REQUEST FOR EXPRESSION OF INTEREST (REoI)
FOR
ESTABLISHMENT OF DATA RECEPTION SYSTEM FOR LEO SATELLITES

DECEMBER 2014

RF & Base Band Systems Division
Satellite Data Systems Group/SDAPSA
National Remote Sensing Centre
Indian Space Research Organization
Balanagar, Hyderabad
Request For Expression of Interest
# Request For Expression of Interest

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1. INTRODUCTION

National Remote Sensing Centre (NRSC), located at Hyderabad is one of the centres of Indian Space Research Organisation (ISRO) and is a key player in Earth Observation Programme and Disaster Management Support programme.

National Remote Sensing Center (NRSC) has the responsibility of establishing Remote Sensing Satellite ground stations at two locations, New Delhi and Doom Dooma for receiving data from Low Earth Orbiting (LEO) Satellites. The ground station shall have capability to receive data in S-(2.2 – 2.3 GHz) and X -(7.9 8.5 GHz) Bands, both in RHCP & LHCP simultaneously. The ground station antenna system shall consist of a 7.5 meter diameter or less to track the satellites and receive signals in both S and X Bands. It should also have Uplink transmission capability in S-Band (2.025-2.125 GHz) signals. The ground station comprises of RF and Base Band Systems, Servo and Mechanical Systems as major constituents.

The objective of this document is to identify suitable and prospective vendor who has vast experience in the establishment of ground station for LEO satellites. Document provides the technical specifications, system description, configuration requirements and other details essential for the establishment of the ground station.

The work includes supply, installation and commissioning of Antenna Systems and all related mechanical, RF and servo subsystems at two different locations in India. The ground station shall have the capability to track the LEO satellites at an orbit height of 400 KM and above. The ground station systems shall be installed and interfaced with the station control room systems. The operations of ground station shall be performed from the centralized control room which is located within a maximum distance of about 500 meters away from the Antenna pedestal room.

The proposal submitted in response to this Request for Expression of Interest (REoI) should be in conformity with the requirements / specifications laid down in the document.
All the valid technical bids will be evaluated for their suitability by a committee at NRSC and the decision of this committee shall be final for accepting / rejecting any of the technical bids.

**Condition for intellectual property**

The intellectual property rights pertaining to the technical information of system establishment & commissioning shared by NRSC shall remain exclusive property of NRSC. Vendor shall make no attempt to unlawfully reveal, misuse or encroach upon the intellectual data/information provided by NRSC.

**2. SCOPE OF WORK**

NRSC intends to assign the task of Supply, Installation & Commissioning of Satellite Ground Station to an industry on turnkey basis. The work includes establishment of data reception system for LEO Satellites. The Vendor is defined as the entity responsible for establishment of the work either independently or with sub vendors.

The quote for the data reception system with dual polarized feed shall be submitted for the following three options. The quotation shall include the details of all subsystems (excluding demodulators) required for the ground station:

1. S/X Band Antenna System (main reflector, sub reflector, feed and support structure) fabrication using design drawings of NRSC.

2. S/X Band Antenna System (main reflector, sub reflector, feed and support structure) fabrication using design drawings of Vendor.

3. S/X/Ka Band Antenna System (tri-band feed) design and fabrication by vendor.

The technical specifications and requirements are provided in section 3 of the document for options 1 and 2 and in section 8 of the document for option 3.

The vendor has to establish and demonstrate the performance of the Remote Sensing Data reception to track and receive data from Remote Sensing Satellites with Transmit Capability in S-Band for Telemetry and Tele Command (TTC) operations.
Request For Expression of Interest

System should be capable of simultaneous reception in both the polarizations (RHCP & LHCP) in the specified bands, based on the option. Tracking channel and data channels (single or dual) which are tunable according to the mission requirements should be provided.

The vendor is requested to submit following:

- Technical Compliance Table along with supporting documents
- Detailed technical proposal.
- Bill of material.
- Budgetary proposal
- Delivery Schedules.
- List of ground stations with similar requirements/Specifications commissioned by vendor.

The establishment & commissioning will involve (not limited to) the minimum activities as under:

- Understanding the requirements
- System engineering and finalization of requirements
- Design reviews
- Development / procurement of various subsystems
- Vendor has to provide inputs for Pedestal civil works (against vibration, wind, earth quakes etc.) immediately after the placement of the purchase order for antenna pedestal construction by NRSC.
- Inputs on Electrical and other requirements shall be mentioned by vendor
- Equipment Transportation to site
- Installation and Commissioning
- Documentation and Training
- Warranty and AMC Services.
- Supply of required interfacing cables of all types, wave guides, patch panel, patch cords, coaxial connector, etc.
List of critical spares shall be provided

All the systems at the site shall be operated, monitored and controlled in local and remote mode of operation. The required hardware and software have to be supplied and installed by the vendor.

The system shall be designed and constructed for a minimum operating life of 15 years.

The required software licenses shall be provided by the vendor. This shall include upgrades as & when required.

Suitable standard 19” instrument racks along with power distribution boards shall be provided by the vendor to mount all the equipments. The equipments shall be standard 19” Rack Mountable.

The detailed specification and configuration of critical subsystems like Feed, Down Converters, Fiber Optic Link, Servo System shall be included in the proposal.

