter rules shall be based on radar site name, type of volume (dBZ, W, etc.), type of product (dBZ, cappi, etc.)
MANDATORY: The converter must be started as soon as the desired radar product or radar volume is available on the server to ensure satisfactory product generation rate.
MANDATORY: The tenderer shall supply a converter for converting radar volumes and radar products from the native file format to ODIM/OPERA HDF5 format as specified in “EUMETNET OPERA weather radar information model for implementation with the HDF5 file format“ (http://www.knmi.nl/opera/opera3/OPERA_2008_03_WP2.1b_ODIM_H5_v2.1.pdf).

5.4.5 3rd party interface

MANDATORY: The centralised server shall have a rule based event system that can be triggered whenever a slice, volume or product is completed. The event shall at minimum provide the file path for the slice/volume/product. The events shall fire without any delay as soon as the slice/volume/product is complete. The event system will be used for forwarding data to ProRad.
IMPORTANT: It shall be possible to pass the triggered filter rules to the converter as command line arguments.

5.4.6 Redundancy

MANDATORY: The centralised server be configured as a duplicated server system with an automatic failover system. If one server fails to produce radar products, the backup server must take over the production automatically without any human intervention. Configuration changes done on the running server shall reflect over to the standby server.
INFORMATION: The tenderer must supply documentation on how the feature works.

5.5 Software in general

5.5.1 Software source code

INFORMATION: The tenderer shall describe the possibility for providing the source code of latest releases of all radar related software in case of the tenderer stopping maintaining it, e.g. bankruptcy, change of business scope, etc. This includes centralised server software, signal processing software, diagnostic software, etc.
INFORMATION: The tenderer shall specify on what terms any software source code, or relevant parts of it, can be made available to the buyer with the understanding that the code will only be used by the buyer to accommodate the system to external changes in the data processing and management standards and procedures or to internal development work within the integrated data processing system of MET Norway.
MANDATORY: If a severe security issue/vulnerability is discovered in the software (either developed by the tenderer itself or third parties) delivered by the tenderer, the tenderer is committed to notify MET Norway immediately. This requirement must be met regardless of whether any software maintenance agreement is signed or not.

5.5.2 Remote Access

MANDATORY: Protocols used for remote accessing any part of the system or servers shall use modern key-exchange and encryption methods. This means that protocols like FTP and TELNET are not compliant.
MANDATORY: The tenderer shall provide root level access or similar to all parts of the system.

5.5.3 General

INFORMATION: The software language(s), methods, standards and formats used in developing, testing and documenting the software.
COST: A price breakdown showing the cost of each part of the software package must be included. This breakdown should at least list the prices for: cost of chosen interface method, server and client licenses, product licenses, software for monitoring/maintenance of the radars, cost of software support and cost of a software upgrade service. Any other costs relating to the software, optional or mandatory, should also be listed in the price breakdown.
MANDATORY: Full documentation for all software modules associated with the system shall be provided.
INFORMATION: All medium and formats used for transferring, storing and updating software (e.g. EPROM, ROM, hard disk, pen-drive etc.).

5.6 Communications

MANDATORY: The radar system shall be connected to the customers data network with Ethernet TCP/IP using 8P8C connectors.
INFORMATION: The tenderer must state the lowest transfer speed the system can operate at running in dual polarisation mode, with pulse width 2.0μs. Due to MET Norway's very remote sites, high speed communication infrastructure may be unavailable. MET Norway will therefore prefer a system operating at lower communication speeds.

6 PUBLIC GREEN PROCUREMENT REQUIREMENTS

6.1 Hazardous materials

INFORMATION: The tenderer shall provide a list of all components found inside the radar-system, which can pose as a threat to the health or environment, if not handled with special care. A description of the correct procedure to handle these items must be provided as a part of the system documentation.

6.2 CO2 footprint

INFORMATION: The tenderer shall provide documentation of the impact on the global warming potential, in the form of CO2 equivalents (CO2e), for the delivered radar system. This should include everything from radar parts, delivered consumables, packaging, transportation to site and installation.

The tenderer shall provide documentation on the packing materials used, including type, amount, percentages recycled etc. Instructions for waste disposal shall be provided (reuse, return, recycle, dispose etc).

MANDATORY: The tenderer shall upon order of spare parts, calculate CO2e emissions for each item ordered.

