भारत सरकार GOVERNMENT OF INDIA
अंतरिक्ष विभाग DEPARTMENT OF SPACE
अंतरिक्ष उपयोग केंद्र-इसरो
SPACE APPLICATIONS CENTRE-ISRO
अहमदाबाद AHMEDABAD - 380 015

सं.: सैक/आरएफपी/02/2025-26
No.: SAC/RFP/02/2025-26 **Date: 20/11/2025**

शुद्धिपत्र-I CORRIGENDUM-I

भारत के राष्ट्रपति के लिए और उनकी ओर से, प्रधान, क्रय एवं भंडार, अंतरिक्ष उपयोग केंद्र, अहमदाबाद, निम्नलिखित के लिए निविदा आमंत्रित करते हैं। For and on behalf of the President of India, Head, Purchase & Stores, Space Applications Centre, Ahmedabad invites tender for the following.

फाइल सं. File No.	संक्षिप्त विवरण Brief Description	नियत तिथि और समय Due Date & Time	संशोधित नियत तिथि और समय Revised Due Date & Time
AHHA 202500000801	**अंतरिक्ष अर्हताप्राप्त रुबिडियम परमाणु आवृत्ति मानक (आरएएफएस) हेतु प्रस्ताव के लिए अनुरोध REQUEST FOR PROPOSAL For Space qualified Rubidium Atomic Frequency Standard (RAFS)**	**14/11/2025; 1500 Hours**	**26-12-2025; 1500 Hours**

1. कृपया अपने विस्तुत प्रत्युतर सिर्फ मोहरबंद लिफाफे में नियत तिथि तक या इससे पूर्व अधोहस्ताक्षरी को भेंजे |
   Please submit detailed response to the undersigned on or before due date in sealed cover only.
2. विस्तृत तकनीकी दस्तावेज इसरो वेबसाइट **www.isro.gov.in** और **www.sac.gov.in** पर उपलब्ध है जिसमे विनिर्देश, विक्रेता की पूर्व अपेक्षाओ का उल्लेख है और इसे वेबसाइट से डाऊनलोड किया जा सकता है |The detailed technical document including specifications, pre-requisites that a vendor should possess etc. are available on ISRO website **www.isro.gov.in** & **www.sac.gov.in** and the same can be downloaded from the websites.
3. कृपया अपने विस्तृत प्रत्युतर मोहरबंद लिफाफे में नियत तिथि 26-12-2025 (15.00 Hrs. IST) तक या इससे पूर्व अधोहस्ताक्षरी को नीचे दिए गए पते पर भेजें। Please submit detailed response to the undersigned on or before due date 26-12-2025 (15.00 Hrs. IST) in sealed cover on below address.

क्रय एवं भंडार अधिकारी Purchase & Stores Officer,
निविदा समूह Tender Cell,
अंतरिक्ष उपयोग केंद्र (इसरो) Space Applications Centre (ISRO),
जोधपुर टेकरा, आम्बावाडी विस्तार पी.ओ., Jodhpur Tekra, Ambawadi Vistar PO,
सेटेलाइट Satellite, अहमदाबाद Ahmedabad – 380015

4. नियत तिथि बढ़ाने जाने के निवेदन पर कोई विचार नहीं किया जायेगा |
   No request for extension of the due date will be considered
5. विलम्ब/देरी से प्राप्त प्रस्ताव स्वीकृत नहीं किए जाएँगे| Late/Delayed offers will not be accepted.
6. कृपया अपने विस्तुत प्रत्युतर **सिर्फ मोहरबंद लिफाफे** में नियत तिथि तक या इससे पूर्व अधोहस्ताक्षरी को भेंजे |
   Please submit detailed response to the undersigned on or before due date in **sealed cover only**.
7. किसी भी तकनीकी पूछताछ के लिए, 079-2691 3056/51, ईमेलः psoe@sac.isro.gov.in पर संपर्क करें।
   For any technical query, contact on 079-2691 3056/51, Email: psoe@sac.isro.gov.in.

Sd/-
प्रधान, क्रय एवं भंडार **Head, Purchase & Stores**

REQUEST FOR PROPOSAL

For

Space qualified

Rubidium Atomic Frequency Standard

(RAFS)

April 2025

Space Applications Centre

Indian Space Research Organization

Ahmedabad

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Acronyms

Index	Acronym	Explanation
C	CDR	Comprehensive Design Review
D	DPL	Declared Parts List
	DML	Declared Materials List
	DPrL	Declared Process List
E	ESCC	European Society for Space Coordination
F	FIT	Failure in Time
	FR	Failure Rate
	FMECA	Failure Mode Effects and Criticality Analysis
G	GCR	Galactic Cosmic Rays
H	HLC	High Level Command
I	IB	Isolation & Bonding
	IRNSS	Indian Regional Navigation Satellite System
	ISRO	Indian Space Research Organization
J	JAN-S	Joint Army Navy- Space
M	MIL	(US) Military standard
N	NVS	Navigation Satellite
	NavIC	Navigation with Indian Constellation
P	PAD	Parts Approval Document
	PDR	Preliminary Design Review
Q	QM, PFM and FM	Qualification Model, Proto-flight Model and Flight Model
	QPL	Qualified Parts List
	QML	Qualified Materials List
	QPrL	Qualified Process List
	QSL	Quasi Static Load
R	R&QA	Reliability &Quality Assurance
	RAFS	Rubidium Atomic Frequency Standards
	RFP	Request For Proposal
	RDM	Radiation design margin
S	SAC	Space Applications Centre
	SEE	Single Event Effect
	SET	Single Event Transient
T	TID	Total Ionizing Dose
	TM /TC	Telemetry /Tele-command

Introduction

Indian **S**pace **R**esearch **O**rganization **(ISRO)** requests your company to submit proposal for **R**equest **F**or Proposal (RFP) being floated for the procurement of space qualified **R**ubidium **A**tomic **F**requency **S**tandard (**RAFS**) as detailed in this document. These units will be used in Payloads of **N**avigation **s**atellites (NVS).

This document consists of five sections:

EXHIBIT-A: Brief Description of Organization & Project

EXHIBIT-B: Interface & Electrical, Mechanical Requirements

EXHIBIT-C: Reliability & Quality Assurance Plan

EXHIBIT-D: Test Sequence & Test Details

EXHIBIT-E: Deliverables & Delivery Schedule

Scope of Document

This document provides the specifications of the Rubidium Atomic Frequency Standards planned to be used in satellite constellation of **Nav**igation with **I**ndian **C**onstellation **(NavIC)**. The document also contains details of the spacecraft interfaces and **R**eliability & **Q**uality **A**ssurance **(R & QA)** requirements to be complied by the vendor for the RAFS.

The proposal submitted in response to the RFP should be in conformity with the requirements /specifications laid down in this document. In case the supplier is unable to meet the specification requirement, he should point out highlighting the deviations. Additionally, whenever the realization of the specifications or the conduct of any test is having very significant technical and /or cost impact, the same should be indicated.

The specifications in the document may be modified by SAC on any ground before the finalization of the contract. This RFP is primarily for qualified product with sufficient space heritage, however minor modifications in heritage or proven designs to meet SAC specifications may be considered after review of changes & accordingly can be suggested for Proto Flight or afresh qualification based on severity of changes. SAC reserves the right to witness the qualification/ acceptance tests and to review the progress of work at various milestones. The vendor shall suggest the review scheme along with the proposal.

The vendor has to provide a detailed profile of the company indicating the contracts executed in the related field and the resources available for taking up the present work. The vendor has to provide the information tracing the heritage of the unit proposed. Vendor has to provide information regarding the export control restrictions and any other restrictions prevailing on the vendor due to any previous contractual obligations or ownership of the Intellectual property or any form of restrictions put forth by any authorities.

EXHIBIT-A Brief Description of Organization & Project

A.1 Space Applications Centre (SAC)

Space **A**pplications **C**entre **(SAC)** is one of the major centres of the ISRO. SAC focuses on the design of space-borne instruments for ISRO missions and development and operationalization of applications of space technology for societal benefits. Over the years, SAC designs & develops transponders for the INSAT, GSAT, NVS series of satellites and optical and microwave sensors for IRS series of remote sensing satellites.

