Sustainable, transformative and resilient for a Blue Pacific

# REQUEST FOR TENDERS

RFT: 2023/024
File: AP_ 3/28/2
Date: 19 July, 2023
To: Interested Suppliers and Service Providers
From: Sunny Seuseu – VanKIRAP SPREP PMU and Rupeni Mario – Project Coordination Unit

**Subject**: **Request for tenders (RFT):** Supply, provide training, installation, and commissioning of the Vanuatu C-Band Dual Polarization Weather Radar (a turnkey project)

## 1. Background

1.1. The Secretariat of the Pacific Regional Environment Programme (SPREP) is an intergovernmental organization charged with promoting cooperation among Pacific islands countries and territories to protect and improve their environment and ensure sustainable development.

1.2. SPREP Members comprise 21 Pacific Island countries and territories (PICTs), and five developed countries with direct interests in the region: America Samoa, Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu and Wallis and Futuna. Metropolitan members are Australia, New Zealand, France, United Kingdom and United States of America.

1.3 The Climate Information Services for Resilient Development in Vanuatu (CISRD) or Vanuatu Klaemet Infomesen blong redy, adapt mo protekt (Van-KIRAP) Project, is a full size Green Climate Fund project implemented through the Secretariat of the Pacific Environment Programme (SPREP). The Van-KIRAP Project is implemented in the Republic of Vanuatu and managed by the Vanuatu Meteorological and GeoHazards Department (VMGD) and SPREP Climate Change Resilience Programme (SPREP CCR), the Project Executing Agencies, in partnership with multiple partners in Vanuatu, Australia and South Korea.

1.4 SPREP approaches the environmental challenges faced by the Pacific guided by four simple Values. These values guide all aspects of our work:

- We value the Environment
- We value our People
- We value high quality and targeted Service Delivery
- We value Integrity

1.5 For more information, see: www.sprep.org.

## 2. Specifications: statement of requirement

2.1. SPREP wishes to call for tenders from a qualified and experienced company/firm who can offer their services to supply, provide training, installation, and commissioning of the Vanuatu C-Band Dual Polarization Weather Radar (a turnkey project).

2.2. The Terms of Reference on the technical requirements for the C-Band Doppler Dual Polarization Weather Radar with a magnetron transmitter and the necessary software for integration into the weather forecasting workstation (Synergie) is set out in Annex A.

2.3 Annex B provides details on the site where the Radar will be installed including a geo-technical assessment conducted by the Geology & Mines Unit, Ministry of Lands & Natural Resources, Port Vila, Vanuatu.

2.4 Annex C is a list of construction companies and engineering consultants that are currently based in Port Vila, Vanuatu.

2.5. The successful tenderer will be required to provide a performance security (bank guarantee) equivalent to 10% of the contract value with SPREP. The bank guarantee shall be valid from its issuance until 30 days after the warranty liability period.

2.6 The successful company/firm must supply the equipment and provide the services to the extent applicable, in compliance with SPREP's Values and Code of Conduct: https://www.sprep.org/attachments/Publications/Corporate_Documents/spreporganisational-values-code-of-conduct.pdf. Including SPREP's policy on Child Protection, Environmental Social Safeguards, Fraud Prevention & Whistleblower Protection and Gender and Social Inclusion.

2.7. SPREP Standard Contract Terms and Conditions are non-negotiable.

## 3. Conditions: information for applicants

3.1. To be considered for this tender, interested companies/firms must meet the following conditions:

i. Submit a detailed Curriculum vitae detailing qualification and previous relevant experience for each proposed personnel;
ii. Provide three referees relevant to this tender submission, including the most recent work completed;
iii. Complete the **tender application form** provided *(Please note you are required to complete in full all areas requested in the Form, particularly the Statements to demonstrate you meet the selection criteria – DO NOT refer us to your CV. Failure to do this will mean your application will **not** be considered).*
*Provide examples of past related work outputs*
*For the Technical and Financial proposals you may attach these separately.*
iv. Provide financial statements as outlined in Section 4.2 (e)
v. Provide a copy of valid business registration/license.

3.2 Tenderers must declare any areas that may constitute conflict of interest related to this tender and sign the **conflict of interest form** provided.

3.3 **Tenderer is deemed ineligible due to association with exclusion criteria, including** bankruptcy, insolvency or winding up procedures, breach of obligations relating to the payment of taxes or social security contributions, fraudulent or negligent practice, violation of intellectual property rights, under a judgment by the court, grave professional misconduct including misrepresentation, corruption, participation in a criminal organisation, money laundering or terrorist financing, child labour and other trafficking in human beings, deficiency in capability in complying main obligations, creating a shell company, and being a shell company.

3.4 Tenderer must sign a declaration of **honour form** together with their application, certifying that they do not fall into any of the exclusion situations cited in 3.3 above and where applicable, that they have taken adequate measures to remedy the situation.

## 4. Submission guidelines

4.1. Tender documentation should demonstrate that the interested supplier and service provider satisfies the conditions stated above and in the Terms of Reference and is capable of meeting the specifications and timeframes. Documentation must also include supporting examples to address the evaluation criteria.

4.2. Tender documentation should be submitted in English and outline the interested supplier and service provider's complete proposal:

a) **SPREP Tender Application form and conflict of interest form.** *(Please note you are required to complete in full all areas requested in the Form, particularly the Statements to demonstrate you meet the selection criteria – DO NOT refer us to your CV. Failure to do this will mean your application will **not** be considered).*
*Provide examples of past related work outputs*
*For the Technical and Financial proposals you may attach these separately.*

b) **Honour form**

c) **Curriculum Vitae** of the proposed personnel to demonstrate that they have the requisite skills and experience to carry out this contract successfully

d) **Business license/registration**

e) **Financial statements** (balance sheet including all related notes, and income statements) for the past 2 financial years, complying with the following conditions:

- The financial statement must reflect the financial situation of the Tenderer and not sister or parent companies;
- The financial statement must be complete, including all notes to the financial statement

The financial statement must correspond to the latest financial year already completed and audited (no statements for partial periods shall be requested or accepted).

f) **Technical Proposal** which contains the details to achieve the tasks outlined in the Terms of Reference.

g) **Financial Proposal** – provide a detailed outline of the costs involved in successfully delivering this project submitted in United States Dollars (USD) and inclusive of all associated taxes. The VanKIRAP Project has a Vanuatu VAT zero certificate, valid until December 2023 that applies for all purchases made within Vanuatu.

4.3. Provide three referees relevant to this tender submission, including the most recent work completed.

4.4. Tenderers/bidders shall bear all costs associated with preparing and submitting a proposal, including cost relating to contract award; SPREP will, in no case, be responsible or liable for those costs, regardless of the conduct or outcome of the bidding process.

4.5. The tenderer/bidder might be requested to provide additional information relating to their submitted proposal, if the Tender Evaluation Committee requests further information for the purposes of tender evaluation. SPREP may shortlist one or more Tenderers and seek further information from them.

4.6. The submitted tender proposal must be for the entirety of the Terms of Reference and not divided into portions which a potential tenderer/bidder can provide services for.

4.7 The Proposal must remain valid for 90 days from date of submission.

4.8 Tenderers must insist on an acknowledgement of receipt of tender.

## 5. Tender Clarification

5.1. a. Any clarification questions from applicants must be submitted by email to procurement@sprep.org before 23 August 2023. A summary of all questions received complete with an associated response posted on the SPREP website www.sprep.org/tender by 25 August 2023.

b. The only point of contact for all matters relating to the RFT and the RFT process is the SPREP Procurement Officer.

c. SPREP will determine what, if any, response should be given to a Tenderer question. SPREP will circulate Tenderer questions and SPREP's response to those questions to all other Tenderers using the SPREP Tenders page (**https://www.sprep.org/tenders**) without disclosing the source of the questions or revealing any confidential information of a Tenderer.

d. Tenderers should identify in their question what, if any, information in the question the Tenderer considers is confidential.

e. If a Tenderer believes they have found a discrepancy, error, ambiguity, inconsistency or omission in this RFT or any other information given or made available by SPREP, the Tenderer should promptly notify the Procurement Officer setting out the error in sufficient detail so that SPREP may take the corrective action, if any, it considers appropriate.

## 6. Evaluation criteria

6.1. SPREP will select a preferred supplier and service provider on the basis of SPREP's evaluation of the extent to which the documentation demonstrates that the tenderer offers the best value for money, and that the tender satisfies the following criteria:

6.2. A proposal will be rejected if it fails to achieve 70% or more in the technical criteria and its accompanying financial proposal shall not be evaluated.

### I. Technical Score – 80%

| Criteria | Detail | Weighting |
|---|---|---|
| **Qualifications and Experience** | i. Similar services and supply of equipment in the Pacific region. | 15% |
| | ii. Track record of such services and supply of similar equipment over the past 7 years with experienced and qualified personnel. | 15% |
| | iii. Appropriate tertiary qualifications (degree, postgraduate, certified technician, etc.) such as on instrumentation, engineering, and meteorology. | 5% |
| **Technical Proposal / Methodology** | iv. All details of manufacture, supply (with all transportation needs), training, installation and commissioning of the C-Band Radar including local partner responsibilities such as logistics and construction. A clear timeline with the milestones is to be presented as well. | 35% |
| | v. Training schedules, both at the factory and onsite during installation to be clearly presented. | 10% |

### II. Financial Score – 20%

The following formula shall be used to calculate the financial score for ONLY the proposals which score 70% or more in the technical criteria:

$$\text{Financial Score} = a \times \frac{b}{c}$$

Where:
a = maximum number of points allocated for the Financial Score
b = Lowest bid amount
c = Total bidding amount of the proposal

## 7. Variation or Termination of the Request for Tender

7.1 a. SPREP may amend, suspend or terminate the RFT process at any time.

b. In the event that SPREP amends the RFT or the conditions of tender, it will inform potential Tenderers using the SPREP Tenders page (**https://www.sprep.org/tenders**).

c. Tenderers are responsible to regularly check the SPREP website Tenders page for any updates and downloading the relevant RFT documentation and addendum for the RFT if it is interested in providing a Tender Response.

d. If SPREP determines that none of the Tenders submitted represents value for money, that it is otherwise in the public interest or SPREP's interest to do so, SPREP may terminate this RFT process at any time. In such cases SPREP will cancel the tender, issue a cancellation notice and inform unsuccessful bidders accordingly.

