Draft Statement of Work for the SGP VGOS Antenna

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Section 1 Overview

1.1 Introduction

This Request for Information (RFI) is for the construction, deployment, and commissioning of up to three Very Long Baseline Interferometer (VLBI) antennas that will be part of a new NASA Space Geodesy Network (NSGN) and the VLBI2010 Global Observing System (VGOS).

One of the main objectives of the Space Geodesy Project (SGP) is to produce the necessary observations for realization of the Terrestrial Reference Frame (TRF). Scientific objectives dictate the desire for an ITRF definition with accuracy of 1 mm and stable to 0.1mm/yr. (millimeters per year), including geocenter and with a scale accurate to 0.1ppb (parts per billion), and stable to 0.01 ppb/yr. *(Source: Gross et al., 2009).* This is a factor of 10-20 beyond current capability.

The NASA SGN will comprise integrated, multi-technique next generation space geodetic observing systems, as the core NASA contribution to a global network designed to produce the higher quality data required to maintain the ITRF and provide information essential for fully realizing the measurement potential of the current and coming generation of Earth Observing spacecraft. It is anticipated that to achieve the desired level of accuracy and stability the SG sites will co-locate and use in unison several key techniques of observation, including VLBI, Satellite Laser Ranging (SLR), Global Navigation Satellite Systems (GNSS) and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS).

1.2 Background

The SGP is responsive to two important reports from the National Research Council (NRC): 1) "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond", a.k.a. the "Earth Science Decadal Survey"; and 2) "Precise Geodetic Infrastructure, National Requirements for a Shared Resource". These reports highlight the importance of maintaining and enhancing the geodetic infrastructure that enables modern geodesy and supports NASA's Earth Science missions.

The global geodetic infrastructure, with its terrestrial- and space-based assets, enables the realization of the Terrestrial Reference Frame (TRF), the foundation for virtually all airborne, space-based and ground-based Earth observations. Through its tie to the Celestial Reference Frame (CRF) by time-dependent Earth orientation parameters, it is also fundamentally important for interplanetary spacecraft tracking and navigation. The TRF determined by geodetic measurements is the indispensable foundation for all geo-referenced data used by society. Furthermore, modern geodetic measurements are making fundamental contributions to mitigating the impact of geo-hazards such as earthquakes, volcanic eruptions, debris flows, landslides, land subsidence, sea level change, tsunamis, floods, storm surges, hurricanes and extreme weather. Geodesy is also at the heart of present day ocean studies and contributes to atmospheric science and hydrological studies.

In 2006, The International VLBI Service for Geodesy and Astrometry (IVS) defined the requirements for a next generation network (VGOS) of broadband VLBI antennas as described in technical memorandum number 2006-022v01 found on the IVS website at http://ivscc.gsfc.nasa.gov/publications/memos/index.html. NASA recently implemented the first broadband antenna in this new network at the Goddard Geophysical and Astronomical Observatory (GGAO) in Greenbelt, MD. NASA is also currently building a second station at the Kokee Park Geophysical Observatory (KPGO) on Kauai, HI in partnership with the United States Naval Observatory. Future NASA stations will be based upon the design of the KPGO station with only minor modifications that take into account advances in technology.

The SGP has selected the McDonald Observatory (MCD) located near Fort Davis, TX as a NASA core geodetic site. This contract is to fabricate, ship, and install a VGOS radio antenna at MCD with the option to develop and deploy up to an additional two (2) antennas at international sites yet to be determined. Current sites under consideration by NASA are in Tahiti, Brazil and Colombia.

Additional information on the SGP, the prototype site, and the VGOS stations can be found on the SGP website at http://space-geodesy.nasa.gov.