The project management team of NRSC will periodically review the technical, commercial and managerial aspects of the activity. The typical reviews will be as under:

- Preliminary Design Review
- Critical Design Review
- Factory Acceptance Tests
- Final On site Acceptance Tests
## 3. OVERALL TECHNICAL SPECIFICATIONS (S/X-BAND)

### Table 3-1. S/X-Band Antenna System Specifications

<table>
<thead>
<tr>
<th>SL NO</th>
<th>PARAMETERS</th>
<th>SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Antenna</td>
<td>Diameter of ≤ 7.5 meter Parabolic reflector in Cassegrain Configuration.</td>
</tr>
<tr>
<td></td>
<td>Main Reflector</td>
<td>Parabolic - 7.5 meter or less diameter</td>
</tr>
<tr>
<td></td>
<td>Sub reflector</td>
<td>Hyperbolic – with suitable diameter</td>
</tr>
<tr>
<td>2.</td>
<td>G/T dB/deg K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-band (8.25 GHz)</td>
<td>32 or better at 5 deg EL @ 23 deg C, clear sky,</td>
</tr>
<tr>
<td></td>
<td>S-band (2.25 GHz)</td>
<td>17 or better at 5 deg EL @ 23 deg C, clear sky</td>
</tr>
<tr>
<td>3.</td>
<td>Frequency Range</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-Band Rx</td>
<td>7.90 to 8.50 GHz</td>
</tr>
<tr>
<td></td>
<td>S-Band Rx</td>
<td>2.20 to 2.30 GHz</td>
</tr>
<tr>
<td></td>
<td>S band Tx</td>
<td>2.025 to 2.125 GHz</td>
</tr>
<tr>
<td>4.</td>
<td>Feed Polarization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-band Receive</td>
<td>Data Rx RHCP &amp; LHCP Simultaneous or Selectable</td>
</tr>
<tr>
<td></td>
<td>S-band Receive</td>
<td>Data Rx RHCP &amp; LHCP Simultaneous or Selectable</td>
</tr>
<tr>
<td></td>
<td>S band Transmit/Receive</td>
<td>Simultaneous</td>
</tr>
<tr>
<td></td>
<td>TX/RX Isolation</td>
<td>120 dB min</td>
</tr>
<tr>
<td></td>
<td>TX polarization</td>
<td>RHCP &amp; LHCP switchable</td>
</tr>
<tr>
<td></td>
<td>Transmit Power</td>
<td>100 W</td>
</tr>
<tr>
<td>5.</td>
<td>On Axis Axial Ratio/Cross polarization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-band</td>
<td>0.5 dB/30 dB</td>
</tr>
<tr>
<td></td>
<td>S-band</td>
<td>1.5 dB/20 dB</td>
</tr>
<tr>
<td>6.</td>
<td>First Side Lobe Level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-band</td>
<td>15 dBC min from the beam Peak</td>
</tr>
<tr>
<td></td>
<td>S-band</td>
<td>15 dBC min from the beam Peak</td>
</tr>
<tr>
<td>7.</td>
<td>S &amp; X band Auto Track</td>
<td>Single Channel Monopulse</td>
</tr>
<tr>
<td>8.</td>
<td>Down Conversion</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>X-band Tracking</td>
<td>Single</td>
</tr>
<tr>
<td>2.</td>
<td>X-band Data</td>
<td>Single or Dual</td>
</tr>
<tr>
<td>3.</td>
<td>S-band Data &amp; Track</td>
<td>Single</td>
</tr>
<tr>
<td>4.</td>
<td>Intermediate Frequency (IF)</td>
<td>720 MHz</td>
</tr>
<tr>
<td>5.</td>
<td>Modulation Schemes</td>
<td>8PSK/BPSK/QPSK/OQPSK/UQPSK</td>
</tr>
<tr>
<td>6.</td>
<td>Tracking modes</td>
<td>Program Track, S Auto track, X Auto track (R &amp; L)</td>
</tr>
<tr>
<td>7.</td>
<td>Auto tracking Accuracy &amp; Pointing Accuracy over hemispherical coverage in X-band</td>
<td>1/10&lt;sup&gt;th&lt;/sup&gt; of 3 dB beam width at operational wind and occasional gusting 1/5&lt;sup&gt;th&lt;/sup&gt; of 3 dB beam width at operational wind and occasional gusting</td>
</tr>
<tr>
<td>8.</td>
<td>Acquisition/Manual modes</td>
<td>Standby, Manual, Slew, Stow, Designate &amp; command angle, Program Track</td>
</tr>
<tr>
<td>9.</td>
<td>Antenna Mount</td>
<td>EL over AZ Option: Third Axis to support overhead passes</td>
</tr>
<tr>
<td>10.</td>
<td>Auto Diversity</td>
<td>SR/SL/XR/XL</td>
</tr>
<tr>
<td>11.</td>
<td>Type of Drive</td>
<td>Dual in Azimuth, Elevation Option: Third Axis</td>
</tr>
<tr>
<td>12.</td>
<td>Drive configuration</td>
<td>Two motor Counter-torque (Torque bias)</td>
</tr>
<tr>
<td>13.</td>
<td>Antenna Coverage</td>
<td>AZ ± 360°; EL -5° to +185°</td>
</tr>
<tr>
<td>14.</td>
<td>Wind speed (kmph)</td>
<td>Operational wind speed: 60 Occasional gusting: 80 Drive to stow: 100 Survival wind speed: 200</td>
</tr>
<tr>
<td>15.</td>
<td>Temperature Range Operating Storage</td>
<td>0 to + 55 deg C -10 to + 65 deg C</td>
</tr>
</tbody>
</table>

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NRSC/ISRO/INDIA 6
4. **SYSTEM DESCRIPTION**

S/X-band Remote sensing antenna system consists of Antenna & Feed, tracking pedestal, RF systems, Servo system and Mechanical systems. Complete block diagram of the Antenna system is shown in Figure 1.

![Figure 1. Block Diagram of Data Reception System](image)

The station shall consist of a dual shaped Antenna System with a parabolic reflector. The dual shaped antenna along with feed in Cassegrain configuration should provide $G/T$ of 32.0 $\text{dB}/^\circ \text{K}$ at 5$^\circ$ EL in X-band and $G/T$ of 17 $\text{dB}/\text{degK}$ at 5$^\circ$ EL in S-band. The antenna diameter shall be less than or equal to 7.5 m to meet the $G/T$ requirements. S
band feed system shall have the capability for S band transmission. The offered system should have the provision to upgrade the UP link Chain for TTC application.