## 8. Deadline

8.1. **The due date for submission of the tender is: 13 September 2023, midnight (Apia, Samoa local time).**

8.2. Late submissions will be returned unopened to the sender.
8.3 Please send all tenders clearly marked 'RFT 2023/024: *Supply, provide training, installation, and commissioning of the Vanuatu C-Band Dual Polarization Weather Radar (a turnkey project)*'

Mail: SPREP
Attention: Procurement Officer
PO Box 240
Apia, SAMOA
Email: tenders@sprep.org (MOST PREFERRED OPTION)
Fax: 685 20231
Person: Submit by hand in the tenders' box at SPREP reception,
Vailima, Samoa.

Note: Submissions made to the incorrect portal will not be considered by SPREP. If SPREP is made aware of the error in submission prior to the deadline, the applicant will be advised to resubmit their application to the correct portal. However, if SPREP is not made aware of the error in submission until after the deadline, then the application is considered late and will be returned unopened to the sender.

SPREP reserves the right to reject any or all tenders and the lowest or any tender will not necessarily be accepted.

SPREP reserves the right to enter into negotiation with respect to one or more proposals prior to the award of a contract, split an award/awards and to consider localised award/awards between any proposers in any combination, as it may deem appropriate without prior written acceptance of the proposers.

**A binding contract is in effect, once signed by both SPREP and the successful tenderer. Any contractual discussion/work carried out/goods supplied prior to a contract being signed does not constitute a binding contract.**

**For any complaints regarding the Secretariat's tenders please refer to the Complaints section on the SPREP website** http://www.sprep.org/accountability/complaints

# Annex A

Term of Reference on the technical requirements for a C-Band Doppler Dual Polarization Weather Radar with a magnetron transmitter and the necessary software for integration into the weather forecasting workstation (Synergie)

**Supply, Training, Installation, and Commissioning of the Vanuatu C-Band Dual Polarization Weather Radar** (a turnkey project)

for the

Climate Information Services for Resilient Development in Vanuatu (CISRD) or Vanuatu Klaemet Infomesen blong redy, adapt mo protekt (Van-KIRAP) Project



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# 1. INTRODUCTION

## 1.1 Background

The Climate Information Services for Resilient Development in Vanuatu project (known locally as VanKIRAP – Vanuatu Klaemet Infomesen blong Redy, Adapt mo Protekt) aims to enhance and fill gaps in meteorological, climate and hydrological services. This includes establishing new instruments to augment the observation network, delivering technical skills training for Vanuatu Meteorology and GeoHazard Department (VMGD) staff, developing customized climate and information service tools and products for sectors and communities, and establishing effective delivery and communication mechanisms to increase awareness, dissemination, and uptake.

The VanKIRAP is intended to support resilient development through the strengthening and application of Climate Information Services in five targeted development sectors: agriculture; fisheries; tourism; infrastructure; and water. Van KIRAP is funded by the Green Climate Fund (GCF) with SPREP Project Coordination Unit as the Implementing Agency /accredited entity and SPREP Climate Change and Resilience (CCR) Programme and the VMGD as Executing Agencies.

An activity in the installation of new instruments to augment the observation network for the VMGD is the procurement, installation, and commissioning of a C-Band Radar Dual Polarization Weather Radar.

This term of reference specifies the technical requirements for a C band Doppler dual polarization weather radar with a magnetron transmitter and the necessary software for integration into the weather forecasting workstation (Synergie). In the longer term, a radar network is envisioned comprised of radar data exchanged with neighbouring countries and additional SPREP/VMGD radars.

## 1.2 Guide to preparation of Bids

The Bidder shall prepare its responses to the technical specification in English. In addition, responses to technical specifications shall also be submitted in electronic pdf format.

The Bidder shall submit original catalogues and documents in English which include the technical information of the offered system (e.g., original technical catalogues shall be submitted together in English approved by the Bidder). Any corrections on the original technical catalogues by hand or any other way shall not be accepted, in case of determining such a situation, the bid will not be evaluated. In addition, technical catalogues and documents shall also be submitted in electronic in pdf format.

The Bidder shall reply each item of the technical specifications and its attachments one by one in accordance with the order of the specifications, there will not be any contradiction between the answers and the technical document and catalogues submitted. The answers to the technical specifications shall be clear and understandable; the items defining the responsibilities of the Bidder, except the items written to give information to the Bidders, and technical requirements shall not be answered as “ok”, “understood”, and if a document is referred for the detailed explanation for an answer to any item, full name of the document and the page numbers of the related subject shall be stated at the end of the item (such as, 2.8 … for more information, see Technical Maintenance Manual Page 24).

The Bidder shall state the hardware, auxiliary units and software manufactured by itself, and shall submit a list including the hardware, software and other units and their suppliers, the co-operated companies for related civil works, and detailed information of the companies.

## 2. GENERAL TECHNICAL REQUIREMENTS OF THE RADAR SYSTEM

Standard ISO 9001 (EN 29001) shall be adopted, and Bidder's certificate issued by an official authorised organisation shall be submitted with the bid.

Acronyms are provided in **Appendix 1**.

**Appendix 2** provides a scan strategy for the radar for tender evaluation purposes.

### 2.1 Physical Construction and Architecture

#### 2.1.1 Materials

Material and components of a high grade shall be employed. The provided hardware equipment shall be new and it shall belong to a series production. No refurbished parts are allowed to be used in the system.

#### 2.1.2 Working Environment

Full attention must be paid to the effects of the wide outdoor temperature variations. The antenna-pedestal subsystem, when installed inside a radome, shall operate in the temperature range from 10°C to +40°C and in relative humidity range from 0% to 100%, non-condensing. The radome shall be equipped with a suitable temperature and humidity control for the prevailing conditions of the installation site.

The proposed radome shall be dust- and waterproof, withstand wind speeds up to 65 m/s, and its operating temperature range shall be from 10°C to +55°C.

The subsystems in the radar equipment cabinet shall operate in the temperature range from +10°C to +40 °C and in relative humidity range from 0% to 100%, non-condensing.

### 2.2 Power supplies.

#### 2.2.1 Mains supplies

The mains power supply shall be three-phase 230/400 V (+/- 10%), 50-60 Hz + 5 %. A 5-conductor system is used. The signal ground shall be separated from the protective ground. The AC neutral and the protective ground shall be kept separated in the equipment. All power supplies shall have adequate internal protection against supply transients. The bidder shall provide a voltage stabilizer to supply all voltage-sensitive parts of the system.

#### 2.2.2 Power Consumption

The maximum power consumption shall not exceed 3.8kW.

#### 2.2.3 Uninterruptible and Backup Power Supply (UPS)

The radar system shall be provided with an UPS system to (i) condition the power fluctuations, (ii) provide sufficient time to transition to backup generators and (iii) provide graceful shutdown capability for the radar system. The proposed UPS system shall support full operation of the radar for a minimum of 30 minutes.

### 2.2.4 Back-up generator system

A back-up power generator system shall be included to keep the radar system operational with dual tanks to provide safe refilling capability for a minimum of one week in total. The back-up power generator must automatically and completely start up within 10 minutes of a failure of the main power.

### 2.2.5 Automatic System Start After Complete Power Failure

Automatic start-up capability, including radar scanning and data acquisition and transmission, after power recovery is required. The automatic startup must not require any manual operation of the radar.

The bidder shall provide the time from power attainment on to all aspects of the subsystem becoming operational. At system power-up start all control signals shall be in predefined states.

It must be possible to reset the radar system equipment remotely be means of a TCP/IP connection. In the event of a missing TCP/IP connection, it must be possible to reset the radar equipment remotely by means of a mobile phone connection.

### 2.2.6 Earthing

All equipment shall be earthed. The bidder shall state the recommended maximum earth resistance that the equipment should be connected to.

### 2.2.7 Lightning Protection

Lightning protection shall be provided for all external structures constructed at the radar site.

The adequate protection shall be used on and between the various units, e.g., antenna and transceiver, and for external line interfaces. Over-voltage protection shall be provided on all IO lines for each subsystem. Bidders shall describe the method used to protect IO lines.

### 2.2.8 Electrical Interference

All equipment shall be protected from radiated or conducted electrical interference.
The means and the extent to which the equipment offered will be protected against HF, VHF, UHF, microwave and radar transmissions from external sources, which may be nearby.

The following standards and recommendations shall be fulfilled:

- R&TTE Directive (99/5/EC) (Radio and Telecommunications Terminal Equipment Directive
- CEPT / ERC / 74-01 E (unwanted emissions in spurious domain)
- ITU-R SM.1541-2 (Out-of-band -emission limits)
- ITU-R M.1177-3 (Unwanted emissions measurement methods, measurements on-site)
- Revised ECC Recommendation (02)05 (Emission masks for radars)
- EN 301 489-1 v. 1.7.1 (Common technical requirements)

Written evidence must be presented, including Declaration of Conformity by the bidder and an official notified body statement.

### 2.3 Protection against radiation

#### 2.3.1 Non-Ionizing Radiation -Electromagnetic Fields

The following standards and recommendations shall be fulfilled:

- COUNCIL RECOMMENDATION 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields.

#### 2.3.2 Ionizing Radiation – X-radiation and Radioactivity

The levels of X-radiation from all transmitter components must be fulfilled:

- EN 60950-1: 2001 + A11 Information technology equipment – Safety – Part 1: General requirements.