A.2 Navigation with Indian Constellation (NavIC)

Navigation with Indian Constellation (NavIC) (earlier known as Indian Regional Navigation Satellite System or IRNSS) is regional navigation satellite system providing position accuracy better than 20m within India and up to 1500 kms range around the Indian region. NVS satellite constellation is supported by Ground networks, which is responsible for the maintenance and operation of the NavIC constellation. NVS satellite constellation is under control of Indian Space Research Organization (ISRO).

A.3 Rubidium Atomic Frequency Standard (RAFS)

The Rubidium Atomic Frequency Standard (Rb-AFS) is a high-precision timekeeping technology that plays a crucial role in satellite navigation systems. It operates by utilizing the natural resonance frequency of rubidium atoms to provide stable and accurate time references, essential for synchronization in global navigation systems. RAFS works by exploiting the hyperfine transition in rubidium isotopes, where microwave radiation induces a transition between energy states. The resulting frequency is highly stable and serves as a time reference, critical for maintaining synchronization in satellite systems. By ensuring precise timing, Rb-AFS enhances the accuracy and reliability of satellite-based navigation, facilitating high-precision positioning, geolocation, and time synchronization for a wide range of applications.

EXHIBIT-B Interfaces & Electrical, Mechanical Requirements

A typical RAFS unit consists of sub modules like physics package, EPC, electronics package, TC/TM etc. Vendor to provide detailed block diagram/schematic clearly identifying each modules, their specification & supplier if not designed/developed by vendor itself.

B.1 Electrical Interfaces

RF & telemetries of RAFS will be connected to the NVS Navigation payload via **A**tomic **C**lock **M**onitoring **U**nit **(ACMU)**. Figure 1 depicts interface block diagram of RAFSs with ACMU & navigation payload.

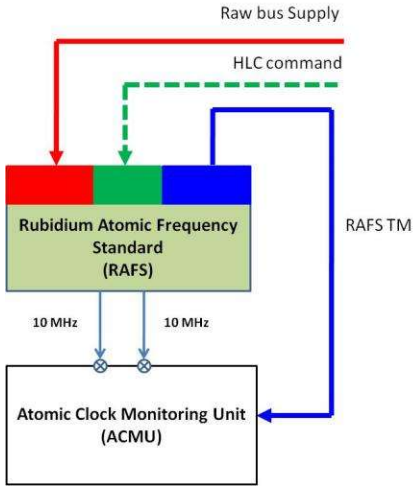

Figure 1 Interface block diagram of RAFS with ACMU & Navigation payload

B.1.1 Raw Bus Interface

RAFS will be powered from DC bus of the spacecraft.

26V-42.5V unregulated raw power bus. The RAFS should have its own regulated supply with sufficient protection.

Vendor should ensure EPC switching frequency should not interfere & deteriorate RAFS output frequency stability. There should not be any failure propagation from EPC to the spacecraft bus.

B.1.2 Tele Command Interface

High Level Command (HLC) command Pulse is to switch ON/OFF the RAFS. Interface must withstand 42.5V or short circuit permanently without damage in case of failure or interconnection error. Tele-command shall be Galvanically isolated from the power bus.

The specification of high-level command for ON/OFF of the system is as follow:-

- Single ended pulse commands
- Amplitude: 26V - 42.5V
- Pulse width: 64±4 ms or its multiple (128±8 ms, 256±16 ms or 512±32 ms)
- Pulses of<5ms duration shall be ignored by the RAFS.

B.1.3 Telemetry Interface

Clock health monitoring telemetry interface should be available. The vendor should indicate the parameters which are important to be monitored. Telemetries of the RAFS will be connected to the ACMU for further processing. Vendor to provide the type, number and functionality of all the telemetry signals use to monitor the RAFS.

Minimum telemetries with following interface are:

- **Lamp light intensity, photo detector signal** (**Analog interface)**
  - These are required in form of analog voltages in the range of ±5 Volts. Vendor to provide the resolution & waveform of each telemetry.
- **Power ON/OFF status, Lock indicator(Digital status interface)**
  - These are required in form of bi-level voltages (Low level= 0 Volt and high level=+5 Volt, CMOS compatible).
- **Temperature (Thermistor interface)**
  - These are required to monitor internal RAFS temperature (Ex:-base plate, EPC etc.). 10k Ohm Thermistor is to be used to cover the temperature range.

Note: Vendor has to mention other optional telemetries available at the critical location of the RAFS.

B.2 Functional/Performance Specifications

Each RAFS should meet the following functional/performance specifications throughout the life time of RAFS. The detailed procedure how to set up and operate the unit should be defined in the operation manual of the RAFS.

B.2.1 Output Frequency and Isolation

Each RAFS should provide two outputs F_{o1} and F_{o2} both at 10 MHz (Sine Wave). These outputs should be made available through SMA connectors and are DC coupled.

B.2.2 Isolation between ports

Isolation between two ports should be >50 dB at 10 MHz ± 2 MHz

B.2.3 Output Power

Output power level at both the ports= +10 dBm±1.5 dB.

B.2.4 Return Loss

Each of the reference signals should have Return Loss better than 20 dB at 50Ω.

B.2.5 Phase Noise

The Maximum allowed single sideband spectral density induced on carrier should not exceed as indicated below:

Offset from F_o	**Level dBc/ Hz**
1Hz	-85 dBc/Hz
10 Hz	-100 dBc/Hz
100 Hz	-125 dBc/Hz
1 kHz	-135 dBc/Hz
10 kHz	-145 dBc/Hz
100 kHz	-145 dBc/Hz

B.2.6 Spurious and Harmonics Signals

B.2.6.1 Harmonics

The level of harmonics should be less than -30 dBc.

B.2.6.2 Spurious

The Spurious Signal within the band (10 MHz ± 1MHz) should be less than -80 dBc. Outside the band, spurious should be less than -60 dBc (to be measured up to 200 MHz).Vendor to specify the lamp oscillator frequency & ensure its level should not exceed -30 dBc.

B.2.7 Initial Frequency Accuracy

Initial frequency accuracy of RAFS output should be less than ±1 x 10^{-9} after 6 hours of warm up under vacuum condition.

B.2.8 Frequency Drift

Frequency drift of the RAFS should be less than ±5 x 10^{-13} / day. RAFS should meet the drift specification within 6 weeks of continuous operation under operating environmental condition.

B.2.9 Frequency Stability

Frequency stability of RAFS output at any fixed temperature in the operating temperature range should be better than the following:

τ in Sec	**σy (τ)**	
1s	≤ 5.0 x 10^{-12}	
10s	≤ 1.5 x 10^{-12}	
100s	≤ 5.0 x 10^{-13}	
1000s	≤ 1.5 x 10^{-13}	
10000s	≤ 5.0 x 10^{-14}	(drift removed)

B.2.10 Frequency Temperature Stability

The satellite base plate operating temperature range should be in the range of -5^{0}C to +15^{0}C. The temperature coefficient should be less than ±1x10^{-13} /^{0}C.

B.2.11 Frequency Magnetic Sensitivity

The frequency variation due to magnetic field variations should be less than ±1 x 10^{-13}/ Gauss. The static magnetic field up to ±2.5 Gauss should also be permissible as long as the sum of static and dynamic magnetic fields shall not exceed 2.5 Gauss.

B.2.12 Power Supply Stability

The frequency variation due to power supply variation should be less than ±3 x 10^{-14}/V.

B.2.13 Power Consumption

B.2.13.1 Steady State

The Power consumption of the RAFS should not exceed 40 Watts under steady state of operation.

B.2.13.2 Turn On

The Power consumption of the RAFS should be less than 70 Watts at turn on.

B.2.14 Barometric Sensitivity

Vendor shall clearly indicate the barometric sensitivity. Venting details and time required for venting to be specified by vendor.

B.2.15 Frequency Jumps

The RAFS should be free from frequency jumps and other abnormal behaviour. The vendor has to take special care during the design in this context. The frequency jumps (if any) should not be higher than 5×10^{-13}. However, **RAFS which will have lower number of jumps/year will be preferred**. In support of their offer, **Vendor should provide the history of the in-orbit clock jumps in terms of number & magnitude.**

Vendor can provide Telemetry to monitor the sources of frequency jumps in real-time. The sources may include monitoring of the light level variation, signal level variation and temperature variations or any other physical parameters as per vendor's suggestion.