6.3 Environmental responsibility

INFORMATION: The tenderer shall describe how your organisation works to reduce the environmental footprint throughout their supply chain, production and transportation. This can include statistics, strategies to reduce waste, information campaigns, and vendor influence through procurements. The tenderer can also list strategies which are not effective yet, but will take place during the course of the agreement (within the next 5 years). Strategies which are to be implemented in the future will be subject for follow up during the contract period.

INFORMATION: The tenderer will be awarded for any energy-saving measures the supplier has implemented the last 2 years, or plan to implement during the next 5 years. With energy-saving measures we mean strategies and documentable changes within the tenderer's own organisation which reduces the energy consumption. This can be in the supplier's organisation (development, production/manufacturing, sales, administration), or in the supplier’s first level of subcontractors. Described future projects will be subject for follow up during the contract period, and failing to see through these energy saving measures will count towards breach of contract. Future energy saving goals will be added to the contract as an appendix.

6.4 Recycled materials

INFORMATION: The tenderer should calculate how much of the ordered system is made from recycled metals (percent weight), rather than virgin metals.

6.5 RoHs directive

MANDATORY: All electronics delivered as part of the radar system shall be RoHs 3 (EU 2015/863) compliant.

7 DOCUMENTATION AND TRAINING

7.1 Documentation

MANDATORY: The tenderer will be required to supply one printed set of manuals, and one set in digital form (e.g. PDF document); containing full information on construction, maintenance and operation for each installation, covering all parts of the system, whether of his own manufacture or that of a subcontractor. These manuals shall supply all necessary circuit diagrams to component level, giving voltages and waveforms where considered appropriate, together with details of calibration

checks and acceptable limits. The manuals shall contain a complete list of components and parts used in the equipment. Drawings of all mechanical parts, e.g. the antenna rotation mechanisms, shall be provided at a level allowing disassembly, maintenance and replacement. Software documentation shall be provided in a separate manual (two + one set), and shall include at least user's guide to application and utility programs, an installation and maintenance guide and a programmer's interface and format guide containing as a minimum file format descriptions, information-flow-models and a complete description of the entries of all system configuration files. One set of the factory acceptance test specification with measured values shall be supplied for each system.
MANDATORY: The actual measured values for attenuators and couplers in the radar system should be supplied separately as one printed set and one set in digital form (e.g. PDF document).
MANDATORY: The actual measured values for attenuators and couplers for the given transmitter frequency in the radar system should be labelled on the corresponding attenuator/coupler.
MANDATORY: The documentation and manuals shall be written in English only.
MANDATORY: The tenderer shall state if there are certain units for which (e.g. for proprietary secrecy reasons) documentation will not be available, and shall propose an alternative solution to this problem.

7.2 Training

7.2.1 General

MANDATORY: The tenderer must recommend necessary training for service personnel doing maintenance at every part of the radar system, hardware and software. This may include a technical maintenance course and a software course. The following are rough outlined suggested requirements from MET Norway.
INFORMATION: Supply information on organisation and content of all recommended training.

7.2.2 Technical Maintenance Course

INFORMATION: The courses shall give the trainees requisite knowledge of the functioning of the weather radar in association with its controlling programs, so that they will, on completion of the course, be able to calibrate, operate and maintain the weather radar hardware using the appropriate utility software and test instrumentation. Special emphasis is placed on the need for theoretical and practical training to walk hand-in-hand. Duration of the course(s) must be specified. Trainee level: technicians and engineers with experience of weather radar maintenance, and experience in electronics servicing.
COST: Technical maintenance course. Cost quoted per trainee.

7.2.3 Software Course

INFORMATION: The course shall give the trainees a detailed knowledge of the function and interaction of the software modules comprising the radar station programs. On completion of the course, the trainees shall be fully conversant with the software interface to the radar system, the radar measurements, signal processing, and data transmission to allow them to monitor the system performance and diagnose and correct typical faulty operating conditions, as well as carry out upgrades with new program versions. Duration of the course(s) must be specified. Trainee level: programmers and experienced computer operators.
COST: Software course. Cost quoted as daily rate per trainee.

7.2.4 Training Material and Documentation

MANDATORY: The course material will remain with the trainees for later reference. The course shall include the use of the actual manuals that make up the official documentation of the radar system.

7.2.5 Time and Place

IMPORTANT: Training shall be held at tenderes factory, in English, with necessary measuring equipment available. Content of the training and schedule will be agreed later on.