The antenna system should be capable of receiving dual circular polarized signals (RHCP and LHCP) simultaneously in S & X-bands. The operating frequency range for reception is 7.90 to 8.50 GHz in X-band and 2.2 to 2.3 GHz in S-band. 2.025-2.125 GHz frequency range is used for transmission. All antenna parameters should meet the specifications over the operating frequency range.

The antenna and feed system should be mounted over an Elevation (EL) over Azimuth (AZ) drive pedestal. The feed and front-end system shall be realized using single channel mono pulse tracking technique. The system should track the satellite in X-band auto track mode with S-Band auto track and program tracking as backup modes.

The X-Band RHCP and LHCP data and tracking error signals are amplified in corresponding Low Noise Amplifiers and down converted to an IF frequency at 720 MHz. The S-band Telemetry Data and Tracking signals are down converted to 70 MHz IF. The down converted X and S band \textbf{data IF signals} shall be fed to Fiber Optic (FO) link which consists of a respective FO Transmitter at the Antenna Pedestal, Armoured 12-Core Cable and a FO Receiver at the control room. These S and X-band Data IF signals are further driven to receivers in control room for processing. The down converted X and S band \textbf{tracking IF signals} shall be fed to suitable S and X band Tracking receivers at the pedestal to extract AZ and EL DC errors for Auto Track. The Digital Servo System shall control the antenna movement for satellite tracking in Program Track and Auto Track modes.

The receive system shall have built-in provision for end-end testing and performance evaluation through local loop checks.

The Digital Servo System shall consist of Antenna Control Computer, Drive Power Amplifiers, Drive motors and Optical shaft Encoders to operate the Antenna in different modes of operation viz, Rate mode, PTS mode, command angle mode and
Auto mode. The System should have provision for remote control and configuration through Ethernet interface.

The Drive system consists of Power Amplifiers, Brush less DC motors, Gear boxes (Dual drive mode) and Slew-rings in each EL and AZ axis. Each axis is driven by two motors in counter torque mode to avoid backlash. Absolute optical shaft encoders with desired resolution are used for measuring the angular position of the antenna. All safety interlocks are provided in the drive system.

The total data acquisition system should operate in fully automated environment and also it should have full autonomy to meet any contingency requirements. The Antenna system pedestal shall be designed to withstand heavy winds, earth quakes, vibrations etc.

5. **RF SYSTEMS**

RF Systems consist of Antenna & Feed, feed electronics, down converters, data and tracking receivers, up converters and Fiber Optic Link with Tx/Rx modules.

5.1 **ANTENNA & FEED**

The Antenna & Feed system shall have Parabolic main reflector, Hyperbolic sub reflector and feed in Cassegrain configuration. The station should provide a G/T of 32 dB/K at 5° EL in X-band and 17 dB/K at 5° EL in S-band. The G/T shall be realized with a highly efficient 7.5 meter or less diameter Antenna system. Surface accuracy should be less than 300 micron on the main reflector. A Low Noise Amplifier with best possible Gain and Noise temperature shall be used to meet specified G/T. S band & X- band feed shall have the capability to receive data simultaneously in both RHCP and LHCP polarizations. Feed shall have the capability to track in one of the polarizations which are selectable [or both polarizations] in both S & X- band. For future transmission applications, S band feed shall have the capability to transmit in either of the circular polarizations based on manual/remote mode of selection. The
transmission capability shall be 100 Watt RF power. The system shall have provision to upgrade antenna system for transmission in S band as and when required.

5.2 X- BAND UP/DOWN CONVERTERS

X-band Data and Tracking signals from RHCP & LHCP feed ports shall be down converted using single conversion from 7.90 – 8.50 GHz to an Intermediate Frequency (IF) of 720 MHz. Arrangement for down converting dual polarized input signals shall be made available.

Data down converters in each polarization (RHCP/LHCP) should have three identical channels ( 2 Main and 1 Redundant). It shall cater to the multi -carrier requirement in each polarization with built-in programmable frequency synthesizers whose frequency can be selected (Manually/ Remotely) as per the mission configuration.

5.3 FIBER OPTIC LINK

The RHCP and LHCP down converted data IF signals (720 MHz) shall be fed to Fiber Optic (FO) link which consists of a respective FO Transmitter at the Antenna Pedestal, Armoured 12- Core Cable and a FO Receiver at the control room. These Data IF signals are driven to demodulators in control room for further processing. To meet wide bandwidth requirements of the channel i.e, 600 MHz, components should be selected with appropriate characteristics to meet the overall specifications. These sub systems can be placed closer to the feed to reduce the cable loss from feed to pedestal room.

Vendor shall supply the required Fiber Optic (FO) channels from pedestal to Control room and vice versa. Required Channels along with spare shall be provided. Trench for laying FO cable will be provided by NRSC. Installation and commissioning of FO link is the responsibility of the vendor.
The RHCP and LHCP down converted tracking **IF signals** (720 MHz) shall be fed to suitable receivers at the pedestal to extract Azimuth (AZ) and Elevation (EL) DC errors for Auto Track.

### 5.4 S-BAND UP/DOWN CONVERTERS

S-band Data and Tracking Signals in RHCP (2.2 - 2.3 GHz) should be down converted to 70- MHz using single conversion. Spare down converter Channel should be provided in addition to the two main channels. It shall have built-in programmable frequency synthesizers whose frequency can be selected as per the mission configuration.

Down converted data signal at 70 MHz should be driven to control room through FO link for further processing. The tracking signal at 70 MHz is fed to an appropriate receiver at the pedestal to extract Azimuth (AZ) and Elevation (EL) DC errors for Auto Track.

All the Down converters in dual polarized S and X-Bands should be configurable locally via front panel interface and remotely through TCP/IP.

**NRSC** is responsible for the demodulators required to process the baseband signals at 720 MHZ and 70 MHz.
5.5 LOCAL LOOP FACILITY

The receive system shall have built-in provision for end-end testing and performance evaluation through Local Loop testing. UP Converter (720 MHz to X-band frequency range), FO Link, Test Coupler and other necessary components for Local Loop test facility should be provided.