1.3 Scope

This SOW documents the project management, engineering development, system build, documentation and delivery of one to three VGOS antennas to NASA, and the deployment of the first system to MCD and the following optional two to international sites selected by NASA at a future date. Acceptance testing at the Vendor's facility and at the final location are included in this work, as are periodic reviews of the engineering design, system development, documentation and system performance. The Vendor shall be responsible for the deployment of each system to its final location, including shipping and system setup. There shall be a commissioning period at each final location where the Vendor demonstrates the operational system performance after the signal chain has been integrated with the antenna.

Deliverables include the VGOS antenna and all associated subsystems, spares for critical parts, test instrumentation needed to maintain the system, documentation, system analysis, drawings and models, all data collected during Functional and Acceptance Testing, all data collected during commissioning, and all software source code and firmware code developed under this contract and used in the system (with the exclusion of any proprietary licenses that were purchased as commercial-off-the-shelf).

Section 2 VGOS Antenna Requirements

A VGOS radio antenna has precise technical specifications necessary to achieve the desired observational data quality. This statement of work includes physical characteristics, performance characteristics, interface requirements, environmental requirements, safety requirements, quality factors and documentation requirements.

2.1 Physical Characteristics

2.1.1 Diameter.

The antenna diameter shall be $\geq$ 12.0 m.

2.1.2 Antenna Type.

The antenna reflector/sub reflector type shall be Cassegrain.

2.1.3 Antenna Mount.

The antenna mount shall be a standard azimuth-elevation (az-el) type mount.

2.1.4 Mount Materials.

The antenna mount materials shall be composed of steel-galvanized and painted to NASA specifications and/or industry best practices.

2.1.5 Antenna Reflector Panel Materials.

The antenna reflector panel materials shall be composed of Aluminum and painted to NASA specification and/or industry best practices.

2.1.6 Antenna Optics:

The antenna optics shall give maximum sensitivity with the quad-ridge flared horn (QRFH) feed.

2.1.7 Antenna Subreflector Subtended Angle.

The antenna optics shall support a QRFH feed having a 50-60 degree subtended half angle.

2.1.8 Antenna Reference Point.

The geodetic reference point, or "invariant point", is the intersection point between the fixed rotation axis and the plane that contains the moving axis and is perpendicular to the fixed axis. For an elevation-over-azimuth mount, the fixed and moving axes are the azimuth and elevation axes, respectively. If the offset between the rotation axes is zero, the reference point is the point where the axes intersect. The vendor shall provide the location of the antenna reference point to an accuracy of less than 0.3 mm.

2.1.9 Antenna Reference Point Stability.

Relative to a local geodetic network external to the antenna and its foundation, the antenna 3-dimentional position of the reference point shall be either stable or able to be modeled, as a function of elevation and temperature (and possibly other parameters), to less than 0.3 mm RMS.

2.1.10 Antenna Reference Point Measurement and Monitoring.

The vendor shall describe, for their system, how they will provide for accurate measurement and monitoring of this reference point.

2.1.11 Antenna Reference Point Survey Target Interface.

The antenna shall provide an external precise survey target interface to the antenna reference point with known offset dimensions accurate to 0.3 mm.

2.1.12 Sky Coverage-Azimuth.

The antenna shall have an azimuth travel range of +/- 270° with no constraints on location or direction of travel within this range. The elevation travel shall range from +5 degrees above the horizon to 90 degrees.

2.1.13 Antenna Cable Wrap.

The antenna shall have a cable routing mechanism (i.e., antenna cable wrap) to route and manage cables. The antenna cable wrap shall comply with IVS Memorandum 2009-003v02, August 04, 2015.

2.1.14 Antenna Cable Wrap Range of Motion.

The antenna cable wrap shall have a range of motion of -270 degrees to +270 degrees relative to the center of the range of motion.

2.1.15 Antenna Cable Wrap.

The antenna cable wrap shall be able to accept and route network (Ethernet-CAT5/6) cables, electrical cables (AWG 6), fiber optics cables, and helium hoses. These cables and hoses can be up to 1 inch in diameter.