B.2.16 Physical Requirements

B.2.16.1 Dimension

The size of RAFS should be within the envelope of 240 mm x 140 mm x 140 mm inclusive of the EPC, additional magnetic shielding, additional thermal control (if required) and any other additional structure required to make the unit complete.

B.2.16.2 Mass

The weight of each of the RAFS should be less 5 Kg inclusive of the EPC, magnetic shielding, thermal control (if required) and any other element required.

B.2.17 Block Schematics

Vendor need to provide block schematic diagram and the basic design approach of the RAFS including all sub-module like EPC, temperature controller physics package etc. along with the proposal. The vendor shall provide the detailed design during design reviews at various stages of development.

B.2.18 Mounting Requirements

Vendor should indicate any special mounting requirements.

B.3 Mandatory Eligibility Criteria

The vendor must have a proven track record in the development of space-qualified RAFS. Only vendors whose RAFS units have been launched and operated in space as part of Navigation Satellite Systems are eligible to participate. The vendor must provide details of the number of RAFS units launched and the corresponding duration of successful in-orbit operation for each unit.

B.4 Warranty

All units must carry a warranty of 30 months from the date of receipt and acceptance at purchaser end.

EXHIBIT-C Reliability & Quality Assurance Plan

Reliability and Quality are important prerequisites of any space program hardware. It is therefore very essential for the vendor to understand and implement the R & QA requirements. RAFS need to be designed, fabricated and tested as per approved procedures commensurate with high reliability, long life space mission application requirements. This section provides the details on R&QA requirements, which shall be assured by the vendor for this program. The RAFS is referred as 'Unit' in this exhibit. ***These R & QA requirements are applicable for all sub modules of RAFS & vendor should address compliance of each sub modules.***

C.1 Design Life

- The unit shall meet all the design requirements for use on-board spacecraft with a minimum on-orbit life of 12 years.
- The unit shall be capable of meeting all the functional requirements at various stages of spacecraft assembly and storage as follows:
  - 3 years' storage at various levels of spacecraft assembly.
  - 5 years in controlled environment conditions in class 100k clean-room.

The vendor shall specify exact method of storage and retest criteria in case of longer storage.

Vendor should indicate life-limiting items/components in RAFS.

C.2 Environmental Conditions for RAFS

C.2.1 Thermal & Pressure Environment

Table 1 Environmental condition for RAFS

Non Operating Environment	
The Units shall be capable of withstanding following environmental conditions:	
Temperature	-40°C to +60 °C
Pressure	Ambient to 10^{-6} torr or better
Humidity	Relative humidity Up to 70% without condensation of water at $+40^{0}$C (Short duration).
Operating Environment	

Turn ON	The Units shall be capable of being turned-on without any damage at –25°C. While the unit need not meet its performance specifications, it should not get damaged, at this temperature.	
Temperature while Operating under vacuum (< 1e-5 mbar)	QM/ PFM	–10°C to +20°C
	FM	–5°C to +15°C
Magnetic field	QM/ PFM/ FM	< ±2.5 Gauss

- All temperatures are referred to the base plate near RAFS.
- Vendor to provide the precautions/ limitations (if any) while operating the RAFS in ambient pressure in 100K clean room at 25°C±2°C. Vendor to provide precaution for safe operation in ambient condition.
- Vendor to provide the acceptable magnetic field variation near the RAFS to meet the full performance including long term (10k second stability).
- Vendor can declare other environmental parameters like micro-vibration level etc. which are to be maintained.
- The environmental levels given above are indicative. The actual environmental levels shall be confirmed prior to placement of order.

C.2.2 Radiation environment

The unit shall be designed and fabricated to operate without any degradation in performance or life for the following:

a) 1.5×10^7 Rads ionising dose absorbed in silicon.

b) 6.0×10^{14} electron / cm^2 (3 MeV bulk damage equivalent)

c) Immunity against SEE / SEL (Single Event Effect / Single Event Latch-Up): LET 75 Me V /mg/cm^2

Vendor should indicate their compliance to the Radiation requirements by considering the shield offered by satellite structure as 0.5 mm

The dose in silicon at the centre of spherical Aluminium shield for 15 years is as given in Figure 2.

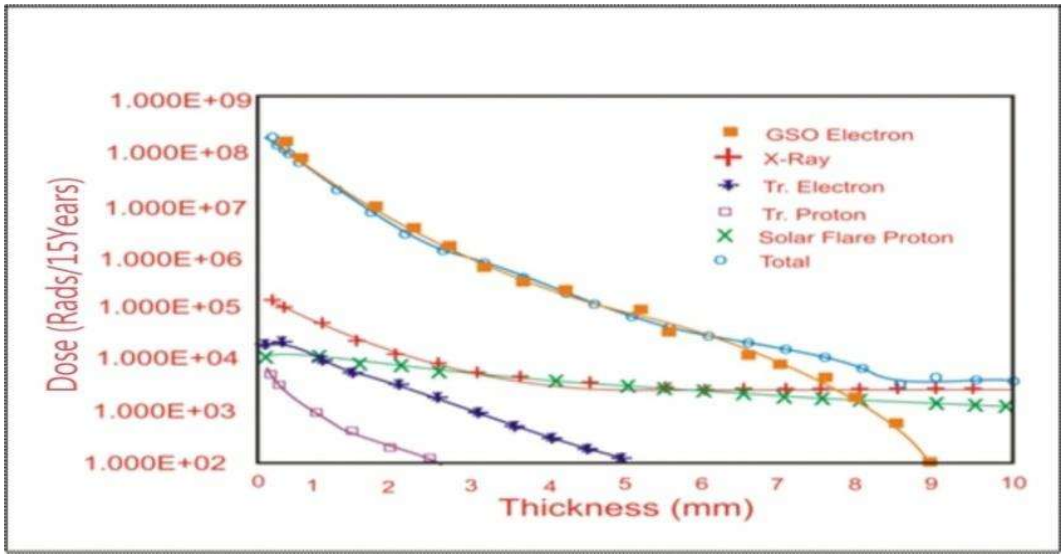

Figure 2 **Dose at the centre of spherical aluminium shield**

Table 2 **Total Dose at the Centre of Spherical Aluminium Shield (Geostationary Orbit)**

Spherical shield thickness mm (Al)	Thickness (gm/cm^2)	Total dose (Rads/15 years) GSO
0.05	0.0135	696 M
0.10	0.027	423 M
0.20	0.054	223 M
0.50	0.135	52.2 M
1	0.27	13.8 M
2	0.54	2.17 M
3	0.81	542.0 K
4	1.08	161.0 K
5	1.35	64.8 K
6	1.62	29.0 K
7	1.89	18.6 K
8	2.16	12.1 K
9	2.43	9.98 K
10	2.70	8.71 K

Note: To calculate equivalent thickness of any other material, divide column two by the density of material.

- Radiation shielding shall be applied to establish 20% margin over the estimated dosage for 15 years in GSO orbit.
- SET analysis also needs to be carried out.

- The radiation analysis has to take into account the worst case levels such that RAFS will operate as per specifications. If the units have already undergone appropriate tests/analysis which meet the levels indicated in Table 2, the same may be provided.

C.2.3 Vibration / Shock

The unit shall be designed and fabricated to meet the vibration (Sine and random), and mechanical shock, as per the test plans given in section D.2.7.

C.2.4 Quasi-Static Load (QSL)

These quasi-static loads should be considered for the design. The qualification for the steady state acceleration loads shall be shown by test/analysis.

- Out of plane : 25g
- In plane : 15g

C.3 Design Quality Assurance

C.3.1 Reliability Analysis

The units shall be designed and fabricated to achieve an estimated failure rate of about 1500 FIT in orbit at 20^0C base plate temperature. Vendor shall quote the failure rate and reliability figure for 12 years & 15 years in orbit of RAFS calculated at maximum operating temperature.

Vendor should provide the complete reliability analysis of the RAFS, during the design review. This shall include:

- **Part stress de-rating analysis** as per applicable ESA /NASA standards.
- **Reliability Prediction** at the end of 12 years (Using MIL-HDBK-217FN2)

Vendor should also specify the methodology including analysis, test data / test reports taken as reference, used in arriving at the failure rate of components not mentioned in MIL-HDBK-217FN2.