To perform the X-band checks in Local Loop mode, two IF signals (720 MHz) shall be routed through FO link to pedestal and then up converted to X-band frequency range. X-Band feed shall have inbuilt 30 dB coupler to inject the outputs of up converter to complete the data chain for Local loop testing.

S band feed systems shall have the provision to test the S band down link chain in both polarizations by feeding S-band (2.2-2.3 GHz) signal at the feed coupler. The test signals at 70 MHz from control room shall be routed through FO link to pedestal. The 70 MHz simulated signal received at pedestal room shall be up converted to 2.2-2.3 GHz signals before they are fed to the feed coupler. S band up converter shall have built in synthesizer to select the required simulation frequency.

The Down link and Up link configuration shall be compatible for simulation and reception of single polarized or dual polarized X-band signals. Selection of the same shall be through manual and remote mode. The system should operate in fully automated environment and also it should have full autonomy to meet any contingency requirements.
6. SERVO CONTROL & STATION AUTOMATION

6.1 SYSTEM DESCRIPTION

The Antenna Control Servo System (ACSS) performs the task of precisely positioning the ground station antenna for tracking data from remote sensing satellites. The block diagram of ACSS is illustrated in Fig.2 below.

![Figure 2 Block Diagram Of Antenna Control Servo System](image)

The ACSS shall have capability to track Remote Sensing LEO satellite passes of different elevations from horizon to horizon including overhead zenith passes with high precision tracking and pointing accuracies under maximum operating wind conditions. The antenna system is mounted on EL over AZ mount pedestal with tilt axis (train axis with programmable tilt) provision for tracking high elevation passes including zenith passes without loss of tracking and data. Antenna control system is a Type-II closed loop system with software configurable servo loops. The drive system consists of high
torque brushless servo motors with resolver feedback and PWM power amplifiers. It is a dual drive system with each axis driven by two motors configured with precision anti backlash gear system and torque bias arrangement to provide better tracking and pointing accuracies. The drive amplifiers are housed in the antenna room and motors are located inside the pedestal housing with length of interface cables from antenna pedestal to antenna room upto 30 metres. Absolute encoders shall provide accurate angular position of the antenna. Auto track is the prime mode of tracking and Program track acts as backup mode. Auto diversity feature facilitates tracking on S or X-band based on the signal strength. The system shall have two operating control environments, from Remote Antenna computer (RAC) at control room and from Local Antenna computer (LAC) at Antenna pedestal room. ACSS should have access both from the control room and antenna pedestal room. The real-time operations are supported from the control room / antenna pedestal room and all maintenance activities from antenna pedestal room. All the sub systems should have Ethernet interface with TCP/IP support. The Antenna control software shall facilitate for tracking satellite in real-time, monitoring & control of tracking and servo subsystems, built-in test and evaluation software for comprehensive maintenance. ACSS should have the capability to exchange data with Station Control Computer to meet the operational requirements. The system shall be equipped with safety interlocks and protection features to protect the antenna structure and servo system. Dedicated FO link shall be established between control room and antenna room with length of interface cables between antenna room and control room upto 500 metres.

6.2 FUNCTIONAL REQUIREMENTS

The Antenna Control Servo system shall meet the following functional requirements.

- Control the antenna in various defined operational modes.
- Steer the antenna at the maximum specified rate and acceleration in Azimuth, Elevation and train axes to track remote sensing satellites.
- Interlock functions for sequencing operations under various operating modes and provide safety of Antenna, drive Amplifiers, brush-less servo motors and cable
wrap. A hard-wired EMERGENCY STOP switch shall be provided on the front panel of RAC, ACU & Pedestal

- Logging of angle data and transmission to station computer as per the specified format and rates.
- Ethernet interface for all sub systems
- Fully automated operations
- Interpolation of command data @ 100Hz or above.
- Automatic selection of Bandwidth/gains in both auto and program track modes
- Automatic gain adjustment of Auto loop with error slope changes (X-band or S-band tracking, single or Double motor).
- M&C functions, Status transmission to station computer, Monitoring and Control System in the specified format and interval
- Graphic screen based display of Antenna angles; command angles; position error and satellite pass support details and display of all other system parameters and alarms.
- Configuration control for important software controls like encoder bias, time offset, adaptive bandwidth selection i.e. wide/narrow, loop gain, angle offset, data rates, Single / Double motor drive etc.
- Counter torque drive configuration with torque bias (typically 20%) and fade out adjustment (field configurable as per requirement).
- Hardware and software antenna coverage limits including programmable pre limits and end limits.
- Interlocks for all alarm features, Motor brakes, Stow lock, Emergency stop, cable wrap indication etc.
- Handheld manual control module for testing and maintenance.
- Built in Test and evaluation and system diagnostic functions.
- Auto Acquisition and tracking methodology, using sequencing/stacking of operational modes. The priority of modes shall be user programmable.
- Tracking-aid display (Bull’s eye)
- Programmable servo loop compensation
## 6.3 SPECIFICATIONS OF ANTENNA CONTROL SERVO SYSTEM