Written evidence of this conformity must be presented by the bidder. In addition, safe levels shall be demonstrated on site, while the radar is operation.

### 2.4 Electrical Safety

The electrical equipment in the proposed radar installation must conform to the appropriate international safety standards and regulations (i.e., EC/EN norms, ISO standards, etc.).

The following standards and recommendations for electrical safety shall be fulfilled:

- Low Voltage Directive (2006/95/EC)
- EN 60950-1: 2001 + A11 Information technology equipment – Safety – Part 1: General requirements.

Written evidence must be presented, including Declaration of Conformity by the bidder and electrical safety test reports.

### 2.5 Physical Safety

The bidder shall ensure safe and efficient mechanical operations of the radar.

The following standards and recommendations shall be fulfilled:

- Machinery Directive (2006/42/EU)
- EN 12100-1 or equivalent, Safety of machinery – Basic concepts, general principles for design – Part 1: Basic terminology, methodology (ISO 12100-1:2003)
- EN 12100-2 or equivalent, Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles (ISO 12100-2:2003)

Written evidence must be presented, including Declaration of Conformity by the bidder.

### 2.6 System Reliability

The radar system shall function for a minimum of 10 years without other changes than those resulting from normal wear and tear. Correspondingly, mechanical (moving) parts shall be designed to withstand at least 50000 hours of continual use without failure or significant degradation of performance.

The radar as considered as a whole system, shall be designed, and constructed so that it shall not require maintenance more frequently than every 8760 hours using the scan strategy proposed in Appendix 2 hours.

### 2.7 Maintenance and Installation

#### 2.7.1 Test, Maintenance Equipment and Special Tools

All test equipment suitable for C-band radar operation and measurement required for the proper maintenance shall be proposed. In minimum the below mentioned test equipment shall be proposed by the Bidder. The bidder shall be prepared to provide full information and training for using of this equipment set.

- Digital oscilloscope with 2 channels, e.g. Tektronix TDS2012C
- Spectrum Analyser suitable for C-band measurements (range 1 MHz… 6 GHz)
- External signal generator suitable for C-band (CW 1 MHz... 6 GHz, -120 ... +18 dBm)
- Power meter & Power sensor (with CW Power Sensor, 10 MHz to 8 GHz, -63 to +23 dBm), USB-connection of the power sensor to analyzer, power meter and a PC/notebook
- Digital multimeter
- Power attenuator set (3dB, 6dB, 10dB, 20dB, 30dB, 40dB) with sufficient power rating
- RF detector (4.0 - 8.0 GHz)
- Set of test cables, RF adapters and RF connectors
- Standard set of tools for radar maintenance
- One set of non-standard tools, required for special operation/repairs

#### 2.7.2 Maintenance Support

The maintenance support shall be available for a period of at least 10 years from the date of commissioning.

The bidder shall provide information, including costs, and recommendations, which will assist the customer in selecting an appropriate technical maintenance approach for the system. The recommended option shall be cost-effective, preserve equipment integrity and achieve optimum integration of skills and resources. The recommendations shall include downtimes for preventive maintenance.

The bidder shall supply the cost of a full set of consumable spares, complete with prices, to support operation for an initial period of 5 years. Spare parts shall be available for the period of at least 10 years from the vendor. For discontinued components, form-fit-function replacements must be made available.

Estimates shall also be given for the annual number of maintenance/repair trips required to the radar station, and their total (annual) duration.

### 2.8 Acceptance

The radar system acceptance shall contain the following procedures:

- Factory Acceptance Tests (FAT)
  As per the mutually agreed test procedures, Factory Acceptance Tests shall be carried out at the supplier's premises prior to shipment. The equipment shall be shipped only after satisfactory conclusion of the pre-shipment FAT. The bidder shall include the proposed FAT procedure in his offer.

- Site Acceptance Test (SAT)
  As per the mutually agreed test procedures, the Site Acceptance Test shall be carried out at site after installation. The supplier shall arrange for necessary test equipment. Any defects / deviations noticed during the site acceptance tests shall be rectified within a maximum period of one month from the completion of the tests. After such rectification, the complete SAT shall be repeated to verify the rectification and side-effects. The SAT shall include running the radar with the scan strategy in Appendix 2, with optimized signal and data processing configurations, data and product transmission, product generation and formatting verification in VMGD's Synergie workstation environment. The bidder shall include the proposed SAT procedure in his offer.

- Operational Test (OT)
  As per the mutually agreed test procedures, the Operational Test period of two (2) weeks shall be carried out at site after the accepted SAT.

  This test shall include a data flow test for data to arrive at Synergie (VMGD HQ).

### 2.9 Warranty

2.9.1 All bids must adhere to the following warranty requirements.

The supplier warrants that the radar equipment, components and supplies are:

a) free from defects in design, materials and workmanship;
b) fit for their purpose;
c) be new, and unused unless SPREP has agreed otherwise in writing;
d) be packaged so as to protect the contents and keep them clean, dry and in a new condition until they are first used, if appropriate.
e) at least of merchantable quality
f) the goods do not breach any law or standard;
g) supply of goods in accordance with this RFT will not infringe the rights of any person;
h) all information provided by the Supplier to SPREP is accurate in all material respects and;
i) otherwise comply with the requirements of the RFT and technical specifications, for the period of 12 months following the acceptance by SPREP and VMGD of the Operational Test (OT) under section 2.8.

2.9.2 All bids must provide "options" for a multi-year warranty for 2-year and 3-year warranty and associated costs for consideration, in addition to the initial 12-month warranty under section 2.9.1.

**2.10 Performance Security (Bank Guarantee).**

A Performance Security (bank guarantee) is required:
The amount of the Performance Security shall be 10% of the Contract value. This shall be provided in the currency of the financial offer and of the contract. The performance security shall be valid from its issuance until 30 days after the warranty liability period as defined in 2.9.

2.10.1 The supplier must present the Performance Guarantee:

a) within 5 Business Days of the Contract Commencement Date.
b) Any other time requested by SPREP.

## 3. RADAR SYSTEM REQUIREMENTS

The radar site shall comprise the radar together with its related processor hardware and software, allowing complete remote control and surveillance of the radar from an authorized computer terminal at the Vanuatu Meteorology and Geohazards Department (VMGD) Office in Port Vila.

The requirement is for a magnetron C Band Doppler polarization radar running in simultaneous transmit and receive (STAR) mode. Appendix 1 provides a list of acronyms and Appendix 2 provides a scan strategy for tender evaluation.

### 3.1 System Level Performance

The proposed radar system shall be capable to observe precipitation, using the scan strategy proposed in Appendix 1 for all configurations, equivalent to **Z = -40 dBZ, or better,** when translated to the distance of 1km from the antenna.

a) obtained with the site and system characteristics of
- effective length of the wave guide from the transmitter cabinet to the antenna reference point: 10m (defining the site specific losses),
- width of the antenna mainlobe: 0.95-1.0 degrees (half power),
- RF filters, in compliance of CEPT / ERC 74-01E (2005)

b) in the following test conditions
- radar is operating in the STAR-mode (H+V),
- receiver uses filters matched to the pulse,
- echo are censored for less than one false echo due sky noise in sweeps of $10^5$ gates (FAR), accounting for conditions where noise may vary up to 2 dB, and the probability of detection (POD) of 50% is required.

All the relevant aspects of the proposed system shall be identified and accounted for, such as:

- transmitter peak power measured at TX output flange [kW], (ref. 3.4.2 e);
- TX power losses from the TX output flange to the antenna ref. point [dB] (ref. 3.4.1 a),
- antenna gain measured with respect to the antenna ref. point [dB] (ref. 3.3.4 c);
- radome attenuation [dB] (ref. 3.3.2 d);
- RX power losses from the antenna ref. point to the ref. point of RX input [dB] (ref. 3.4.1 b);
- minimum detectable signal of the receiver defined at the ref. point of RX input, for a single sample of signal at SNR=1 [dBm] (ref. 3.4.4 l.c.);
- impacts of the advanced digital signal processing techniques in use [dB] if (ref. 3.4.4 k)

Each item above shall be answered by a numerical value obtained from the proposed system by the tenderer in their response.

The Bidder shall present the details of tests, using the scan strategy in Appendix 2, demonstrating that the sensitivity of Z=-40 dBZ @1km is achieved and as well as the full composition of relevant system parameter values used. The Bidder shall provide the polar raw data for independent evaluation and verification by the VMGD or their representative. The Bidder shall provide the data in a format specified in section 4.4.3 in this specification.

### 3.2 Radome, Antenna and Pedestal Requirements

The Radar System shall operate in the C-band, in the frequency range from 5.5 GHz to 5.7 GHz.

The Radar System shall have full Doppler measurement capabilities.

The Radar System shall be a dual polarization radar with Simultaneous Transmission and Reception (STAR).

In order to ensure reliable and accurate data processing, the radar signal processor, digital receiver, and radar control processor must be well integrated and proven to work properly together. References must be provided.

The proposed Radar System availability shall be 99% or more throughout the year. This high level of reliability and availability shall be fulfilled over the stated environmental conditions and taking into account possible periodic maintenance breaks. The detailed calculation of the system availability shall be presented by the bidder.

#### 3.2.1 Sites

The bidder shall provide details on the following for the equipment to be installed at the radar site:

- number and size of equipment racks,
- antenna tower (in case of a turnkey project) or instructions for radar tower design
- recommended minimum equipment room size, including space for normal maintenance work, testing instruments, tools and spare parts,
- recommended equipment room layout,
- any other aspects relevant to building design,
- specification for air-conditioning, ventilation and heating for radome and equipment room

The radar cabinet subsystem shall be compact and suitable for crane lifting. The radar cabinet shall be equipped with an integrated cooling system.