- **FMECA**
- **Worst-Case Drift &Tolerance Analysis** taking into accounts the drift due to aging, temperature, space radiation, magnetic field and other related parameters that can affect the RAFS performance.
- **Radiation Analysis** (TID,SEE including SET Analysis)

- **Thermal Analysis** under worst case operating conditions
- **Mechanical / Structural Analysis**
- **Venting Analysis**
- **EM Analysis**
- Confirmation that the circuit designs are compliant to the ESA/NASA parts usage guidelines and alerts. Detailed justification along with risk assessment shall be provided for components that are used beyond the recommended configurations/limits.

C.3.2 Safety

The unit design shall be failsafe, so that any failure within unit shall not degrade or affect the performance of other subsystems in the spacecraft. This shall be assured through adequate usage of protection mechanisms/ circuitry and shall be detailed in relevant design documents.

C.3.3 Software Quality Assurance (SQA)

Software embedded in all FM units/automated test set-up and Onboard FPGA/ASIC designs will be robust and fail safe. This shall be assured through adequate Verification and Validation (V & V) procedures and shall be detailed in relevant design documents.

Software development process shall follow IEEE-12207-2008 and FPGA/ASIC design shall follow best practices or other mutually agreed equivalent standard for space systems. All development activities like Requirement Analysis, Architecture & detailed design, Coding, Verification and Validation (V & V), generation of documents shall follow IEEE (e.g. IEEE 830 for SRS) or equivalent standards. Vendor shall be responsible of Test plan and Test case document. Vendor shall perform test at various phases of design and development of software and FPGAs/ASICs to ensure the reliable, testable, and reproducible product for space applications.

C.4 Parts, Materials and Processes

Parts, materials and processes proposed to be used in the unit shall be selected from qualified parts/materials/process list (QPL/QML/QPrL) and shall be procured from a qualified vendor / sub-vendor. Vendor shall provide Declared

Parts list (DPL)/ Declared Materials List (DML)/ Declared Processes List (DPrL) for the unit to SAC for approval.

C.4.1 Parts

The quality levels of the parts that are used to build the flight module of the unit shall meet the quality requirements as detailed in Table 3. In general, the Quality of components for the flight deliverable units shall be Space grade. Wherever, space grade components are not available, the next lower quality may be used after adequate up-screening & qualification tests, to be mutually agreed upon.

All components proposed to be used in the unit shall have previous space flight history, which shall be verifiable, through reference documents. The Quality level for parts used (Part Approval Document) shall be provided as a part of relevant documents.

Table 3 EEE-Parts Quality Level and Screening requirements

SN	Part Type	Quality Level
1	RF semiconductors	(i) ESCC level B (ii) Non QPL / QML devices – equivalent to JANS procured with full screening and quality conformance tests & DPA and shall have space flight history. (iii) JANTXV with 240 hrs. Burn-in and quality conformance tests.
2	General Semiconductors	(i) JANS or ESA / SCC level B (ii) JANTXV with quality conformance tests.
3	Passive Parts (Capacitors, Resistors, Inductors, Coils and Transformers)	(i) ESCC level B or MIL-ER failure rate 'S' (ii) MIL-ER failure rate 'R' only for the part types where 'S' is not available (iii) Non QPL / QML parts – with manufacturer's in house screening program equivalent to 'R' level with group A testing.
4	Microcircuits (Including ASIC, memory etc).	(i) ESCC level B or MIL-PRF-38535 QML class V. (ii) ESA approved parts with LAT 2 test.
5	Opto-couplers	(i) ESCC Level B or JAN-S
6	RF passive parts (attenuators, terminations, etc.)	(i) ESCC level B (ii) ESA approved part with LAT-2 tests. (iii) With adequate screening & LAT as per manufacturer's Hi-Rel program.
7	RF connectors	(i) ESCC level B (ii) MIL-PRF-39012 qualified with group A & B testing.

		(iii) TNC connectors shall have 3dB higher power handling capability.
8	Thermistors	ESCC Level B or GSFC Space level
9	Cermet fuses	ESCC Level B or GSFC space level
10	Quartz	ESCC Level B
11	Heaters	ESCC Level C
12	Multi-pin connectors (Only miniature D-type connectors shall be used)	(i) ESA / SCC level B (ii) Connectors as per NASA – GSFC requirements

Note: (i) For all the parts, quality levels listed above are preferred. Other quality levels are acceptable only if parts with quality level as listed above are not available.

(ii) For parts procured with manufacturer's Hi-Rel program, the test plan along with test report & procurement specifications shall be supplied to SAC for review. (As part of PDR/CDR document)

C.4.2 Materials

a. Ferrous and non-ferrous material used shall be of corrosion resistant type or suitably treated to resist corrosion caused by atmospheric conditions existent in storage or normal operational conditions. Non-magnetic materials shall be used for parts except where magnetic materials are essential. Materials which are nutrients for fungus shall not be used.

b. Organic and inorganic materials shall be stable under atmospheric and high vacuum conditions. These materials shall have a Total Mass Loss (TML) of less than 1% and Collectable Volatile Condensable Materials (CVCM) of less than 0.1% when subjected to test condition of $+125^{O}C$ and $1x10^{-5}$ mbar pressure for 24 hours. Only space qualified epoxies, potting materials, etc. shall be used, within their shelf life and with cure schedule as specified by the vendor. However, their use shall be restricted and failure due to these shall be recorded and analysed as and when detected.

c. The selection and use of dissimilar materials shall be avoided, where it is impractical to avoid dissimilar metals in direct contact with each other, suitable protection shall be provided by space proven coatings/plating etc. and shall be informed to SAC.

d. Where a new material is required, the performance of the material on any comparable previous Space program, and Space qualification test data shall be submitted to SAC for consideration.

As a part of data pack, a detailed list of materials to be used shall be provided to SAC for review; along with their Quality and Out-gassing specifications.

C.4.3 Processes

a. Only qualified and space flight compatible processes shall be used in the fabrication of the hardware. In case of any new processes, the processes should under-go qualification before being used in the fabrication of the hardware.

Particular attention shall be paid, as a minimum, in respect to the following:

- Neat, clean, smooth, and fully welded homogeneous solder joints.
- Eliminate bubble entrapment in coatings / epoxies where ever used.
- All components including toroidal / bead inductors / coils shall be suitably supported on PCB by RTV etc.
- Wherever wires will be attached to casing for grounding etc., a higher melting point solder than that used for lid (cover) soldering, shall be used.
- The input / output connections on pins form the PCB etc. shall also be made with high melting point solder to avoid detachment of these connections while soldering the pins to external system using SN-63 solder.
- The marking and plating etc. shall be permanent and should not get damaged during normal cleaning process using Isopropyl Alcohol and other recommended cleaning solvents.

b. All tolerances, not specified shall be consistent with the best engineering practices. Units shall be uniform in quality and free from blemishes and defects.

c. The packages have to be thermally treated suitable for space use.

C.5 Qualification & Test Philosophy

The vendor shall clearly specify if the proposed RAFS has already been qualified for other similar program and / or the RAFS has been flown in space. The vendor shall provide the qualification test reports and flight history along with the proposal. However, following philosophy will be adopted for testing:

C.5.1 Qualification

a. Qualification by Similarity

If the proposed RAFS has:

a) Sufficient flight history.

The vendor shall provide the on-orbit heritage of the unit along with the spacecraft missions and duration in orbit. On-orbit anomalies, if any, and changes incorporated should also be provided.

b) Passed qualification tests successfully and

Vendor shall provide list of space programmes wherein the proposed design has been used, test philosophy followed for that program and qualification test reports with the test conditions.

c) Manufactured in same or similar conditions (as heritage, qualified designs) without any change in design etc.,

Then, it is proposed to carry out Proto-Flight level testing on one Flight unit and may not be required to undergo full Qualification Tests. "i.e., if the qualification by similarity (in some other space programme) of proposed RAFS is established and no major changes are required, the Proto-Flight testing shall be considered as Lot Acceptance Test (LAT).