**Table 6-1 Specifications Of Antenna Control Servo System**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount</td>
<td>EL over AZ with train axis</td>
</tr>
<tr>
<td>Tracking Velocity</td>
<td>15 deg/sec in AZ, 6deg/sec in EL, 6deg/sec in train</td>
</tr>
<tr>
<td>Tracking Acceleration</td>
<td>6 deg/sec² in AZ, 3 deg/sec² in EL, 3 deg/sec² in train</td>
</tr>
<tr>
<td>AZ Travel limits</td>
<td>+/- 360 deg primary, +/-380 deg secondary</td>
</tr>
<tr>
<td>EL Travel limits</td>
<td>-5 deg to 185 deg</td>
</tr>
<tr>
<td>Tilt axis limits</td>
<td>+/- 180 deg in CW &amp; CCW</td>
</tr>
<tr>
<td>Servo pointing accuracy</td>
<td>1/5&lt;sup&gt;th&lt;/sup&gt; of Beamwidth</td>
</tr>
<tr>
<td>Position display Resolution</td>
<td>0.001 deg</td>
</tr>
<tr>
<td>Position Transducer (optical encoders in AZ and El &amp; train axes)</td>
<td>22 bit single turn Absolute rotary shaft encoders</td>
</tr>
<tr>
<td>Operating modes</td>
<td>Standby, Slew, Manual, Program, Designate, X-Auto, S-Auto, Sun/Star, Auto Sequence modes</td>
</tr>
<tr>
<td>Drive configuration</td>
<td>Two motor Counter-torque (Torque bias/share) arrangement with linear fade out to minimize backlash.</td>
</tr>
<tr>
<td>Type of Motor</td>
<td>Brushless AC servo motor with resolver feedback and built in brake</td>
</tr>
<tr>
<td>Type of Drive</td>
<td>Space Vector PWM drive compatible to above motor</td>
</tr>
<tr>
<td>System Control Options</td>
<td>A. LOCAL CONTROL (From RAC/LAC/ACU) Operator controlled (Interactive/Automatic)</td>
</tr>
</tbody>
</table>
### B. REMOTE CONTROL (From M & C)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Fail safe motor brakes, Interlocks, motorized stowing facility with remote control from console</td>
</tr>
<tr>
<td>Secant Correction</td>
<td>To be applied for Az tracking loop in Auto mode through software</td>
</tr>
<tr>
<td>Look angle conversion for Train axis</td>
<td>AZ &amp; EL un-tilted look angles to be converted to tilted angles as per train axis position.</td>
</tr>
<tr>
<td>MTBF</td>
<td>5000 Hours</td>
</tr>
<tr>
<td>MTTR</td>
<td>1 hour (Ground Equipment)</td>
</tr>
<tr>
<td>Wind loads</td>
<td>a) Operational – 60kmph</td>
</tr>
<tr>
<td></td>
<td>b) Drive to Stow – 100kmph</td>
</tr>
<tr>
<td></td>
<td>c) Survival – 200kmph</td>
</tr>
<tr>
<td>Antenna Stow provision</td>
<td>Motorized stow lock &amp; unlock with suitable motors</td>
</tr>
<tr>
<td>Resonance Frequency</td>
<td>&gt;5Hz</td>
</tr>
</tbody>
</table>

### 6.4 BRIEF DESCRIPTION OF SUB-SYSTEMS

**ANTENNA CONTROL UNIT**

Antenna Control Unit (ACU) must be a software configurable digital controller for implementing precision Type II closed loop servo control system in dual drive configuration. It must implement the functions of Position / velocity loop through position & velocity feedbacks and torque bias. The required salient features of ACU are:

- Each axis should support dual drive configuration
- Software Configurable servo loops
- Loop control (Position/Rate/Current) of each axis based on PID/forward/LQG controller
Request For Expression of Interest

- Servo loop execution time better than 500 micro seconds.
- Provision to give offsets to Azimuth, elevation, train & time during real time.
- Time Synchronization to better than 500 micro seconds.
- Downloading of look angles, interpolation before pass and trajectory following.
- Programmable Software and Hardware limits.
- Secant correction.
- Brake Protection circuit.
- Safety limits and Interlocks.
- Self test diagnostic tools for all sub systems.
- Real time data logging, fault indication and event logging.

**Table 6-2 Specifications of ACU**

<table>
<thead>
<tr>
<th>Tracking Modes</th>
<th>Program-track, S &amp; X Auto-track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition Modes</td>
<td>Auto-Sequence Mode</td>
</tr>
<tr>
<td>Other Modes/Features</td>
<td>Safety interlocks, Self Test, Standby, Sun/Star Track, Event Log, S/W Tunable Compensators.</td>
</tr>
<tr>
<td>Offsets Available</td>
<td>Azimuth, Elevation, Train and Time</td>
</tr>
<tr>
<td>Axes Supported</td>
<td>Azimuth, Elevation and Train axis with programmable tilt.</td>
</tr>
<tr>
<td>Interfaces:</td>
<td></td>
</tr>
<tr>
<td>Analog Inputs:</td>
<td>Differential, +/- 10 V max, 16 bit resolution. Preferably OPTO isolated. Suitable no of channels.</td>
</tr>
<tr>
<td>Analog Outputs:</td>
<td>Differential, +/- 10 V max, 16 bit</td>
</tr>
</tbody>
</table>
Suitable no of channels

<table>
<thead>
<tr>
<th>Digital I/O:</th>
<th>48 OPTO isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Input</td>
<td>GPS based NTP server</td>
</tr>
</tbody>
</table>

**SERVO MOTOR AND DRIVE AMPLIFIER**

Motor torque & speed specifications have to be selected to meet the required Antenna torque & velocity requirements through suitable gear box ratio after considering the gear box efficiency, stiffness & torque bias for all the three axes. Digital Drive Amplifiers must be highly efficient 3 phase Space Vector PWM IGBT based power amplifiers to drive the brushless AC servo motors as specified above. Drive Amplifier with built in power supply and Ethernet Monitor & Control (M&C) interface for configuration, control, monitoring current, acceleration, fault & status monitoring. The Drive Amplifier shall have EMI/EMC protection and shall not cause electromagnetic interference to the nearby electronic equipment. The drive input is 415V AC, + 10%, 3-Ø, 50Hz. Suitable drive amplifier shall be selected with the following features.