#### 3.2.2 Radome

The radar antenna shall be housed in a radome provided by the vendor. The radome shall have minimum dry attenuation and minimum beam distortion, polarization and side lobe degradation properties. The radome shall be included in the estimation of overall system performance.

a. The radome shall be a quasi-random panel type.
b. The surface of the radome shall be hydrophobic. Further information shall be provided by the bidder.
c. Additional attenuation due to rain shall be as low as possible and, in any case, shall not exceed (one-way) 0.6 dB at 50 mm/h of rain.
d. 2-way loss in dry conditions shall not exceed 0.45 dB. Details of the actual attenuation shall be provided by the Bidder.
e. The radome shall withstand Tropical Cyclone wind speed; max. and or above 255km/h (135 knots) and max. tropical cyclone wind gusts of 355km/h (190 knots).
f. The radome shall withstand hail of 10 mm diameter.
g. The radome shall be ventilated / air conditioned properly for preventing condensation and the eventual formation of mildew.

h. The radome shall include a suitable lightning protection system. The following options shall be offered with the radome:
   - Option 1: One air terminal at the top of radome (height minimum 1 m and material diameter 20 mm)
   - Option 2: Additional 5 air terminals (height minimum 0.6 m and material diameter 20 mm) equally spaced around the circumference of the radome making an angle of 45 degrees with the radome center axis. These air terminals shall be interconnected together with a ring shaped equalizer conductor. This equalizer ring shall be connected to the air terminal at the top of radome and to a perimeter cable that performs a loop around the base of the radome. This interconnection shall be made with two radials down conductors situated on opposite sides of the radome and positioned optimally for polarization performance..
   - All air terminals shall be solid copper, bronze, or aluminum or in areas of high corrosion, stainless steel. Copper air terminals may be nickel-plated.
   - Above mentioned interconnections shall be made with a copper conductor (cross section 50 $mm^2$). All conductors shall be installed inside of the radome. The down conductors shall be installed with the shortest possible path following the contour of radome panels as much as possible.
   - The radome's perimeter cable at the base of radome shall be connected by 4 down conductors (bare copper conductors) to the earthing system of tower. These down conductors shall be bonded to each leg section and exothermically welded to the lowest section of each leg (in case of a metal constructed tower).

i. A dual flight obstruction light shall be providing on the radome with an automatic day/night switch and high voltage lightning protection for the power input of the light system.

j. The proposed flight obstruction light system shall fulfill ICAO recommendations. Life time for the light source of the obstruction light shall be more than 100.000 hours. It shall be possible to set the light into both continuous or blinking operation.

k. A suitable roof hatch shall be provided with the radome to maintain the flight obstruction light and the lightning system.

l. Radome entry hatch shall be equipped with an interlock switch to disable radiation and antenna motion when opened. It shall be possible to override the switch.

m. The radome flanges should be well sealed to avoid water leaks. An estimate should be provided on how often a new sealing is required and the estimated cost.

n. A list of spare parts shall be provided.

### 3.2.3 Pedestal requirements

a. The antenna system shall be capable of operation in the range of elevations from -2° to 92° or greater and in full 360° azimuth range.

b. The positioning accuracy in azimuth and elevation shall be better than 0.1° in the whole range of climatic conditions given in section 0. The long-term stability of the pointing direction shall be less than 0.1 degrees. Written evidence shall be presented in the offer.

c. Antenna drive system shall allow fast and precise antenna movement.

d. The antenna shall be capable of the scan strategy proposed in Appendix 2 and be completed within 600 seconds or better.

e. The mechanical subsystem should be constructed to permanently sustain all stresses during normal operation for a period of 10 years or better.

f. The geographical alignment shall be supported by an automatic sun tracking utility.

g. Bearings and gearboxes used should not require replacement during the 10 years lifecycle.

h. Rotary joint and slip rings' replacement interval shall not be less than 3 years.

### 3.2.4 Antenna requirements

To guarantee the best suitability of the antenna for high quality weather radar observations, including dual polarization operation, the proposed antenna shall have the following minimum capabilities:

a. The beam width is required to be 1.0° or better (3 dB points).
b. The antenna gain is required to be greater than or equal to 45 dB
c. The maximum difference in the 3 dB beam widths shall be less than 0.1 degrees between the horizontally and vertically polarized beams (main beam matching error)
d. The side lobe level in the principle polarization planes (horizontal and vertical) is required to be:
   - less than -28 dB closer than 2.5 degrees from the center of the main beam
   - less than -40 dB more than 5.0 degrees from the center of the main beam
   - envelope curve, in the dB scale, declining between 2.5 and 5.0 degree points
e. The squint angle shall be less than 0.1 degree.
f. The cross-polarization isolation shall be more than 28 BdB, measured at the antenna terminals.
g. The antenna gain difference between the horizontal and vertical beams shall be less than 0.2 dB, measured at the antenna terminals.
h. The antenna performance as listed above shall be proven by written measurement reports. The report shall be presented for an antenna of identical type in the offer and for the delivered antenna unit prior to delivery from the factory.

## 3.3 Radar Characteristics

This describes the requirements for the components of the radar system. The components are described in conceptual terms and bidders are free to offer functionally equivalent architecture(s) but the required characteristics shall be fulfilled.

### 3.3.1 Waveguide assembly

The visualized connection diagram of the waveguide components assembly in the receiving and the transmitting paths [dB] with the power loss calculation shall be provided with the following details:

a. The bidder shall provide detailed calculation for TX power losses calculated from the TX output flange to the antenna reference point [dB], accounting for all passive RF components, including the antenna filters. The reference length of waveguide shall be 10 m in the calculation.
b. The bidder shall provide detailed calculation for RX power losses from the antenna reference point to the reference point of the RX (LNA) input. The reference length of waveguide shall be 10 m in the calculation or less if an antenna mounted receiver type is proposed.
c. The waveguides shall be provided with dry air over pressurization for condensation and arcing prevention. The bidder shall provide details on waveguide pressurization as well as any other aspects, including dry air feed.
d. Measuring couplers shall be provided for facilitating direct measurements of waveguide losses between transmitter/receiver and antenna.
e. Waveguide filters shall not be filled Sulfur hexafluoride or similar gas

### 3.3.2 Transmitter /Modulator

The radar transmitter shall operate in the C-band in a frequency range of 5.5 – 5.7 GHz. The exact frequency of operation will be allocated by the local frequency authority.

a. The transmitter type shall be a magnetron tube.
b. The maximum duty cycle available from the transmitter shall be at least 0.12%.
c. The pulse repetition frequency shall extend from 200 Hz to 2400 Hz (while maximum PRF for each pulse length for each PRF is limited by the magnetron duty cycle). Dual-PRF operation shall be available.
d. The transmitter/receiver unit shall operate in a coherent-on-receive mode, such that the phase of the transmitted signal is measured directly by digital means and the result used to digitally adjust the phase of the received signal.
e. The RF peak power at the transmitter output flange shall be at least 250 kW.
f. The transmitter shall support a minimum of 4 pulse widths that shall be selectable by means of software. The pulse width must be adjustable within a range of 0.5 µs to 2.0 µs.
g. The coherency of the transmitter shall ensure CCR (clutter cancellation ratio) for the entire radar sensor that is greater than 40 dB. In their proposal, bidders shall state the test procedure for verifying this performance.
h. Phase coherency of the radar system shall be better than 0.5 deg.
i. The system shall support velocity de-aliasing methods using dual PRF techniques in different ratios of 2:3, 3:4, and 4:5, for 2x, 3x and 4x de-aliasing, respectively.
j. The modulator shall feature a full solid-state design.
k. The system shall include inherent self-protecting circuits against faults of the transmitter. Further protection is required to prevent duty cycles that are outside of the design limits of the transmitter.
l. The radar transceiver shall include the means to minimize both the production and reception of frequencies other than the main radar signal, i.e. spurious and harmonic radiation. Spurious domain emissions (peak envelope power PEP in the reference bandwidth) for a fixed radar installation shall be according to the recommendations in CEPT/ERC/RECOMMENDATION 74-01E.

### 3.3.3 RF-to-IF Receiver

The receiver system shall consist of a front-end analog RF-to-IF down-converter that takes as input the RF received signal from the radar and a sample of the transmit pulse and mixes these to IF, which is then be sampled and processed by the digital IF receiver to generate wide dynamic range I/Q samples for each range bin, for each pulse. This section specifies the mandatory requirements of the RF-to-IF down converter. The next section specifies the mandatory requirements of the digital IF receiver.

a. The noise figure of the receiver shall be less than 2 dB. The dynamic range of the receiver shall be more than 105 dB with 2 µs pulse.
b. The image frequency rejection of the RF-to-IF receiver shall be more than 80 dB.
c. The image frequency rejection of the receiver together with waveguide filters shall be more than 100 dB.
d. The analog to digital converter in the digital IF receiver and the STALO in the down-converter shall be phase locked to a common reference signal, in order to improve system coherency.

e. The receiver shall include a built-in noise source for test and calibration purposes. The control and use of the noise source shall be integrated into a calibration utility program that can be invoked either manually or scheduled automatically during routine operation.