Only after review of heritage, qualification test reports, qualification by similarity can be accepted.

Wherever, design changes will be incorporated at module level for this program; that individual module shall be subjected to qualification level testing as per the mutually agreed plan. After successful qualification of individual module, the design may be implemented in the actual FM Units.

b. Full Qualification

In the case of major changes in heritage design / development, minimum one QM unit shall under go full qualification tests.

C.5.2 Test Philosophy

The test philosophy primarily will be decided on the basis of Flight history, Qualification status, confidence level etc. In general, it will depend on different models of UNIT, namely

Qualification Model (QM) OR Proto-Flight Model (PFM)

Flight Model (FM)

a. Qualification Model (QM)

QM's will be fully representative of the FM units in all aspects, and will be used for demonstration of capability of unit to meet all functional requirements over the environmental range. One QM unit shall be subjected to full qualification test as per Table 4. QM shall have the same electrical and mechanical interfaces as the flight model.

b. Proto Flight Model (PFM)

Wherever qualification by similarity is established through qualification test report and Space flight Heritage, **the first FM unit**, fully compliant to specifications, shall be tested to PFM level as per Table 4(qualification severity with test duration of FM acceptance levels).

c. Flight Model (FM)

- Flight model units represent the final electrical and mechanical design and configuration using screened Hi-Rel parts, materials and processes of qualified standard and workmanship.
- All the flight model units shall be subjected to Flight Acceptance Level Testing (FALT) as per Table 4.
- RAFS fall-out during Acceptance (screening) Tests shall state the number of times that each test parameter failed and quantity of units failed in one or more test parameters. This shall identify all catastrophic, degradation failures and failure modes observed.
- Any failure observed, shall be reported to SAC immediately. This shall be followed by a detailed failure analysis, clearly identifying the type of failure (random or design). Any modifications required in electrical, mechanical or process related aspects shall be approved by SAC. In case of mechanical or electrical design related failure, a retest plan or modification in the test plan may be necessary. Based on failure analysis, such retest plan / modified test plan shall be decided and implemented after approval from SAC.

EXHIBIT-D Test Sequence & Test Details for RAFS

As a part of quotation, vendor to provide details of final production test, prior to formal acceptance testing. This should also include acceptance criteria.

Manufacturer shall submit the test sequence & test plan for the functional and environmental tests to be conducted on the unit during Qualification, Proto-Flight& Flight Acceptance Level Test. The test plan shall include the test conditions, procedures for conducting each test, the test equipment used and their calibration, status etc. The test sequence & test plan shall include but not be limited to the tests and specifications indicated in Table 4. The test parameters to be measured in each functional and environmental test are shown in Table 11.

D.1 Test Sequence

Vendor shall provide details of final production & acceptance testing carried on each of the sub modules, listing out parameters & their acceptance criteria.

Vendor shall provide detail of ESD test & Shock test performed on similar unit qualified for any other space program.

Table 4 indicates the qualification, proto flight & acceptance test sequence for integrated RAFS unit, with the nature of tests and the methods/condition.

Table 4 Test Sequence

SN	Test	QM	PFM	FM	Method/Condition
1	Burn-In /Screening Test	x	x	x	Section:D.2.1
2	Physical Measurement	x	x	x	Section:D.2.2
3	Visual Inspection	x	x	x	Section:D.2.3
4	Initial Bench Test	x	x	x	Section:D.2.4
5	Temperature Storage Test*	x			Section:D.2.5
6	Humidity Storage Test*	x			Section:D.2.6
7	Post Storage Electrical Measurements	x			Ambient condition
Dynamic Tests*					
8	Sine Vibration	x	x		Section:D.2.7
	Random Vibration	x	x	x	
	Mechanical shock	x			
9	EMI/EMC Test	x	x	x	Section:D.2.8
10	ESD test	x			
11	Post EMI/EMC Bench Test	x	x	x	Ambient condition
12	Isolation &Bonding	x	x	x	Section:D.2.12
13	Pre-thermo-vacuum Test	x	x	x	Ambient condition
Thermo Vacuum Tests					
14	Thermo-vacuum Cycling	x	x	x	Section:D.2.9

	Full Performance Test	x	x	x	Section:D.2.10
	Final Functional Test	x	x	x	Section:D.2.11
15	Isolation &Bonding	x	x	x	Section:D.2.12
16	External Visual Inspection	x	x	x	Section:D.2.13

* Package shall not be in powered condition.

NOTE: At the end of each environmental test, visual inspection and electrical performance check will be carried out.

D.2 Test Details

D.2.1 Burn In/Screening Test

The burn-in test shall be carried out on all the QM/PFM/FM units at maximum qualification/acceptance temperature for period of 240 hrs. The unit shall be in powered on condition during this test. Power consumption and output frequency shall be monitored continuously during the test.

Logging of time duration during various phases of testing of QM/PFM/FM units should be recorded in support of cumulative operating time and provided in data pack.

During the burn-in, the electrical performance measurements shall also be carried out and critical parameter shall be monitored & recorded.

D.2.2 Physical Measurement

The unit shall be examined for Mass & Dimensions and analysed for Moment of Inertia & Centre of gravity. The vendor shall provide the measured data of mass and dimension of all the units.

D.2.3 Visual Inspection

The unit shall be inspected for surface finish, mechanical, process & workmanship related defects. Each unit shall be examined visually before and after each environmental test is carried out.

D.2.4 Initial Bench Test

The initial functional test shall be conducted at ambient temperature for all models and shall consist of measurement for parameters as indicated in Table 11. This test can be performed under ambient conditions. Environmental conditions (room temperature and humidity) during this test in the lab will be noted in the test report.

D.2.5 Temperature Storage Test

Hot & cold storage test is intended to demonstrate the ability of the unit to survive the conditions encountered during storage, shipment and pre-launch etc. **Storage test is applicable to qualification units ONLY.** The unit shall be in non-operative conditions for this test.

D.2.6 Humidity Storage Test

This test shall be carried out on qualification unit ONLY. This test shall be carried out at 95% relative humidity and +40°C for 24 hours. The unit shall be in non-operative condition during this test. After the humidity exposure, the unit shall be inspected visually and functional tests be conducted.

D.2.7 Dynamic Test

The Dynamic Test will be performed in accordance with test levels and durations as given in table 5, 6 & 7, as per the sequence given in Table 4.

The natural resonance frequency of RAFS shall be more than 100 Hz. **The acceptable change in resonance frequency & magnitude of amplification shall be ± 10 %.**

The unchanged signature in resonance searches before and after tests will establish its successful completion of the individual test steps.

D.2.7.1 Sine Vibration

Vendor shall carry out resonance search (5-2000 Hz, 0.5g) before & after the vibration test on each unit. Following level shall be applied separately along the orthogonal Axes (X, Y& Z).

Table 5 Sine Vibration

Qualification/Proto Flight model			
Axis Normal to mounting plane		Axis Parallel to mounting plane	
Frequency (Hz)	Amplitude	Frequency (Hz)	Amplitude
5 – 20	12.4 mm	5 - 18	11.5 mm
20 - 70	20 g	18 - 70	15 g
70 - 100	10 g	70 - 100	8 g
Sweep Rate	2 Oct./min	Sweep Rate	2 oct./min
For PFM Sweep Rate will be 4 Oct/min.			

D.2.7.2 Random vibration

Random vibration test shall be conducted for QM, PFM and FM. The test levels for this test are as below:

Table 6 Random Vibration (QM/PFM)

Frequency (Hz)	Qualification/Proto Flight model	
	Axis Normal to mounting plane	Axis Parallel to mounting plane
20-100	+3dB/Oct	+3dB/Oct
100-700	0.28 g^2/Hz	0.1 g^2/Hz
700-2000	–6dB/Oct	–3dB/Oct
Overall (g_{rms})	17.5 g_{rms}	11.8 g_{rms}
Duration (Minutes)	2	2
For PFM duration will be 1 minute.		

Table 7 Random Vibration (FM)

Frequency (Hz)	Flight model Acceptance	
	Axis Normal to mounting plane	Axis Parallel to mounting plane
20-100	+3dB/Oct	+3dB/Oct
100-700	0.12 g^2/Hz	0.04 g^2/Hz
700-2000	–6dB/Oct	–3dB/Oct
Overall (g_{rms})	11.7 g_{rms}	7.9 g_{rms}
Duration (Minutes)	1	1

D.2.7.3 Shock levels

The shock test shall be conducted on Qualification units. The unit shall be in non-operative condition.