- Integrated Power Supply and controller with all the protection circuits.
- Dynamic braking facility.
- Configurable for Velocity / Torque modes
- Programmable control parameters
- Potential free contacts for interlocking the drive amplifier.
- Resolver/encoder interface
- Ethernet interface for remote monitoring & control
- Provision for monitoring current, faults, status etc.,
- Protection features
ENCODER, LIMIT SWITCH ASSEMBLY & CABLE WRAP

The encoder shall be absolute rotary shaft encoder for antenna position sensing. Encoder & limit switch assembly should use precision gearing mechanism with anti backlash facility. Limit switches mounted on the antenna pedestal restrict the antenna movement within safe operating limits. There should be provision for Hardware and Software Pre-limits & End Limits. Cable wrap sensor in the pedestal housing provides signal proportional to the antenna position for graphical display on GUI to avoid excess twisting and damage to the cables. The input to the encoder shall be derived from the antenna Azimuth/Elevation/Train slew ring bearing having internal gear teeth. The resolution of encoder should be 22 bits or better. Separate encoder and limit switch assemblies are preferred. All signal lines specially encoder signal lines shall be protected against surge voltages.

STOW LOCK MOTOR CONTROL UNIT

The stow lock unit shall be designed to operate two separate stow lock motors on the antenna and shall have interface for stow limit switches (stow locked/released status feedback) fixed to the stow motors. The unit shall also incorporate required logic circuits/interlock functions for the purpose of stowing and stow releasing operations in conjunction with the present status of stow lock pin. The stowing and stow releasing commands from ACU energize the stow motors so that the stow lock pin is engaged or disengaged through the motor control (direction control). The stowing or stow releasing commands shall be interlocked such that they will be enabled only when the system is in stand-by mode condition, antenna drive power is on, AZ, EL & Train axis are off and no emergency on condition. The input supply is: 415V AC, 3-Ø, 50 Hz

ANTENNA CONTROL COMPUTER(ACC)

The RAC shall be a 19" Rack mount PC with 24inch TFT LED display monitors, wireless keyboard and mouse. The RAC shall be configured with the M&C Windows-based operator interface providing local GUI operation as well as the Servo Test & Evaluation Toolkit allowing for comprehensive diagnostic and performance monitoring. The RAC provides the interface to remote operations via the local area network (LAN). The Local Antenna Computer (LAC) resides in the Antenna Pedestal Room with display
monitors fixed to the servo panel racks. The Hardware/Software specifications of LAC shall be identical to RAC.

Table 6-3 Specifications of ACC

| PC Specifications (RAC & LAC) | Industrial PC 19-inch slide-in 4U Rack mount chassis with lockable front flap. Intel Core i7 3rd Generation processor or better. ATX Mother Board with 7 full size slots. Minimum of 3 x PCI and 1 PCIe x16 graphics slot Memory: 8GB DDR3 RAM, expandable to 16GB. Drives: 3 x 2TB HDD 7200 RPM 128 GB solid-state disk SSD, SLC flash, 2½-inch. DVD Writer. Integrated Graphic adapter with 1 DVI-I, 1 DVI-D and 1 DisplayPort connector. 2 of the 3 ports are in use at the same time. 2 x Gigabit Ethernet ports. 2 x serial ports, 6 x USB 2.0 / USB 3.0 Ports. PS/2 keyboard socket and PS/2 mouse socket. Wireless keyboard with Wireless mouse. |
| Display Monitors for RAC (control) | 24” TFT LED Monitor (1920 x 1080) |
Request For Expression of Interest

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>room)</td>
<td>1200 resolution) with two DVI ports, Dual input selectable through button. <strong>Quantity: 02Nos</strong></td>
</tr>
<tr>
<td>Display Monitors for LAC (Pedestal room)</td>
<td>Suitable LED monitors as per the rack layout. Minimum 19inch Full HD (1920 x 1080 resolution) with two DVI ports, Dual input selectable through button. <strong>Quantity: 02Nos</strong></td>
</tr>
<tr>
<td>Operating System</td>
<td>Windows 2008 Server Standard or better</td>
</tr>
<tr>
<td>Input Power Supply</td>
<td>180 – 250 volts, 50Hz.</td>
</tr>
</tbody>
</table>

**ANTENNA CONTROL SERVO SYSTEM SOFTWARE**

The software shall broadly have the following packages. The software shall be based on Windows server Platform and provide a suite of system monitor, control and diagnostic tools.

1. ACU M&C windows application software
2. RAC M&C windows application software
3. Instrumentation Software: Consists of Test and Evaluation software
4. Mission Scheduler: schedules multiple satellite tracking tasks
5. Gateway GUI: Controls and manages the flow of data
6. Reporting Services: Generate system reports.

The antenna control software should consist of TCP/IP interface to facilitate remote monitoring and control of servo system. The antenna control software shall track the satellite in real-time either in auto track or in program track mode. Auto track is the prime mode of tracking and Program track acts as a backup. The major functions of the Antenna Control software are

- GUI to display the station configuration and pass schedule
- Monitoring & Control of Tracking & Servo subsystems
• Interpolation of AZ & EL angles up to 500 micro seconds
• Software tunable control loops
• Implementing different tracking modes
• Implementing different acquisition modes
• Utilities to carryout different servo tests like velocity and acceleration tests, gradient measurements, S curve, step response etc.
• Data logger to monitor and log different engineering parameters of Antenna Control Servo System[ACSS]
• Pre pass configuration
• Loading of antenna trajectory in to ACU
• Positioning the antenna to initial lookup angles
• Configuration of Tracking & Servo sub systems
• Program tracking of the satellite
• Real time monitoring, data logging & data plot display
• Display of safety limits and Interlocks
• Utilities to track Sun/Star

SYSTEM STATUS DISPLAY
The RAC/LAC screen shall show a detailed system status. Following are the parameters to be displayed on the RAC/LAC operating screen.