2.1.16 Mounting Provisions.

The antenna shall make provisions to mount geodetic instrumentation, such as reflectors or corner cubes, on the antenna primary and secondary reflectors and around the feed to allow measurements of path length variations for different pointing directions.

2.1.17 Heating, Air Conditioning and Ventilation (HVAC).

The antenna shall be outfitted with a heating, air conditioning and ventilation (HVAC) system to maintain the antenna pedestal environmental condition that is optimum for safe operations of people and equipment inside the antenna.

2.1.18 Heat Shielding and Insulation.

The antenna shall have heat shield and insulation to reduce heating of the antenna interior.

2.1.19 Limit Switches, Emergency Stops and Brakes.

The antenna limit switches, emergency stop buttons, and failsafe brakes shall be installed to ensure the safety of personnel and equipment in the case of equipment failure or malfunction.

2.1.20 Antenna Movement Disable Switch (Emergency Stop Switch).

The antenna shall have a movement disable switch provided at the base of the antenna pedestal. The switch shall allow for quick access to disable the antenna in an emergency situation. Any interlock shall be indicated on both local and remote antenna status displays.

2.1.21 Antenna Stop Protection.

The antenna shall be protected with software, hardware, and hard stops or equivalent protection to prevent damage to antenna in both azimuth and elevation.

2.1.22 Inhibit-Failsafe.

The antenna shall prevent uncontrolled movement of system components in the event of a system fault or failure.

2.1.23 Inhibit-Hazardous Energy.

The antenna hazardous energy shall be capable of being isolated and locked when maintenance or service is required to protect personnel and equipment.

2.1.24 Battery Backup System.

The antenna shall be outfitted with a battery backup system to safely stow the antenna during power outages.

2.2 Performance

2.2.1 RF Frequency Range.

The antenna structure frequency range shall be 2–32 GHz and 2-14 GHz for the feed and Low Noise Amplifiers (LNAs).

2.2.2 Aperture Efficiency.

The antenna aperture efficiency shall be greater than 50.0 % (over 2-14 GHz) instantaneously.

2.2.3 Antenna Blind Pointing Accuracy.

The antenna blind pointing accuracy shall be < 0.1 half-power beam width (HPBW) at 32 GHz (equivalent to < 20 arc sec) for primary operating conditions; 0.3 HPBW at 32 GHz (equivalent to < 1 arc min) for secondary operating conditions. These limits apply both to pointing to an arbitrary position on the sky and to tracking at a specified rate.

2.2.4 Encoder Angular Accuracy.

The antenna encoder angular accuracy shall be 10.0 % (of the required pointing accuracy).

2.2.5 Antenna Path Length.

The antenna provider shall define the antenna path length. The antenna path length shall be the difference between the arrival times (converted to length by multiplying by the speed of light) of a plane wave front at the reference point and at the feed after passing through the antenna optics.

2.2.6 Antenna Path Length Stability.

The antenna path length difference shall be stable or able to be modeled, as a function of elevation and temperature, to less than 0.3 mm RMS for all pointing directions under primary operating conditions.

2.2.7 Antenna Surface Accuracy.

The antenna surface accuracy shall be <0.2 mm RSS combined error for primary and secondary reflectors for all pointing directions under the primary operating conditions.

2.2.8 Adjustments of Reflector Panels.

Provision shall be made for adjusting the height and tilt of the reflector panels above the back-up structure if the surface accuracy cannot be guaranteed for 20 years without adjustment.

2.2.9 Slews per Day.

The antenna mount, drives, and antenna shall be able to withstand nearly continuous operation with more than 2,500 slews per day.

2.2.10 Antenna Slew Rate.

The antenna slew rate shall be greater than or equal to 12°/s (minimum) in azimuth and 6°/s (goal) / 3.5°/s (minimum) in elevation.

2.2.11 Antenna Slew Accelerations.

The antenna slew acceleration shall be 3°/s/s (goal) / 2.5°/s/s (minimum).