Table 8 Shock Level (All 3 Axes)

Frequency (Hz)	SRS
100-600	+15dB/Oct
600-5000	700 g
2 pulses /axes	

Note: Levels given above for dynamic test (Sine vibration & random vibration) are indicative. Actual levels shall be **confirmed prior to placement of order**.

D.2.8 EMI/EMC and ESD

This test shall be conducted as per and to meet the requirements as specified in MIL-STD-461E. During the test, parameters to be measured are listed in Table 11.

ESD test (7 kV, radiated discharge, 5 kV Point discharge and structural current) shall be conducted on qualification units only and if no QM model is ordered, the results from a previous program shall be made available.

Table 9 Applicable EMI/EMC tests

QM	PFM	FM
CE-102	CE-102	CE-102
CS-101,114,115,116	CS-101	
RE-102	RE-102	RE-102
RS-103	RS-103	

D.2.9 Thermo Vacuum Cycling

Thermo Vacuum cycling testing shall be conducted on all units under vacuum conditions of 10^{-5} mbar or better. The number of cycles shall be one non-operating cycle (only for QM/PFM) & minimum four short cycles of 4 hrs dwell (**Unit shall be in 'ON' during the short cycles)** at each extreme temperature (Qualification /Proto-flight unit shall be subjected to Qualification level temperature while Flight units shall be tested at acceptance level temperature) followed by Hot & cold soak of 24 hrs each. Electrical measurements will be taken at the end of dwell periods.

Turn-ON shall be demonstrated at temperature mentioned in Table 10. Figure 3 indicates the Thermo-Vacuum test profile for QM/PFM units while Figure 4 indicates the Thermo-Vacuum profile of the FM units.

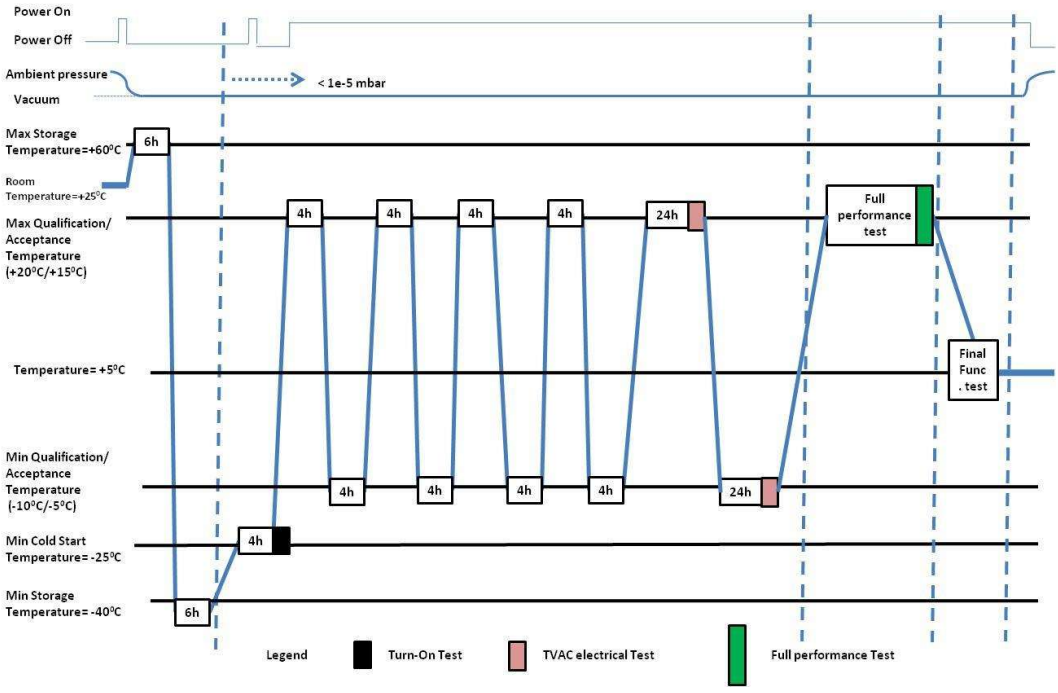

Figure 3 Profile For Thermo Vacuum Test- QM/ PFM

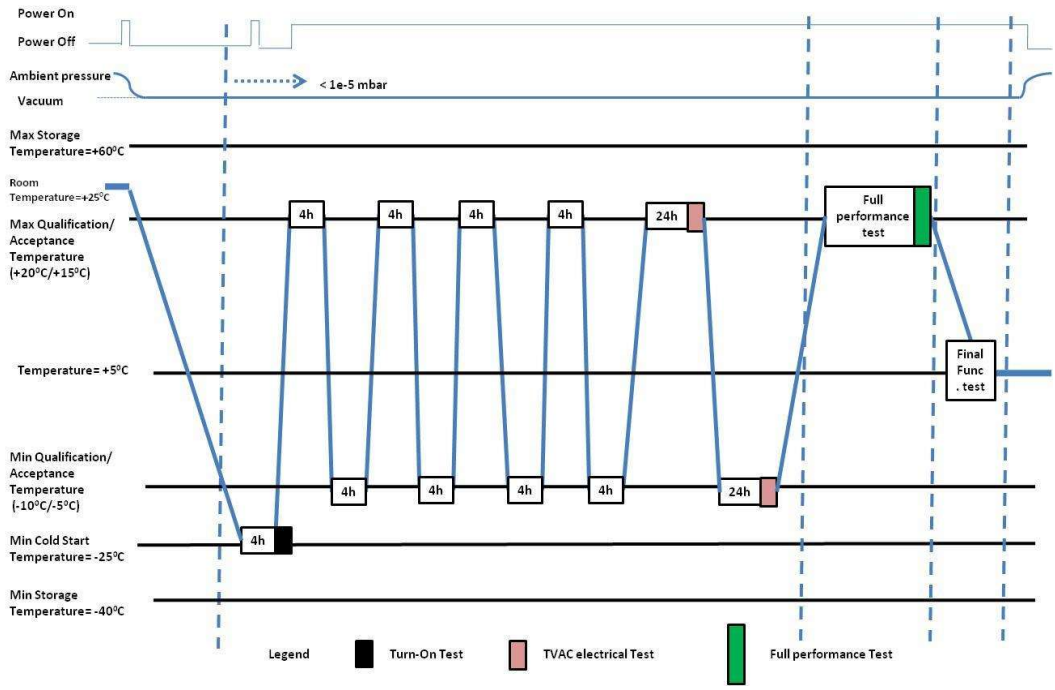

Figure 4 Profile for Thermo Vacuum Test- FM

Table 10 Temperature levels

Model	Storage	Turn ON	Operating	Full Performance Test	Final Functional Test
QM/PFM	-40°C to +60 °C	-25^0C	-10^0C to $+20^0$C	$+20^0$C	$+5^0$C
FM	Not Applicable		-5^0C to $+15^0$C	$+15^0$C	

Note: 1 All temperatures are referred to the base plate.

Note: 2 Vendor to provide the temperature transition rate.

D.2.10 Full Performance Test

Full Performance Test shall be carried out in thermo vacuum condition on all the QM/PFM/FM units at maximum qualification/acceptance temperature for a minimum period of 4 weeks. The unit shall be in powered on condition during this test. Power consumption and output frequency shall be monitored continuously during the test.

Full Performance Test includes demonstration of ***Jump Free*** operation of the RAFS, for a minimum 2 weeks. This ***Jump Free*** operation may be either after completion of 4 weeks of full performance test or after achieving the drift/day

specification (whichever is earlier). The unit should meet its long-term stability and drift/day with-in 6 weeks.

During the test, the electrical performance measurements shall also be carried out and critical parameter shall be monitored & recorded.

Operating time of each RAFS unit should be logged during various phases of testing of QM/PFM/FM, in support of cumulative operating time and provided in data pack.

D.2.11 Final Functional Test

Final Functional Test shall be conducted at thermo vacuum condition at +5°C and shall consist of measurement for parameters as per Table 11.