1. Azimuth, Elevation and Train antenna position in deg (0.001 resolutions).
2. AZ, EL and Train command position in deg (0.001 resolutions).
3. Difference between Antenna and Command position in deg (0.001 resolutions).
4. Antenna operating modes.
5. Azimuth limits and pre-limits.
6. Elevation limits and pre-limits.
7. Train axis limits and pre-limits.
8. All interlock and alarm status
9. Azimuth, Elevation and Train rates in degrees/sec
10. AZ, EL & Train Drive currents in Amperes.
11. Azimuth Drive system fault status.
12. Elevation Drive system fault status.
13. Train Drive system fault status.
15. Graphical representation of Tracking receiver AGC, Tracking errors and cable wrap.
16. Universal Time (ddd: hh:mm:ss) and date.
17. Local time (hh:mm:ss).
18. Tracking aids (Bull’s eye etc)
19. RAC/LAC/ACU Active/hanged status.
20. Cable wrap position.
21. Station Code

**NETWORK ELEMENTS**

All the sub systems should have Ethernet interface with TCP/IP support. Dedicated point to point Fiber Optic link is to be planned and installed between control room and antenna pedestal room. Network switches should be installed, one at control room and the other at antenna pedestal room for remote M&C of various systems via TCP/IP.

**Table 6-4 Specifications of Network Elements**

<table>
<thead>
<tr>
<th></th>
<th>Single mode, 6core</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO link</td>
<td></td>
</tr>
<tr>
<td>Length of FO cable</td>
<td>Upto 500metres</td>
</tr>
<tr>
<td>Switches</td>
<td>Gigabit Ethernet switches (Cisco make)</td>
</tr>
<tr>
<td>No of switches</td>
<td>Two</td>
</tr>
<tr>
<td>No of ports for each switch</td>
<td>24</td>
</tr>
<tr>
<td>No of SFP ports for each switch</td>
<td>4</td>
</tr>
</tbody>
</table>
6.5 QUALITY AND RELIABILITY

The system design should be planned in terms of selection of materials, connectors for signal lines and AC/DC power supply lines taking care of modular design and maintenance flexibility. The attributes shall include the following.

- Components, PCB’s, modules etc should undergo 72 hours burning Test
- Connectors as per the mil standards; PCB’s with conformal coating
- Shielded cables are to be used with proper grounding of shields.
- Keeping in view the distance between Antenna Pedestal Room and Control Room, low loss cables to be used between Pedestal Room and Control Room.

6.6 OPERATING ENVIRONMENT

All equipment shall withstand the following environmental conditions.

Temperature : Operational : 0 to 50 Deg.C
               Storage : -10 to +70 Deg.C.
Humidity      : 95% Non Condensing @ 40 Deg.C.

All the sub-systems and interface cables shall meet the standards for safety and EMI/EMC compliance.

6.7 DOCUMENTATION

The following documentation shall be made and submitted during the Installation and testing phase. All the documentation shall be prepared in English language.

- Installation Manuals.
- Operational manuals
- System manuals
7. Mechanical Systems:

7.1 Description of the Proposed System

The Antenna structural & mechanical system can be broadly divided into three categories, namely

- Tracking pedestal (Raiser, Azimuth & Elevation Drive mechanism, Encoder & Limit switch assembly, Stow lock assembly etc)
- Reflector assembly (Main & Sub dish, Quadripod etc)
- Feed system (X/S band dual polarisation feed)

The main 7.5m or less diameter Reflector, mounted on Elevation over Azimuth mount (Tracking Pedestal) shall have the capability to scan the entire sky from 2° above horizon. The mechanical system consists of Aluminum Reflector supporting the Feed and Hyperbolic Sub-Reflector through a Quadripod, an Antenna mounting frame attaching the Reflector to a pair of Yoke arms with Counter weight arms, an Elevation housing containing the necessary drive system for movement about an Elevation axis between 2° below the horizon to zenith and Azimuth housing containing the drives to achieve ± 360° rotation about the Azimuth axis.

7.1.1 Tracking Pedestal Sub Assembly

The tracking pedestal sub assembly consists of the following major parts, namely Azimuth housing, Elevation housing, Yoke fixing plates, Yoke arms, Counter weights, Antenna mounting frame and stow lock mounting brackets.

7.1.2 Antenna Reflector Sub Assembly

Antenna reflector assembly consists of radial panels, radial trusses, central hub, bracing members, Z-Sections, cleat angles, web connecting cleats, sub reflector, sub reflector mounting bracket, quadruped assembly, junction box and lightning arrestor & aviation lamp assemblies.

7.1.3 S/X- Band Dual Polarisation Feed Sub Assembly

The S/X- Band feed sub assembly consists of a feed can, enclosing the plates for mounting RF modules, S & X- band Low Noise Amplifiers, wave guide modules/assembly and a radome to cover Feed elements.
7.2 REQUIREMENTS:

1. Axis Alignment i.e. Orthogonality between Azimuth and elevation.

2. Structural deformation due to wind, temperature and gravity. The required Structural stiffness of the reflector shall be estimated and specified.

3. Minimum Gear backlash and less thermal deformation of reflector is to be achieved to achieve the overall pointing accuracy.

4. Sub-reflector and feed alignment facility shall be provided.

5. Antenna focusing – antenna focus alignment is very sensitive. Photogrammetric and computer aided algorithm techniques are to be adopted for the antenna alignment process along with skilled and experienced technician.

6. Total Antenna Error budget for pointing error has to be made and listed. The overall pointing error should be less than the specification given in the overall specification table.

7. The parameters considered for the pointing error should include all the systematic and random errors of Antenna system. Overall error budget (Absolute) Table shall be provided by the vendor.

8. The gear box specifications should include stiffness test also, not considering only the efficiency.

9. Mounting provision for Encoders and Coverage limits are to be made. In addition, mechanical stopper arrangement shall be provided to the mount.

10. The pedestal errors have to be made barest minimum with optimum design and high precision machining and quality control. High precision Slew Ring Bearings with low bearing wobble shall be provided.