2.2.12 Antenna Settling Time.

The antenna settling time shall be < 2 second from a maximum slew rate to a specified pointing accuracy.

Section 3 Interface Requirements

The external interfaces for the antenna are to the field system, signal chain, the VLBI network and the timing system. The antenna also interfaces with site specific items such as the antenna foundation, a trench and conduit pathway to run cables.

3.1 Field System (VLBI System Controller) Interface Requirements

SGP is adopting new architecture where a centralized command center will be the hub for monitoring and control of the SGP geodesy systems including VLBI. Within the new paradigm it is conceivable that the VLBI system controller would reside within the command center. The VLBI system controller would handle the processing of the IVS schedules, load the antenna commands into the antenna and execute the session remotely over a network connection.

Currently, the NVI Field System (FS) acts as the VLBI system controller for VLBI data acquisition hardware. The FS is used to alter hardware settings and monitor hardware status by using Standard Notation for Astronomical Procedures (SNAP) commands. SNAP is a line-based command language which gives access to low-level hardware features data acquisition hardware. The FS interacts with the antenna controller and other antenna peripheral equipment such as an antenna temperature logger and a tilt meter. During a VLBI session the FS is in continuous communications with the antenna controller exchanging positioning (coordinates, cross-elevation, elevation, time and speed) commands and antenna position data. After the antenna has settled on a quasar source the field system interacts with the antenna controller to track the quasar while energy is collected by the antenna and the signal chain. FS calibration tools are used to calibrate antenna pointing and gain.

3.1.1 Transfer of Configuration, Control and Status Commands.

The antenna shall interface with a VLBI system controller to transfer configuration and control commands.

3.1.2 Transfer of Antenna Equipment Parameters.

The antenna shall interface with a VLBI system controller to provide critical component parameters such as temperature, tilt meter readout, and encoder readouts.

3.1.3 Antenna Control Calibration Tools.

The antenna shall interface with VLBI system controller calibrations tools to calibrate antenna pointing and gain.

3.1.4 Antenna Natural Coordinates.

The antenna shall accept, process and execute VLBI system controller epoch, position, and rate commands. These commanded values define a target trajectory for the antenna to follow. The commanded position is the target position at the commanded epoch. The target position evolves (to or from the commanded position) at the commanded rate.

3.1.5 Software Limit Controls.

The antenna shall be protected in case the VLBI system controller commands the antenna to move past the antenna structural limits.

3.1.6 Encoder Status Command Precision.

The antenna shall accept sufficient precision for the commands from the VLBI system controller to cover at least the full resolution of the encoders and not lose precision in the propagation of the coordinates at that level. Typically a propagation time of 1000 seconds is sufficient.

3.1.7 Trajectory Commands.

The antenna shall track smoothly when the antenna receives consistent trajectory commands regardless of the interval between them.

3.1.8 Antenna Movement-Discontinuity Target Trajectories.

The antenna shall slew smoothly when a discontinuity in the target trajectories occurs.

3.1.9 Management of Accelerations and Decelerations.

The antenna shall manage the accelerations and decelerations of the antenna.

3.1.10 Tracking When Disconnected from Control Interface.

The antenna shall continue to track according to the last command if the interface to the VLBI system controller is disconnected and/or reconnected.

3.1.11 Azimuth - Position of the Antenna.

The antenna shall identify azimuth positions of the antenna to the VLBI system controller.

3.1.12 Antenna Cable Wrap-Dead Man Switch.

The antenna shall command to enable/disable a "Dead Man Switch" (DMS) to take action if loss of positive control is detected by the antenna.

3.1.13 Antenna Cable Wrap-Time-Out Interval.

The time-out (interval) for detecting loss of control shall be settable to a value of a few seconds to a few tens of seconds, but typically a fixed value of about 30 seconds is useful. The actions available on timeout will minimally include "stop", and "stow".