D.2.12 Isolation & Bonding Test

This test is to be performed to allow an early detection of potential discontinuities in the unit, which could call for disassembly of the unit and invalidate the result of former tests.

D.2.13 Final Visual Inspection

Visual inspection shall be carried out to confirm that there is no degradation after FM/PFM/QM level testing on the assembly.

Note:-1 Accuracy, calibration etc. of the test instruments shall be verified and the factors shall be stated in the test plan and procedures submitted by the vendor.

Note:-2 Temperature stabilization shall be considered reached when all the temperature readings are within ± 1^0C (± 3^0C for thermo-vac test) of the specified temperature for at least three consecutive readings taken at fifteen minutes intervals.

D.3 Test Matrix for RAFS

Test matrix provided here are indicative in nature. Vendor is required to propose a detailed test matrix consistent with the functionality and requirements of the units. All parameters are to be measured at $Vbus_{max}$ (42.5V).

Table 11 Test Matrix

S.N.	Requirement Identification	Burn-in/Screening Test	Physical Parameters	Initial Bench Test	Vibration	Post Vib Bench Test	EMC	Post EMC Bench Test	Isolation & Bonding	Thermo vacuum			Isolation & Bonding
										Cycling	Full Performance Test	Final Functional Test	
1	**Frequency and output power** Main F_{01} & Secondary F_{02}	x		x		x	x	x		x	x	x	
	Port to port isolation			x									
2	Return Loss			x								x	
3	Freq. accuracy	x		x*						x	x	x	
4	**Frequency Stability**												
	1 sec	x		x		x		x		x	x	x	
	10 sec	x		x		x		x		x	x	x	
	100 sec	x		x		x		x		x	x	x	
	1000 sec	x									x	x	
	10000 sec (drift removed)										x		
5	Frequency Drift per day										x		
6	Frequency Temperature Sensitivity									x			
7	Frequency Magnetic Sensitivity						x**						
8	Frequency stability with respect to power supply											x	
9	Frequency jumps										x		
10	Spurious Signals a) Fc +/- 1 MHz b)Outside of +/- 1 MHz BW up to 200 MHz	**x**		x		x	x	x		x		x	

S.N.	Requirement Identification	Burn-in/Screening Test	Physical Parameters	Initial Bench Test	Vibration	Post Vib Bench Test	EMC	Post EMC Bench Test	Isolation & Bonding	Thermo vacuum			Isolation & Bonding
										Cycling	Full Performance Test	Final Functional Test	
11	Harmonics	x		x		x	x	x		x		x	
12	Phase Noise (10 MHz)												
	1Hz	x		x						x		x	
	10 Hz	x		x						x		x	
	100 Hz	x		x						x		x	
	1000 Hz	x		x						x		x	
	10000 Hz	x		x						x		x	
	100000 Hz	x		x						x		x	
13	Physical Requirements		x										
14	Pmax during Warm-up	X		x		x		x		x			
15	Pmax during nominal operation	X		x		x		x		x	x	x	
16	All Telemetries (TM)	x		x		x		x		x	x	x	
17	Bonding			x			x		x				x
18	Isolation			x					x				x
19	Inrush			x			x			x			

X* Reduce performance as conducted under ambient pressure.

X** To be perform on QM/PFM only.

D.4 Test Methods

Following minimum tests methods will be applicable for respective tests of RAFS.

Vendor can suggest equivalent test methods & can include other test parameters.

Table 12 Test methods

Test	Test methods
DC Power Consumption	Calculation voltage and current measurements

In-Rush and Transients	Current Probe and Oscilloscope
Spurious , Harmonics, Output Power	Spectrum Analyser
Return Loss , Isolation between Outputs	Network Analyser
Frequency, Frequency stability (short-term and long term), Frequency Jumps in amplitude and occurrence.	Phase and Frequency comparison to a reference source e.g. passive H-Maser with superior performance.
Phase Noise	Phase Noise Test Set
All electrical interfaces, including Tele-command and Telemetry	Automated test setup

D.4.1 Measurement Accuracy

The accuracy, calibration etc., of the test instruments shall be verified and the factors shall be stated in the test plan and procedures submitted by the vendor.

D.4.2 Maximum Allowable Tolerance in test conditions

Table 13 Maximum Allowable Tolerance in Test Conditions

Temperature		$\boldsymbol{Tmax}_{+3^{\circ}C}^{0^{\circ}C}$
		$Tmin_{0^{\circ}C}^{-3^{\circ}C}$
Atmospheric Pressure	> 0.1 mbar	± 5%
	< 0.1 mbar	± 50%
Relative Humidity		$RH_{-5\%}^{+0\%}$
Acceleration		± 10%
Vibration	Frequency	0.5 Hz below 25 Hz or ± 2% above 25 Hz
	Sinusoidal Amplitude	± 10%
	Random (g-rms)	± 10%
	Power Spectral Density 20-2000 Hz	± 3.0 dB

Note: The instrument shall be capable of measuring at least 10 times better than tolerance limit.

EXHIBIT-E Deliverables& delivery Schedule

E.1 Rubidium Atomic Frequency Standard (RAFS)

Table 14 shows the various types of models of RAFS which is to be delivered:

Table 14 Deliverables RAFS units

S.No	Model	Quantity	Unit Price (To be quoted separately in price bid)	Remarks
1.	Qualification Model (QM)	1	Vendor to quote for QM in price bid	QM/ PFM shall be selected based on section: C.5. **However, Vendor must furnish separate cost for QM and PFM**
2.	Proto flight Model (PFM)	1	Vendor to quote for PFM in price bid	
3.	Flight Models	4 to 6	Vendor to quote for FM in price bid	Vendor should quote in slabs
4.		7 to 10	Vendor to quote for FM in price bid	
5.		11 to 14	Vendor to quote for FM in price bid	
6.		15 to 18	Vendor to quote for FM in price bid	
7.		19 to 22	Vendor to quote for FM in price bid	
8.		23 to 26	Vendor to quote for FM in price bid	
9.		27 to 30	Vendor to quote for FM in price bid	
10.		31 to 34	Vendor to quote for FM in price bid	
11.		35 to 40	Vendor to quote for FM in price bid	

Selection of QM or PFM is based on purchaser evaluation of the technical bid and will be decided during technical evaluation. However, vendor must quote for QM, PFM and FM models (all three models) separately in price bid.

VENDOR MUST NOT DISCLOSE ANY PRICES IN ANY FORM (FULL OR PARTIAL) IN TECHNICAL BID. DISCLOSING ANY PRICES IN TECHNICAL BID WILL RENDER THE BID DISQUALIFIED.

E.1.1 Criteria for Lowest Price Bid

The order will be placed on lowest technically suitable bid. The price bid offered by the vendor will be calculated as follows:

Cost of 1 unit of QM/PFM (whichever applicable) + Cost of N units of FM

QM/PFM will be decided on Section C.5 and N is the number of FM units. These will be decided at the time of technical evaluation.

However, actual ordering of QM/PFM and number of FM units will be decided at the time of contract.

E.2 Documentation

The following documents shall accompany the quotes:

i. Space History, Space Program, Qualification status details etc for the proposed qualified design with name of Space programs.
ii. List of important parts proposed to be used for this program. Quality level of the parts proposed to be used for flight model units.
iii. Qualification Report of previously qualified designs with test levels.
iv. Reliability Analysis Summary.
v. Screening / Lot Acceptance Test Plans.
vi. Non-conformance Control Plan.
vii. Configuration change control plan.
viii. Final production Test details and assembly sequence.
ix. Tests Details, wherever specified.

Apart from above the documents / reports as given below, but not limited to, shall be supplied later after the award of contract. These have to be full reports (not the summary reports).

Table 15 List of deliverable documents to RAFS.