### 3.3.4 Digital IF Receiver

The digital IF receiver digitizes the 60 MHz output from the RF-to-IF receiver, processes the IF waveform to obtain I/Q and passes these values to the I/Q radar signal processor. This section specifies the mandatory requirements for the digital IF receiver.

a. The digitizing in each channel shall be with a sample jitter less than 1.5 picosec.
b. The digital IF receiver shall include a spectrum analyzer function with GUI to display the IF frequency response of received signals for a user-selected range interval.
c. The digital receiver shall include a GUI for aligning and checking that the transmit burst pulse is properly centered at range zero.
d. A burst pulse tracking feature shall be provided which can automatically adjust the burst pulse position when it drifts from range zero. However, no adjustment shall be permitted while sampling is occurring.
e. The frequency of the burst pulse shall be computed digitally and used to adjust the STALO frequency (AFC) to maintain IF. However, fine frequency adjustment shall be disabled during sampling so as not to interfere with Doppler measurements.
f. The phase of the transmit burst pulse shall be calculated on a pulse-to-pulse basis and used to correct the phase of the I/Q values for each pulse. The radar signal processor shall produce the raw data consisting of calibrated dBZ (corrected and uncorrected for clutter), mean velocity, spectrum width, and SQI. The polarization data shall consist of differential reflectivity (ZDR), differential phase (PhiDP), specific differential phase (KDP), correlation coefficient (RhoHV) and target or echo classification.
g. All data shall be output in either 8 or 16-bit format (parameter selectable).
h. The specifications for the total receiver performance (RF-to-IF down-converter plus digital IF receiver) are as follows (specifications all referenced to a 2 µs pulse):
    I. Dynamic range: >105 dB. (with 0.5 MHz matched filter)
    II. Phase stability: < 0.5 degrees
    III. MDS -115 dBm (2µs pulse)
i. The digital IF receiver shall have self-monitoring and thermal management functions. The A/D temperatures shall be monitored and warning signal shall be generated if safe temperature is exceeded.

### 3.3.5 I/Q Radar Signal Processor

The requirements for the I/Q signal processor are:

a. The RSP shall be based on standard PC technology running under standard Linux
b. Number of range bins: 4096 or more per radial
c. Azimuth Pulse Averaging: Up to 1024 pulses
d. Range Pulse averaging: up to 8 bins
e. Velocity dealiasing: by dual PRF 2:3, 3:4, or 4:5 for 2X, 3X, or 4X de-aliasing
f. Range de-aliasing: by random phase and other pulse modulation techniques to: (i) filter 2$^{nd}$ trip echoes from the first trip and (ii) to recover the 2$^{nd}$ trip echoes
g. Processing Mode: Pulse Pair or DFT that allow arbitrary sample size. The sample size must not be limited to a power of two.

h. Clutter cancellation capability shall include clutter maps, time domain filters, adaptive DFT filters and adaptive width techniques with signal reconstruction. A clutter detection combined with adaptive width techniques is desirable.
i. A robust algorithm shall be provided in the signal processor for calculating the specific differential phase. The algorithm must be able to process wrapped phases, use dynamic range derivatives to retain the spatial gradients of rainfall, and to provide a high-resolution specific differential phase.
j. 1D and 2D speckle filters shall be provided to eliminate spurious pixels
k. 1D and 2D filters for filling missing pixels based on consensus techniques shall be provided.
l. The system shall be able to provide target classification including hydrometeor, ground clutter, sea clutter, electromagnetic interference and other.
m. Thresholding of each moment based on SNR, clutter-to-signal ratio CSR, logarithmic signal power LOG, SQI, and polarization information (target classification or other).
n. The processor shall provide polarization attenuation correction for Z and ZDR.
o. The combined antenna, receive chain, and signal processor shall provide a RhoHV measurement >0.99 in light rain using the scan strategy proposed in Appendix 2. The supplier shall provide analysis and a raw data set from an identical radar to the proposed one as evidence of compliance in the formats specified in section 4.4.3.
p. The Radar Signal Processor shall include ZDR calibration based on zenith observation of light rain.

### 3.3.6 Radar Control Procesor (RCP)

The RCP provides the electrical interface to the radar and the site. The RCP interfaces to the Radar Data Acquisition Workstation RDA to implement high-level commands for control of antenna and transmitter operation modes.

The following functions shall be supported by the RCP:

a. The RCP shall interpret user control commands from the RDA and translate them into the appropriate electrical signals to control the radar. Similarly, the various status signals from the radar are connected to the RCP which then formats and calibrates these and transmits the high-level status information to the RDA.
b. The RCP shall handle the Built-In-Test Equipment (BITE) information (see section 3.5) and identify faulty operating conditions and devices, react accordingly in a timely manner and report the malfunction together with the adopted measures (e.g. transmitter shut down) both to a log file and to a user interface.
c. The RCP shall maintain thresholds for the safe operation of the hardware. In any case, a potential operating error either due to wrong user commands or due to a defective device shall under no circumstances harm the system hardware or the safety of the operating and maintenance personnel.
d. The RCP shall support overall antenna pointing calibration procedures especially regarding the geographical north alignment, shall support automatic sun calibration for Azimuth and Elevation angle alignment and other calibration procedures (e.g., bird bath).
e. RCP shall support automatic ZDR calibration based on zenith observation of light rain.

### 3.4 Monitoring

The radar shall include a capability for Built-In-Test Equipment (BITE) equipment to monitor and report the status of radar functions.

Automatic safety actions, such as power switch-off, must be brought into play locally when undesired operating conditions are detected.

The following parameters shall be monitored:

- receiver noise level
- receiver AFC
- status of the local oscillators
- transmitter pulse repetition frequency
- transmitter pulse length selected
- magnetron current
- motor currents
- motor driver status and alarms
- temperatures at critical positions
- cabinet cooler system status
- antenna elevation position and speed
- antenna azimuth position and speed
- azimuth and elevation limit switches
- interlocks
- magnetron blower
- modulator overload
- signal processor performance
- voltages of individual power supplies
- waveguide pressurization status on/off, duty cycle, airflow, leakage arc detector (if available).

a. The BITE shall include remote reset functionality which support remote login and mobile phone connection capability to reset all the equipment in radar rack.
b. The BITE system shall be flexible enough to include further extensions at minimum additional effort with no re-compilation of software programs.
c. BITE data should be archived for up to 1 year or more.

### 3.5 Maintenance Functionalities in Software

The system software shall support maintenance actions. Minimum requirements for maintenance functions are:

a. The identical maintenance functions that are available locally at the radar site must be made available to maintenance personnel logged in on networked maintenance workstations located at various customer locations.
b. Real time visualization of all supported raw data types in the format of PPI, RHI and ASCOPE presentations.
c. Display of uncorrected Z, corrected Z, V and W data.
d. Comprehensive supervision and monitoring of antenna, receiver, transmitter and signal processor. Malfunctions and faulty conditions must be highlighted automatically.

e. Automatic as well as interactive calibration of the receiver system.
f. Automatic sun tracking to support the geographical north alignment of the antenna subsystem.

# 4 RADAR DATA ACQUISTION WORKSTATION (RDA)

The RDA Workstation is in top-level control of the RSP and RCP to acquire raw data and communicate it via the WAN to the Radar Product Generator Server. It provides the top-level user interface for configuring the radar configuration, scanning and signal processing and provides for local and remote operation of the radar.

## 4.1 RDA Radar Control Requirements

### 4.1.1 General

The RDA controls the radar by controlling the RSP and the RCP. The RDA shall permit the operator to control all major radar station functions and parameters, both switching and adjustment. The following is a minimum list of such functions, which will, however, naturally depend upon the radar hardware controlled:

a. Main power to radar transmitter
b. Antenna positioning and rotation
c. EM radiation on/off
d. Radar pulse length
e. PRF
f. Reset of signal processor and other radar internal processors
g. All combinations of radar parameters selected for use shall be checked for consistency and reasonability. **No operation of the radar outside its safe limits shall be possible**. Selection of forbidden combinations shall result in either corrective action or "help" messages to direct the operator to corrective action
h. The design of software and hardware shall be "fail safe" in any partial or total power failure situation
i. It shall be possible, under certain safeguards, for the radar station to automatically recover from a power failure situation and resume normal operation.

### 4.1.2 Antenna and Scan Control

The following antenna positioning parameters shall be controllable through the application program running in the RDA workstation:

a. Antenna elevation angle
b. Antenna azimuth angle
c. Antenna rotation speed
d. Antenna motion in the vertical plane (nodding or RHI mode).
e. 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 program.
f. The application software shall permit different scan modes, during which data (both Doppler and intensity) shall be collected, as follows:
g. Pointing, stare or “spotlight” mode, at constant elevation and azimuth is desirable
h. Rotation mode, consisting of a single (360 degree) rotation at a constant, user-defined elevation angle at a speed determined: a) by the selected angular width of the sampling sector or b) by the number of pulses selected for averaging. c) by an explicitly defined velocity in degrees/sec
i. 3D-rotation or volume scan mode, consisting of a series of consecutive operations in azimuthal rotation mode with the set of elevation angles and rotation speeds being user-defined. There shall

be no restrictions on the number of different elevation angles used. No data may be collected during periods of elevation angle change. Both decreasing and increasing angles are to be permitted.

In addition to the above-mentioned scan modes, it shall be possible to make the following scans:

a. Sector mode, in which the antenna moves to and from between two given azimuths at a given maximum rotation speed.
b. 3D-sector scan mode, in which the previous scan mode takes place successively at a series of elevation angles with the transmitter blocked between two given azimuths
c. RHI-scan mode, in which the antenna nods between two given elevation angles
d. 3D RHI-scan mode, in which the latter scan is combined with a rotation in azimuth
e. Consecutive “spotlight” or stare mode, in which the antenna automatically points to specific angles gathering data over pre-determined dwell period is desirable.
f. Automatic sun-tracking mode.
g. Any scan mode may be selected to repeat at a given interval, starting from a given time. Once repeating, any scan mode may also be stopped at a predetermined time.
h. The selected or scheduled scan mode shall commence within 10 seconds of its selection or scheduling.
i. The schedule may be constructed of any series of different scan modes, which then repeat according to the schedule.
j. If two different scans are scheduled for execution at exact same time, it must be possible to define which scan his higher priority.
k. The scan schedule shall compute the estimated time of completing each scan to aid in designing the overall schedule. The scan schedule shall also report the actual time required to complete each scan.
l. Automatic changes of the scan schedules shall be logged and users shall be notified when the schedule has changed.