3.2 Signal Chain Interface Requirements

The Signal Chain consists of the frontend, backend, noise and phase calibration, and cable delay measurement systems. The high performance cryogenic receiver front ends are based on the quad-ridge flared horn (QRFH), a dual linearly-polarized radio telescope feed and cryogenically cooled low noise amplifiers (LNAs). The signal chain interface is described in detail in SGP-VLBI-ICD-002 Signal Chain Frontend Interface Control Document.

3.2.1 Signal Chain Interface Compatibility.

The antenna shall interface with the signal chain equipment without causing any changes to the signal chain interfaces that are currently defined in the Signal Chain Frontend Subsystem Interface Control Document (SGP-VLBI-ICD-0002). These signal chain interfaces include the signal chain feed, payload positioning assembly, cryogenics, electrical power , monitoring and control and signal chain frontend installation apparatus/procedures.

3.2.2 Payload Interface.

The antenna shall interface with the signal chain QRFH feed to transfer collected radio frequency (RF) energy from quasar sources.

3.2.3 Subreflector Distance to the QRFH Feed Mating Plate.

The antenna provider shall provide the exact distance from the bottom mating plate (for the QRFH feed) to the antenna subreflector. The combination of the subreflector to mating plate distance and the mating plate to focal plane distance equals the antenna focal length.

3.2.4 Payload Assembly Interface.

The antenna shall provide a physical connection to the signal chain payload positioning assembly.

3.2.5 Signal Chain Electrical Power.

The antenna shall provide an interface to connect power to the payload positioning assembly and signal chain frontend equipment that will be located in the hub and will be positioned inside the antenna feed tube.

3.2.6 Helium Compressor Electrical Power Connection.

The antenna shall provide an electrical interface to connect power to the compressor and supply a 220/480 VAC 3 phase delta 40/20 amperes source of power. This power connection shall be provided on a separate power and shall not be on the same feed as signal chain electronics, data communications equipment and antenna components.

3.2.7 Helium Compressor Mount.

The antenna shall mount and house the helium compressor. The signal chain helium compressor used at KPGO is a M1245 Austin Scientific Cryopump Helium Compressor and is mounted on the antenna turning head.

3.2.8 Feed Wiring and Cryogenics Interface.

The antenna shall provide an interface to transfer helium hoses and data communications cables from the helium compressor to the signal chain frontend providing no obstruction to connect the helium compressor. The signal chain cryogenic subsystem is located in the hub and is positioned inside the antenna feed tube for operations.

3.2.9 Mounting of Signal Chain Equipment in Antenna.

The antenna shall provide space inside the antenna hub to mount signal chain equipment.

3.3 Network and Timing Interface Requirements

The VLBI system network and timing elements performs the function of providing data communications and timing for the VLBI system. The network element provides the connectivity between the antenna and the operations building where the backend, cable calibration, VLBI system controller and timing equipment resides. The network allows for high speed connectivity to the correlator facilities and a lower speed connection to the internet to allow maintenance personnel to remotely access antenna equipment, access to data archives and remote command centers. The network also allows connectivity to other geodesy equipment like Satellite Laser Ranging (SLR) through a vector tie connection.

The timing element provides timing across the entire VLBI system. The timing element consist of an atomic clock and GPS time. It provides Network Time Protocol (NTP), Simple Network Time Protocol which is distributed over the network to synchronize time for VLBI system elements. The timing element provides 1 PPS, 5 MHz and 10 MHz timing sources as a time references. .

3.3.1 Data Communications Needs.

The antenna provider shall define the network interfaces to include protocol, connector type and data rates required for antenna operations.

3.3.2 Timing Needs.

The antenna provider shall define the timing requirements for antenna operations.

3.3.3 Data Communication Equipment Mount.

The antenna shall provide space to mount data communications equipment inside the antenna hub. The space shall accommodate network, power supplies, patch panels and UPS.