SN	Category	Document	Delivery time		
			PDR	CDR	HDR
1	Design	Design/Performance Specification	X	X	
		Circuit Level Block Diagram of RAFS & sub modules	X	X	
		Software Requirement Specification& design Documents	X	X	
		Design Report	X	X	
		Design Analysis/Budgets	X	X	
		Radiation analysis	X	X	

SN	Category	Document	Delivery time		
			PDR	CDR	HDR
		Thermal Analysis	X	X	
		Mechanical/Structural analysis	X	X	
		Venting analysis	X	X	
		Design Verification Matrix	X	X	
2	Configuration Management	CM Plan	X	X	
		Configuration Item Data List	X	X	X
		Drawing List/tree	X	X	X
		Top Assembly Drawing (TAD)	X	X	X
		Interface Control Drawing (ICD)	X	X	X
		Interface Control Sheet	X	X	X
		Log Book			X
		EIDP			X
3	Product Assurance	**Product Assurance plan** ▪ Component Control Plan ▪ Reliability Engineering Documents ▪ Risk Assessment & Management ▪ Software Product Assurance Plan Including designs of FPGA/ASICs ▪ Cleanliness & Contamination Plan ▪ MIP (Mandatory Insp^{tn} Points) List	X	X	
		Critical Item List	X	X	X
		NCR/ Failure Report	Within 48 hours of occurrence		X
		NCR Status List	Monthly		X
		Alerts	X	X	X
		MIP Reports	Within 5 days of MIP		X
		Hardware-Software Interaction Analysis	X	X	
		FMECA	X	X	
		Part Derating Analysis	X	X	
		Worst Case Analysis	X	X	
		Reliability Prediction	X	X	
		Hazard & Safety Analysis	X	X	X
		Declared Materials & Mechanical Parts List*	X	X	
		Declared Processes List *	X	X	
		Material/process Request for Approval (As Required)		X	
		Declared EEE-Parts List *	X	X	
		Parts Approval Documents *		X	
		Critical EEE-Components List*	X		
		EEE-Part NCRs	On issue basis		
4		Design & Development Plan	X	X	

SN	Category	Document	Delivery time		
			PDR	CDR	HDR
	Testing & Handling	Test Plan*	X	X	
		Acceptance Matrix *	X	X	X
		Test Procedure* (To be available 20 days before the test)		X	
		Test report	X	X	X
		Test report for sub modules	X	X	x
		Handling Packaging & Transportation Procedure	X	X	X
		Storage & Retest Plan &Procedure*			X
5	Management	Monthly Progress Report (including Product Assurance)	5 working days after month end		
		Minutes of Meeting	Real time at the end of meeting		
		PDR/ CDR Data Package	15 calendar days prior to review		
			X	X	X
		Review Report	5 working days after review		
			X	X	X

* These are to be provided for approval by SAC.

All the deliverable documents are to be provided as soft copy.

E.3 Delivery Schedule

Below table indicates the delivery schedule of different models of RAFS:

Table 16 Delivery Schedules

Milestone	Time (Month)	Deliverables	Quantity
1	T_0 + 1	BDR	
2	T_0 + 2	PDR	
3	T_0 + 18	QM/PFM	1
4	T_0 + 21	FM	2
5	Beyond	FM	2 FM per 3 month

T_0 = Date of commencement of contract

E.4 Reviews

The following reviews will be held during the contract period. Vendor has to give an advance notice of 15 days for holding the reviews to enable either side to make arrangements.

E.4.1 Kick –Off Meeting/Base-Line Design Review (BDR)

The kick off meeting is intended to address design approaches, over all configurations, consolidation of requirements and other details needed for the execution of the contract. This should be held within **one month** of award of contract.

E.4.2 Preliminary Design Review (PDR)

Preliminary Design Review (PDR) shall review the concept of the design and development program. The detailed design of unit shall be reviewed to demonstrate compliance of the unit with all performance requirements, over the operating environment; in particular, the performance and operational requirements. The review shall address:

- Results of the development and qualification activities (if any).
- Feasibility and ability of the design to meet the specifications.

E.4.2 Comprehensive Design Review (CDR)

Comprehensive Design Review (CDR) shall be conducted on Completion of the Qualification/Proto Flight tests. Objective of the CDR is to formally review and establish confidence in the final design of RAFS. This will be achieved by:

- Test results and final design of the RAFS that has been subjected to the Qualification/Proto Flight testing.
- Final Parts, Material and Processes used for realisation of QM/ PFM unit and to be used for Flight RAFS units.
- Qualification status of the final parts, materials and processes.
- Completeness of test plans and procedures.

The review will establish that the RAFS will meet its performance specification and will verify that the design margins under the qualification/Proto Flight test environment are satisfactory.

E.4.3 Hardware Delivery Review (HDR)

The objective of the Hardware Delivery Review (HDR) is to formally review the acceptability of flight hardware. The requirement and objective shall also apply for on-the-shelf units which have already been manufactured and acceptance tested. The HDR for such units shall also address the results of periodic verification during their storage and revalidation for use.The review shall address:

- Test results of RAFS that has been subjected to the acceptance testing.
- Final Parts, Material and Processes used for realisation of FM units.
- Completeness of test plans and procedures.
- Completion of test program on the RAFS that will be delivered.
- Compliance of the RAFS with the performance, design and test specifications through test results and analyses.
- Status of the manufacturing, assembly and integration.

The review shall establish that the RAFS meets all its specifications and has been manufactured, assembled, integrated and tested according to all appropriate specifications and procedures. The review shall be scheduled prior to the delivery of the units and can be scheduled in batches.

E.5 General

E.5.1 Requirements from SAC

Vendor shall provide a list of requirements from SAC, to carry out the contract.

E.5.2 Specialized Tools/ Software

Vendor has to provide details of the specialized tools/ software etc., if any needed for testing of RAFS units. Such tools where ever applicable should be delivered by the vendor.

E.5.3 Program Management

- Vendor shall identify a dedicated Project manager who is responsible for controlling, managing, coordinating all the activities connected with the contract. He will also be a single point contact with SAC and should be authorised to deal with all the issues connected with the contract.
- A single point contact for management & technical discussion shall be identified from SAC.

E.5.4 Configuration Management &Control

The vendor should institute Configuration Control measures which are consistent with the requirements of critical space hardware.

E.5.5 Training/Participation in Qualification/Acceptance Test

- SAC reserves the right to witness the qualification/acceptance tests and to review the progress of work. If any test is to be carried out at place other than vendor site, appropriate arrangement for the participation of SAC nominee shall be made by vendor.
- During Final functional test, SAC/ISRO personnel shall be trained for carrying out unit acceptance tests at SAC/ISRO. However, during the course of the project, if any other stage deemed more suitable can be defined and mutually agreed upon for training purpose.

E.5.6 Post Acceptance Support and Analysis

- Vendor should support ISRO for the successful integration of the RAFS, including technical clarifications, resolution of anomalies during integration modelling, interpretation of results, including in-orbit. Vendor should address for such support within the scope of their proposal in response to this RFP.
- If RAFS will not meet its performance specification in-orbit, in NVS spacecraft under specified environmental conditions, ***vendor shall assist in identification of Root Cause and possible rectification mechanism on all available RAFS units, including those already delivered and subsequent deliverables;*** in order to meet performance specification in-orbit.
- Vendor's offer should indicate their compliance to the above post-delivery support.
- The possibility of repair/ rework on any delivered RAFS unit; at SAC/ ISRO facilities may be explored. The vendor may identify all special and general facilities required to be provided by SAC/ ISRO to enable the same.

E.5.7 Marking & Identification

The unit shall be identified by assigning unique serial number on the exterior surface by a suitable process applicable for space use. Marking shall not degrade

the performance of the unit. In addition to functional markings like input / output, frequency etc. following marking shall appear on each unit:

Part name

Part Number

Specification Number / Contract Number

Serial Number

Name of the Manufacturer

Date of Manufacture

QM / PFM / FM as applicable

Hazard Alerts / Precautions

The permanency of the marking shall be sufficient to withstand the specified environmental conditions and normal cleaning operations using Isopropyl Alcohol and other cleaning solvents. The test method to demonstrate the same shall be specified by the manufacturer.

E.5.8 Packing & Storage

Considering Rubidium isotope element, Units should be packed in permanently usable type packaging which is suitable for storage and transportation of the unit by air, ship or road without any degradation / damage.

Individual unit package and transportation containers shall be clearly marked with below instructions, along with other mandatory markings. Humidity & shock sensor shall be mounted in transportation container.

"ESD SENSITIVE UNITS"
"To be opened under clean environment with ESD precautions only"
"High Reliability Space Usage Systems"

~~~End~~~
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