11. Anchor bolts and civil foundation design has to be provided by the vendor for civil works by NRSC.

12. The Antenna structure building design (civil) will be done by NRSC, taking into consideration of civil structural inputs provided by vendor (Operational & survival environmental conditions like wind, earthquake resistance etc.).
8. DATA RECEPTION SYSTEM WITH TRIBAND FEED (S/X/Ka-BAND)

S/X/Ka band Feed:
The dual shaped antenna with tri band feed in Cassegrain configuration should provide G/T of 32.0 dB/° K at 5° EL in X-band, 34.0 dB/° K or better at 10° EL in Ka-band and 17 dB/° K at 5° EL in S-band. The antenna system should be capable of receiving dual circular polarized signals (RHCP & LHCP) simultaneously in S, X and Ka bands. The operating frequency range for reception is 25.5 -27.0 GHz in Ka-band, 7.90 -8.50 GHz in X-band and 2.2 to 2.3 GHz in S-band. 2.025-2.125 GHz frequency range is used for transmission. All antenna parameters should meet the specifications as given in the S/X-band Table 3-1.

Ka band Requirements:
Tracking in Ka band where half power beam width is approximately 0.1deg is very critical. Tracking accuracy in the order of 1/10th of 3 dB beam width is required for successful acquisition and tracking of remote sensing satellites. Single channel monopulse tracking shall be adopted for efficient tracking. Signal loss at Ka band is generally high, so sufficient care should be taken in realizing the feed and components at Ka band.

In Ka band, the received signals in each polarization will be 8PSK modulated at a typical data rate of 2.0 Gbps. The received Ka band data signals have to be down converted in two stages. The first IF should be brought down to 1.65-3.15 GHz and then driven to Control room through fiber optic link for further down conversion and Signal processing. Any other suitable configuration with corresponding frequency ranges shall be quoted for the down conversion and up conversion of S, X and Ka band signals.

The receive system shall have built-in provision for end-to-end testing (local loop) and performance evaluation in the absence of satellite signal.
Antenna Tracking:
The antenna system shall be mounted on a suitable (two/three axis) tracking mount (Azimuth(AZ)-Elevation(EL) or any other configuration) to position the antenna over hemispherical coverage without any key hole. The station should track the satellite in Ka band auto track mode using single channel mono-pulse technique with S-Band/X-band auto track and program tracking as backup modes. As the beam width in Ka band is very narrow, in the order of 0.1 deg, the mechanical, RF, Servo system design should be taken care to achieve the desired pointing and tracking accuracies. The Antenna system pedestal shall be designed to withstand heavy winds, earth quakes, vibrations etc. The system should operate in fully automated environment and also it should have full autonomy to meet any contingency requirements.

The specifications and configuration of the Antenna Tracking pedestal, Antenna feed, feed front end electronics, Up/Down converters, Tracking receivers, Fiber Optic Link and Servo Control System suitable for a ground station with a tri-band feed to track and receive data from LEO satellites in S/X/Ka bands shall be provided. The overall Technical specifications for this system shall cater to S/X and Ka Band Auto Track and data reception requirements.
9. RELIABILITY & QA REQUIREMENTS

The operational life of the complete earth station system (including drive, bearings and other moving parts of the antenna & control system) is expected to be of at least 15 years. The earth station will be operational 24x7 in automatic mode/remote control mode. Vendor has to suggest for spares required for the proposed system. Electrical and Mechanical characteristics of proposed Reception system shall comply with the (EIA standard) EIA-411-A document. The station will be operating under controlled environment. However the equipment used shall have the capability to following environmental condition.

**Table 9-1 Indoor Unit Environmental Specifications**

<table>
<thead>
<tr>
<th>SL NO</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Operating temperature</td>
<td>15 to +30\degree C</td>
</tr>
<tr>
<td>2.</td>
<td>Storage temperature</td>
<td>-10 to +65\degree C</td>
</tr>
<tr>
<td>3.</td>
<td>Humidity</td>
<td>80% RH non condensing</td>
</tr>
</tbody>
</table>

**Table 9-2 Outdoor Unit Environmental Specifications**

<table>
<thead>
<tr>
<th>SL NO</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Operating temperature</td>
<td>0 - 60\degree C</td>
</tr>
<tr>
<td>2.</td>
<td>Storage temperature</td>
<td>-10 - 65\degree C</td>
</tr>
<tr>
<td>3.</td>
<td>Humidity</td>
<td>95% RH @ 40\degree C with condensation</td>
</tr>
<tr>
<td>4.</td>
<td>Rain</td>
<td>&gt;= 50 mm/Hr</td>
</tr>
<tr>
<td>5.</td>
<td>Wind Speed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operational</td>
<td>60 KMPH</td>
</tr>
<tr>
<td></td>
<td>Occasional gusting</td>
<td>80 KMPH</td>
</tr>
<tr>
<td></td>
<td>Drive to Stow</td>
<td>100 KMPH</td>
</tr>
<tr>
<td></td>
<td>Survival to Stow</td>
<td>200 KMPH</td>
</tr>
</tbody>
</table>
10. DELIVERY SCHEDULE

Vendor shall supply and install all the Reception systems at respective locations tentatively within twelve months from the release of Purchase order.

11. SYSTEM INSTALLATION & INTEGRATION

The vendor shall be responsible for installation and commissioning of the Reception System at the sites (New Delhi and Doom Dooma). Vendor should demonstrate its functionality in integrated configuration at sites for final acceptance.

12. ACCEPTANCE TEST PLAN

The system will undergo the acceptance tests as per the mutually agreed test plan at the vendor’s site (factory acceptance test) as well as at installation site (site acceptance test) and validation in real time satellite passes. The vendor will be responsible to arrange the tests in the presence of NRSC engineers.
13. VENDOR DETAILS/ELIGIBILITY CRITERIA

The prospective vendors should submit full details of their technical competence for undertaking project of this nature, in the technical part of their proposal document. A preferable format (not limited to) is provided in the following Table 13-1.

**Table 13-1. Vendor details**

<table>
<thead>
<tr>
<th>SL NO</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Year of Establishment</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Vendor’s Area Of Core Competence</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Infrastructure details (Area, facilities, manpower etc.)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Annual turnover in the last two financial years</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Vendor should necessarily have the experience in establishing remote sensing Reception systems</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Details of the similar orders executed along with end user address where the system is currently operational.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Quality Management system (QMS) certification</td>
<td></td>
</tr>
</tbody>
</table>