### 4.1.3 Status and Scheduling Information

a. Radar status messages shall be given on at least two levels (e.g. "information" and "warning".). All variable parameters, which give rise to status messages, shall be provided with at least upper and lower warning limits. Status messages shall be stored in a convenient form as a log for fault diagnosis. Diagnostic summaries shall be prepared on a regular basis from these logs.
b. Key parameters and operation schedules shall be continuously updated and their values are available for scrutiny by an operator. Schedules shall be kept of currently- ordered scans and products required.

### 4.1.4 Diagnostic Test and Utility Programs

The provision shall be made for off-line and on-line diagnostic tests for correct functioning of the radar and the A/D converters and calibration of the radar. Warnings from on-line tests shall be sent to the central computer node.

a. Setting up of the sampling rate of the A/D converters
b. Configuring the FIR Matched filter in time and frequency domains and displaying resultant filter loss, DC Gain, burst pulse frequency and amplitude estimates.
c. Investigation of the range and time properties for the various signal processor data streams, including coherency, signal power, spectrum, etc.
d. Reading-out of the signal processor parameters and registers

e. Examination of the triggers supplied to the radar
f. Examination of file headers and data.

#### 4.1.5 Remote Operation

a. It shall be possible to make the full normal operation and control of the radar and its data processing units, including off- and on-line testing and utility programs.
b. There shall be a rapid response (commensurate with the communication line speed used) to any menu choice made.

#### 4.1.6 On-line Help

A complete on-line help facility is required. The original language should be English.

### 4.2 RDA Hardware

a. The RDA shall be a standard PC using the standard Linux operating system, or any of the following: Debian, Ubuntu and Linux mint
b. Hardware combination (radar/signal processor/radar computer) must be capable of automatic recovery from a power failure. The power-up state of all signals to the radar must be well defined, and must not permit any uncontrolled operation of the radar.
c. After a power supply failure and restoration, all processors and computers shall automatically be restored to a ready state to resume normal operation.

### 4.3 RDA Software

#### 4.3.1 General

a. A list of adjustable software parameters, methods required to change software parameters and system configuration shall be provided.

#### 4.3.2 Data Files

a. All radar data files shall contain a header supplying sufficient information relating to the time and place of data collection and other parameters relevant to archiving and further processing.
b. A system performance and a malfunction shall be recorded continuously in logging files, which shall be easily accessible for off-line analysis.

### 4.4 RDA Data Processing Functions

*Objectives*

a. To further process intensity and Doppler, polarization information from the RSP into formatted polar files
b. To compress polar files for efficient communication to other computers, for disk storage and for archiving
c. To provide automatic radar station close-down and power-up in power failure/restoration situations, and also other switching functions
d. To apply internally consistent control signals to the radar to carry out the required scan (e.g. rotational speed, elevation angle selection) at the correct PRF and pulse length
e. To maintain a schedule of scan sequences to allow e.g. flexible interleaving of various scan types
f. To maintain an updated list of the values of all user-definable parameters, including tasks

g. To provide off-line and on-line diagnostic tests for the correct functioning of the radar
h. To collect radar station security and environment data (e.g. power supply, locks, temperature, humidity) for warning purposes
i. To automatically transmit onward (to e.g. a monitoring node) warning of radar station mal-functioning or security breaks
j. To allow complete remote on- and off-line operation, including the resetting of all processors, of the radar station through a standard interface.

### 4.4.1 RDA Radar Data Products

The primary function of the RDA is to produce raw data and send it to the RPG central server for product generation. Specific requirements are:

a. Polar raw data shall consist of an assemblage of data from single-elevation (PPI) or single-azimuth (RHI) scan. The polar raw data consists of user-selected moments, including both corrected and uncorrected data moments;
b. The polar raw data from a single rotation of the antenna at a constant elevation angle (PPI) or constant azimuth angle (RHI) must be available to the RPG for use immediately upon completion of the scan;
c. The polar raw data from a single rotation of the antenna at a constant elevation angle (PPI) or constant azimuth angle (RHI) shall be user selectable and assembled into a single volume scan.
d. For purposes of local troubleshooting and quality control, the RDA shall have the ability to produce PPI and RHI image products and display them.
e. The polar data shall be subjected to user-selectable height-threshold (i.e. all echoes above a specifiable maximum height shall be removed).

### 4.4.2 RDA Data Formatting

a. All radar data moments shall be stored in either 8-bit or 16-bit (parameter selectable) binary form.
b. Polar data files are to be considered the basic data files in the system for all purposes.
c. Files shall be formatted with detailed headers to describe all aspects of how the data were collected.
d. The RDA shall support at least the following raw radar data formats (polar sweeps and volumes):
    - native format of the radar (format documentation must be supplied),
    - WMO FM 301-cfRadial2,
    - ODIM_H5,
    - NetCDF and
    - UF.
e. In any cases, documentation must be supplied
f. Polar data shall be compressed. The compression shall be lossless. Bidders shall describe their compression scheme.

### 4.5 RDA Communication

The RDA shall be connected to a radar product generator (RPG) computer where control and data processing system is performed.

a. The radar and control and data processing system shall communicate using TCP/IP or other telecommunication protocols.
b. The RDA shall transmit raw data in an efficient manner using loss-less data compression techniques.
c. It must be possible to store and archive at least 200 days of raw data and products locally at the radar site for local maintenance purposes or in case of LAN failure so that data are not lost for climatological studies.
d. The data must be adequately buffered at the radar site so that temporary loss of communications does not result in loss of data communicated to the main RPG.
e. In case communications is lost for short period of time, the RDA shall be capable of re-transmitting the data files to RPG. If communications lost is longer period of time, the RDA shall have function to re-transmit only the most recent data so as to not suddenly load the communication network with large amounts of data.

# 5 RADAR PRODUCT GENERATOR SERVER (RPG)

## 5.1 General Requirements

The RPG is to be located at the radar site, or central processing site (forecast office or other). It receives raw data from any radars in the network or from external radars, processes the data to make meteorological products, including composites, and then distributes these products automatically or on demand to various systems and users such as forecasters, hydrologists, researchers, emergency management personnel, ATC and others. Specific requirements are:

i. The RPG shall be based on standard PC technology running standard Linux. Bidder shall provide a description of the required hardware.
ii. All communication shall be via standard TCP/IP or other telecommunication protocols.
iii. Because the RPG is a critical server on the network, bidders shall offer the option of providing a redundant backup system with automatic switchover.
iv. Radar Formats:

- Radar software shall support at least the following raw radar data formats as per section 4.4.3.
- The radar software shall support at least the following image or data product formats:
  - PNG,
  - GIF
  - JPEG
  - OPERA-BUFR (synergie compatible version),
  - and NetCDF with CF Conventions formats (BOM version).
- The radar software shall support at least the following vertical profile format: WMO XML or BUFR.
- The radar software shall provide nowcasting products such as cyclone and thunderstorm tracks and other radar prediction products.
- In all cases, documentation of the product formats must be provided.

The conversion and the re-conversion from/to original radar data format from/to above mentioned formats shall be performed automatically, manually by both command line (batch mode) and user interface.

v. Bidder shall supply a documented API and source code such as libraries and example programs and a development environment sufficient to allow customer to develop their own input and output format conversions.
vi. A graphical user interface using English language shall be provided to configure the various functions of the RPG.
vii. For local testing and maintenance purposes at the radar site it is mandatory that there be at least limited RPG functions available at the radar site, for example the generation of PPI and RHI products and the ability to display these.
viii. The RPG shall support the use of different projections, including as a minimum,

- Mercator
- Polar Sterographic
- Azimuthal Equidistant
- UTM (Universal Transverse Mercator)
- Perspective

- Equidistance cylinder
- Gnomic
- Gauss conformal
- Lambert conic
- Plate Caree

Bidders should state what projections are supported in their software.

ix. The operator must be able to select the Z-R relationship for converting between reflectivity and rainfall rate. A default value must be supported.

x. The following data corrections shall be implemented on the system, either at the RPG or on the RDA:
   a. Residual clutter removal via clutter map
   b. Reflectivity profile correction including bright band
   c. Attenuation correction by dual polarization technique
   d. Partial beam blockage correction
   e. Particle Fall speed correction to radial velocity
   f. Storm relative velocity correction to radial velocity

### 5.2 Data Quality, Data Archieving, Product Generation and Dissemination

#### 5.2.1 Base Products

The RPG shall ingest the raw data from the radar and generate as a minimum, the following basic products:

i. PPI shows the distribution of the selected data parameter on a constant elevation angle surface.

ii. RHI shows the distribution of the selected data parameter on a constant azimuthal surface or when the antenna is scanning vertically.

iii. Constant Altitude PPI (CAPPI) shall show the distribution of the selected data parameter for a constant altitude. Multi-level CAPPI's shall be possible where multiple height levels are defined by periodic interval.

iv. Where the CAPPI altitude is above or below actual beam heights within a scan, it shall be possible to make pseudo-CAPPI's where the nearest actual data point is used to represent the value at the CAPPI altitude.

v. The Vertically Integrated Liquid (VIL) product shall show the estimated precipitable water contained within user-defined layers. The VIL product shall have capability to display vertically integrated reflectivity (VIR).

vi. The VIL Density product will normalize the VIL value by the distance between the user-defined layers.

vii. The vendor shall provide the following products for any user defined value and radar parameters:
   - ECHOTOPS product will find the highest altitude of any user defined value for any parameter
   - ECHOBASE product will find the lowest altitude of any user defined value for any parameter
   - ECHOLAYER product will find the average value of any input data between two user-defined altitudes for any parameter

- ECHOTHICK product shall find the thickness between the lowest occurrence and high occurrence of any user defined reflectivity value. The MAX product will show the highest data value within a vertical column on a PPI style display.
- HMAX will show the height of the largest data value within a vertical column on a PPI style display.

viii. Bidders shall offer a product that classifies radar echoes as: precipitation (rain, snow, hail and other), clutter (ground clutter sea clutter and other) and other (RF interference, insects, avian, volcanic, fire and other) using polarization or other information. This classification will be presented as a data moment.

### 5.2.2 Hydrological Products

The RPG shall ingest the raw data or base products from the radar and automatic weather station precipitation (rain gauge or other) data and generate as a minimum, the following hydrological products:

i. The RPG software shall use dual polarization data moments and Z-R relationships to calculate precipitation rates. The dual polarization moments shall be based on KDP, Z/ZDR, and Z/ZDR/KDP relationships to rainfall rate.

ii. Surface Rain Intensity (SRI) product will estimate the rainfall rate at the earth's surface. This shall include a Vertical Reflectivity Profile correction accounting for bright band contamination, changes in topography, and convective versus stratiform precipitation.

iii. Surface rainfall estimation shall be correctable by rain gauge data. The rain gauge data and local radar estimate shall appear in the radar data displays in a time vs accumulation graphical display.

iv. Rain accumulation shall be calculated for 1 – 144-hour period. It shall be possible to have sliding or fixed periods through a user interface. For example, it shall be possible to display rain accumulation for the previous 24 hours from any time or fixed 24-hour period from 0:00-24:00 UTC.

v. Average rainfall from 1 – 72-hour period shall be calculated for river catchment areas or watersheds. It shall be possible to create user-defined catchments.

vi. The user shall be able to define a value within catchment areas that signifies a flooding potential. When the radar estimates show that this criteria has been reached there shall be a warning issued to the user in form of alert popup message and/or audio tone.

### 5.2.3 Wind Products

The RPG shall ingest the raw data or base products from the various radars and generate as a minimum, the following Wind products:

i. Vertical Volume Processing (VVP) will calculate the wind speed and direction, axis of deformation, vertical wind speed, and divergence vs height near the radar site. It shall also display the vertical distribution of reflectivity and RhoHV.

ii. The WIND product shall compute a 2-D array of horizontal wind vectors using the radial velocity information using the assumption the wind is uniform over a limited sector

iii. Wind shear shall be calculated from the radial velocities. The wind shear will be calculated in the azimuthal, radial, or elevation directions, or any combination of the three. The user shall be able to define the range derivative over which to calculate shear.

iv. There shall be the ability to identify continuous lines of shear, i.e. such as for those present with gust fronts. These shear lines will be displayed with other radar products. If there are shear lines at multiple data times, the RPG shall calculate the rate of movement for identified shear lines.

### 5.2.4 Multiple Radar Products

The RPG shall ingest the raw data or base products from various radars (including those from other countries and vendors using raw radar data formats specified in 4.4.3 and radar products based on formats specified in 5.1) and generate as a minimum, the following products:

i. A composite (mosaic) product from multiple radar sites from any user selectable product or radar parameter.
ii. Composites shall be possible for PPI, CAPPI, ECHOLAYER, ECHOMAX, ECHOBASE, RAIN, SHEAR, ECHOTOPS, VIL, SRI, ECHOTHICK, and warning and nowcasting products.
iii. The compositing from multiple radars shall be done by maximum value, average value, radar priority, nearest radar, or linear weighted distance.

### 5.2.5 Forecast and Warning Products

The RPG shall ingest the raw data or base products from the radar and generate as a minimum, the following products to aid forecast:

i. There shall be a method to automatically produce nowcasting products using cross-correlation of map-like products as well as to use centroid tracking techniques from centroids identified at two-time steps. The centroids shall be based on reflectivity, VIL, MAX, TOPS, or SRI.
ii. Rate-time-distance equation shall be used to estimate velocity of the track features. The track features shall be extrapolated to a future point in time generating a forecasted track. The forecast time shall be user selectable up to 6 hours. If the forecasted track will intersect a region of interest, such as an airport, the user shall be alerted by pop-up windows and/or audible tone. The user shall be able to select the velocity method use to forecast the track.
iii. The warning regions of interest shall be user-definable.
iv. There shall be a method to compute the average motion of all centroids within the radar view. This average motion shall be used as a forecasting feature to predict where the larger scale storm structures will be located in a future time.
v. There shall be a methodology to automatically search for certain atmospheric phenomena within the radar data to produce an automated warning.
vi. The warning criteria shall be user-definable and shall be able to find regions of mesocyclones, microbursts, tornado vortex signatures, hail, high lightning potential, etc.
vii. There may be multiple criteria used to define one warning definition.
viii. When warning definition has been violated there shall be an alert message in form of pop-up window and/or audio tone.

### 5.2.6 Moments available in each products

The following moments shall be available for input to each product type:

| Product | Input Moment | Primary Configuration |
|---|---|---|
| PPI | Z, V, W, R, SQI, DP* | for selected elevation |
| RHI | Z, V, W, R, SQI, DP* | for selected azimuth |
| CAPPI | Z, V, W, R, SQI, DP* | for selected height |
| Pseudo CAPPI | Z, V, W, R, SQI, DP* | for selected height |
| VIL | Water Content (Z) | for selected layer |
| Tops | Z | for selected dBZ contour |
| Surface rain intensity | Z, DP* | for reference surface |
| Rain accumulation | Z, DP* | for selected time |
| Sector Winds | V | in selected layer |
| VVP | V | in selected annulus |
| ECHOTOP | Z | for selected dBZ value |
| ECHOBASE | Z | for selected dBZ value |
| ECHOMAX | Z, V, W, R, DP* | for selected layer |
| HMAX | height | for selected layer |
| Cross-section | Z, V, W, R, SQI, DP* | along selected line |

DP* means dual polarized variables ZDR, RoHV, PHiDP, KDP, LDR, and target classification

### 5.2.7 Miscellaneous product requirements

a. Bidders shall describe any other products that are available on their systems and whether these are available as options or as standard.
b. A graphical user interface shall be provided to configure and schedule the various products.
c. The mix of active products in the scheduler shall be configurable for each operational mode.
d. The system shall be able to import data from a lightning detection system and to visualize the information in an appropriate graphical format. Lightning data shall be superimposed with the corresponding radar products upon user request.

## 5.3 Radar Display Workstation

a. The system shall include an appropriate software program that provides a convenient user interface for the visualization and the analysis of the radar products. This software shall fulfill the sophisticated requirements of modern meteorological forecasters.
b. It shall be possible to display multiple windows showing different products at the same time.
c. In the online mode, the displays shall be updated automatically as soon as a new product of the selected type has been acquired and generated.
d. The product displays shall include standard zoom, pan, and scroll-functions.
e. It shall be possible to obtain information regarding geographical position, distance and intensity by mouse-click onto the product display.
f. The software shall display radar products with up to 256 selectable radar color levels. The levels can be arbitrarily chosen and configured between 4 and 256 colors.
g. It shall be possible for the users to modify the A, B parameters of the Z/R relationship interactively. The re-calculated intensities shall be displayed instantaneously.

h. The system shall be able to underlay the radar products with 2D topographical maps, geographical maps and other user-selectable maps. It must be possible to configure rivers, roads and cities as separate layers. The user must be able to switch off/on single layers individually. The contractor shall consult with customer to provide suitable maps for each radar.

i. It shall be possible to select two arbitrary positions in a product display by mouse click. The software shall generate and display a vertical cross section along the line as defined by those two selected points.

j. The software shall include a functionality to create an animated loop of products that are displayed as a movie at a selectable frame rate. It shall be possible to include up to 24 hours of radar images of an arbitrary type in one animation.

### 5.4 Internet-based Presentation of Radar Data

a. The system shall include a web browser application for viewing and interacting with weather radar and surface station data. This program shall run via an Internet connection and it shall display radar products using a Web-based environment supporting Web browsers like Microsoft Internet Explorer (v.8.0 or later), Mozilla Firefox (v.3.5.11 or later), Chrome (v. 5.0 or later), Opera (version 10.61 or later) and Safari.

b. Common internet standards such as Java, HTML, PNG and JPG shall be employed. The software shall support any commercial-off-the-shelf computer as a platform without any further requirement for supplementary application software.

c. The Web application shall allow users to select data from individual radars or regional composites. The most recent data shall be displayed or the web server archives shall be browsed for historical information. Animations of the data shall be viewed for up to a 24-hour time period. Tools built into the client shall allow a user to interact and interrogate the radar data. An individual user shall be able to save one or more display states and shall be able to quickly jump between saved states to view particular presentations needed in their applications. It shall provide basic display features such as zoom, pan, scroll, animation and legend/colour map choice as well.

d. It shall be able to display every radar product generated by the radar software including PPI, CAPPI, ECHOTOPS, warnings, cyclone or thunderstorm tracks, VVP, RAIN, etc.

e. The Web application shall include the geographical data layers including roads, terrain, airports, rail, cities, political boundary, latitude longitude grid, and range rings. These shall be given to the web browser by a GeoServer. It shall be possible to add additional geographical data layers to the GeoServer for expansion.

f. The data layers opacity shall be adjustable.

g. The application shall include user authentication. The maximum number of simultaneously connected clients shall be 500.

h. The application shall be modifiable to VMGD look and feel standards and hosted on the VMGD web server.

### 5.5 Data Archival and Retrieval

a. The system shall include an appropriate method to archive the radar data. It must be possible to archive radar data temporarily on a computer hard disk. For long-term storage, the data shall be transferable to external media such as DVDs, Large Disk Arrays, or DAT tapes

b. Local archive and retrieval shall be available at the radar site (RDA workstation), central site (RPG server) and on user displays.

c. The archiving process (temporary and long-term) shall run automatically. The parameters of the archiving process shall be configurable by the user. As a minimum, the data type and the repetition time shall be adjustable.

d. The following data types must be possible to archive: radar raw data, product data, system log files and BITE messages.

e. A log file shall be maintained by the system that records all error, warning or info messages, which are generated by the system.

f. All generated data files shall possess a unique identifier that intuitively identifies at least the type of data and the date and time of recording

g. It shall be possible to archive operational raw data and product data for a time period of at least 200 days on the RPG hard disk.

h. The system shall include tools for retrieval of archived radar data. It must be possible to display or re-process the data for the purposes of post-analysis.

# 6 DOCUMENTATION AND TRAINING

## 6.1 Manuals

The bidder will be required to supply a set of manuals, containing full information on installation, maintenance and operation, covering all parts of the system. 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, and shall include at a minimum a user's guide to on-line and utility programs, an installation and maintenance guide and a programmer's interface and format guide. The documentation and manuals shall be written in English. All manuals shall also be supplied on digital media.

## 6.2 Training

### 6.2.1 General

The following courses shall be offered: Technical Maintenance Course (length: 10 days)

*Objectives:* 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 precede hand-in-hand. Trainee level: engineers with experience of weather radar maintenance, and routine experience in electronics servicing. A maximum quantity of 15 trainees.

### 6.2.2 Factory training (length: 30 days)

*Objectives:* the course shall give the trainees detailed knowledge of the hardware components of the radar, installing and assembling the hardware components together. This will be a hands-on training where the trainees are involve in the hardware components installation of the radar. A maximum quantity of 3 trainees.

### 6.2.3 Software Course (length: 10 days)

*Objectives:* 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. Trainee level: programmers and experienced computer operators. A maximum quantity of 15 trainees.

### 6.2.4 User's training (length: 10 days)

*Objectives:* the course shall give the trainees a detailed knowledge of the radar data products, on completion of the course, the trainees shall be fully conversant with skill to use of radar software and data in meteorology, hydrology, and aviation meteorology. Trainee level: meteorologists and hydrologist with some skills in computer usage. A maximum quantity of 15 trainees.

### 6.2.5 Training Material and Documentation

The bidder will be expected to supply course material well in advance of the actual courses for trainee preparation. The course material will remain with the trainees for later reference. The course shall include the use of the actual handbooks that make up the official documentation of the radar system.

### 6.2.6 Time and Place

In general, all training shall take place in customer location, Vanuatu (with the exception of the Factory Training) using the English language. The technical maintenance course shall be held in two phases, the first being prior to delivery of the system, the second being after the on-site acceptance test.

## 7 NETWORK INTEGRATION

The Bidder shall offer and describe the suitable network solution for integrating of various radars into one network. The solution shall enable remote operation, monitoring and maintenance of each radar in the network as well as product generation.

## APPENDIX 1: ACRONYMS

| | |
|---|---|
| API | Application Programming Interface |
| ASCOPE | Diagnostics and test utility for alignment and calibration of Radar |
| CCR | Clutter Cancellation Ratio |
| CSR | Clutter to Signal Ratio |
| DFT | Digital Fourier Transformation |
| GMAP | Gaussian Model Adaptive Filtering |
| I/Q | In phase/Quadrature signal |
| MDS | Minimum Detectable Signal |
| PCB | Printed Circuit Board |
| PMI | Polarimetric Meteorological Index |
| PPI | Plan Position Indicator |
| PRF | Pulse Repetition Frequency |
| RHI | Range Height Indicator |
| SNR | Signal to Noise Ratio |
| SQI | Signal Quality Index |
| STALO | Stable Local Oscillator |
| SWR | Standing Wave Ratio |

## APPENDIX 2: SCAN STRATEGY EXAMPLE

This is a proposed scan strategy for the VMGD radar. The main purpose is to illustrate the type of scans possible, and the role of meteorological applications described elsewhere.

It is used for the evaluation of minimum detectable signal and antenna performance.

This is NOT the final configuration. More consideration about data quality, number of samples collected, range averaging, ground clutter filtering considerations and other issues are needed and with consultation with users. This is rudimentary 10-minute scan cycle. A fixed antenna settling time or 2 seconds has been assumed. More or less time may be required or realized in reality and therefore extra time of 35 seconds considers this to maintain the 10 min cycle.

It does not contain other calibration scans such as solar tracking for azimuth, elevation and power monitoring. These will be added later.

This is a scan strategy for a C Band radar. STAR and Doppler modes are employed. A 4:3 dual PRF scheme is used for velocity extension but is not used for the short range RHI scans over the airport in this example but may be changed. A 2 second antenna settling time is assumed for simplicity. The range resolution is based on the pulse width used and not to oversampling.

Scan Strategy wavelength= 5 heightTreshold= 20

| n | mode | lmbd | tau | angl | rpm | angRes | angLimits | | nRay | nPRF | prf1 | prf2 | ns1 | ns2 | v1 | v2 | vext | rphase | rmx | rext | htExt | rngRes | rMaxHt | nBins | duty | tScan | accumTime |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | | cm | usec | deg | c/s | deg | deg | deg | # | # | Hz | Hz | # | # | m/s | m/s | m/s | T/F | km | km | km | m | km | # | % | sec | sec |
| 1 | ppi | 5 | 2.0 | -0.5 | 2.0 | 1.0 | 0 | 360 | 360 | 1 | 200 | | 17 | | 2.5 | | 2.5 | False | 750 | 750 | 25.0 | 300 | 679 | 2263 | 0.04 | 30.0 | 32.0 |
| 2 | ppi | 5 | 1.0 | -0.5 | 1.0 | 0.5 | 0 | 360 | 720 | 2 | 900 | 1200 | 75 | 100 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 1.6 | 150 | 679 | 4526 | 0.12 | 120.0 | 154.0 |
| 3 | RHI | 5 | 0.5 | 144.0 | 1.0 | 0.5 | -2 | 43 | 90 | 1 | 2400 | | 200 | | 30.0 | | 30.0 | True | 62 | 125 | 74.3 | 75 | 34 | 453 | 0.12 | 15.0 | 171.0 |
| 4 | ppi | 5 | 1.0 | 0.5 | 1.0 | 1.0 | 0 | 360 | 360 | 2 | 900 | 1200 | 150 | 200 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 5.9 | 150 | 523 | 3486 | 0.12 | 60.0 | 233.0 |
| 5 | ppi | 5 | 1.0 | 1.0 | 1.0 | 1.0 | 0 | 360 | 360 | 2 | 900 | 1200 | 150 | 200 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 8.1 | 150 | 459 | 3060 | 0.12 | 60.0 | 295.0 |
| 6 | ppi | 5 | 1.0 | 2.0 | 1.0 | 1.0 | 0 | 360 | 360 | 2 | 900 | 1200 | 150 | 200 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 12.5 | 150 | 360 | 2400 | 0.12 | 60.0 | 357.0 |
| 7 | ppi | 5 | 1.0 | 5.0 | 1.0 | 1.0 | 0 | 360 | 360 | 2 | 900 | 1200 | 150 | 200 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 25.5 | 150 | 201 | 1340 | 0.12 | 60.0 | 419.0 |
| 8 | RHI | 5 | 0.5 | 144.0 | 1.0 | 0.5 | -2 | 43 | 90 | 1 | 2400 | | 200 | | 30.0 | | 30.0 | True | 62 | 125 | 74.3 | 75 | 34 | 453 | 0.12 | 15.0 | 436.0 |
| 9 | ppi | 5 | 1.0 | 10.0 | 1.5 | 1.0 | 0 | 360 | 360 | 2 | 900 | 1200 | 100 | 133 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 47.1 | 150 | 110 | 733 | 0.12 | 40.0 | 478.0 |
| 10 | ppi | 5 | 1.0 | 12.5 | 1.5 | 1.0 | 0 | 360 | 360 | 2 | 900 | 1200 | 100 | 133 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 57.7 | 150 | 90 | 600 | 0.12 | 40.0 | 520.0 |
| 11 | ppi | 5 | 1.0 | 15.0 | 1.5 | 2.0 | 0 | 360 | 180 | 2 | 900 | 1200 | 200 | 267 | 11.2 | 15.0 | 45.0 | True | 125 | 250 | 68.2 | 150 | 76 | 506 | 0.12 | 20.0 | 542.0 |
| 12 | ppi | 5 | 1.0 | 90.0 | 1.5 | 1.0 | 0 | 10 | 10 | 1 | 2400 | | 267 | | 30.0 | | 30.0 | True | 62 | 125 | 125.3 | 150 | 20 | 133 | 0.24 | 1.1 | 545.1 |

totalTime 545 seconds

The following parameters are set by the user:

- Mode = RHI or PPI
- Tau = pulse width
- Angl = azimuth (RHI) or elevation (PPI) angle
- Rpm = rotation speed
- angRes = angular resolution of the data
- anglimits = the limits of the angles
- prf1,prf2 = pulse repetition frequency (single if only one give, dual PRF at 4:3 if two given for velocity extension)
- rphase = random phase for range extension

The following are computed/set by the radar:

- Lmbd=wavelength in cm
- nRay=number of rays in the scan
- nPRF=number of PRF's
- ns1,ns2 = number of samples (strong influence on data quality)
- v1,v2 = single PRF maximum velocity (Nyquist)
- vext = dual PRF velocity extension
- rmx=maximum range (first trip)
- rext=maximum range assuming random phase (not reliable if strong echoes in the first trip)
- htExt=height of beam at rmx
- rngRes=range resolution based on pulse width
- rMaxHt=range at which the maximum height threshold of 20 km is reach
- nBins = number of data bins in a ray without range averaging
- duty=duty cycle
- tScan=time to perform scan
- accumTime=accumulated time of scan

# Annex B

Details on the site where the Radar will be installed including a geo-technical assessment conducted by the Geology & Mines Unit, Ministry of Lands & Natural Resources, Port Vila, Vanuatu

**Supply, Training, Installation, and Commissioning of the Vanuatu C-Band Dual Polarization Weather Radar** (a turnkey project)

for the

Climate Information Services for Resilient Development in Vanuatu (CISRD) or Vanuatu Klaemet Infomesen blong redy, adapt mo protekt (Van-KIRAP) Project



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## Annex C

List of construction companies and engineering consultants that are currently based in Port Vila, Vanuatu.

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