3.3.4 Data Communication Equipment Power.

The antenna should provide power for the data communication equipment that is inside the antenna pedestal.

3.4 Electrical Interface Requirements

3.4.1 Facility Power Grid Interface.

The antenna shall provide an electrical power interface to the facility electrical power grid.

3.4.2 Power Distribution.

The antenna shall distribute electrical power to all antenna components and other equipment, including the signal chain and data communications equipment that resides in the pedestal and hub.

3.4.3 Electrical Power Outlets.

The antenna shall be outfitted with electrical power receptacles to accommodate power connections for data communications equipment, test equipment, laptops and signal chain equipment in the pedestal, antenna hub and on the external surface of the antenna.

3.4.5 Antenna Interior Lighting.

The antenna shall be outfitted with lights to illuminate the interior of the antenna pedestal and hub to enable personnel to safely perform activities inside the antenna.

3.4.4 Electrical Power Monitoring.

The antenna shall be capable of monitoring power quality and consumption of the power that is being distributed through the antenna's distribution panels.

3.4.5 Uninterruptible Power Supply (UPS).

The antenna shall be outfitted with an UPS to be used for antenna control unit electronics protection in event of a power outage and electrical brownouts.

3.4.6 Electrical Power Generator.

The antenna UPS shall be capable of operating with an electrical generator to switch from battery power to generator power or local electrical power for up to 5 minutes.

3.4.7 System-Grounding Design.

The antenna shall be outfitted with a ground systems. Elements of the safety ground systems (i.e., cable trays and conduit for signal, power, or control cables) shall be installed and connected in accordance with industry best practices for aerospace applications.

3.4.8 Lightning Protection.

The antenna shall be equipped with lightning rods and lightning ground conductors to protect the antenna and lightning rods and ground conductors shall interface with the site's lightning grounding system.

3.5 Antenna Foundation Requirements

3.5.1 Antenna to Foundation Connection.

The antenna provider shall provide an adaptor to connect the antenna pedestal to the antenna foundation.

3.5.2 Antenna Stowage.

The antenna shall provide physical connections on the antenna to secure and stow the antenna.

3.5.3 Antenna Foundation Needs.

Provided with a location-specific geotechnical report, the antenna provider shall specify requirements for its foundation, including footing depth, foundation materials, height above grade, minimum foundation area, grouting, etc.

3.5.4 Electrical Power and Data Conduits.

The antenna shall interface with the foundation to align the location of power and data conduits through the foundation to the pedestal in an optimum location to enable connection to power distribution panels, data communication equipment and routing of cables through cable trays, chases and cable wraps.

3.6 Human Interface Requirements

3.6.1 Personnel Interface.

The antenna shall provide an interface for maintenance and operations personnel to safely maintain and operate the antenna from within the antenna, external to the antenna-in close proximity and remotely.

3.6.2 Personnel Access.

The antenna shall provide an interface to include ladders, hatches, and equipment access panels for personnel to safely access the antenna and perform maintenance on antenna components, structure and signal chain equipment.

3.6.3 Signal Chain Installation and Maintenance.

The antenna shall provide an interface for maintenance personnel to safely install and maintain signal chain components from within the antenna hub and through the antenna feed tube.

3.6.4 Antenna Control Interface.

The antenna shall provide a graphical user interface (GUI) for the antenna control interface (ACI) that allows operators to monitor antenna operations.

Section 4 Environmental Conditions

The site-specific specifications for potential subsequent antenna installation locations may be different and specified within the individual task orders.

4.1 General Environmental Protection:

4.1.1 Dust and Dirt.

The antenna shall be designed to preclude the intrusion of dirt and dust.

4.1.2 Infestation Prevention.

The antenna shall be designed to prevent infestation by insects, birds and vermin.

4.1.3 Materials and Finishes.

The antenna materials, finishes, and seals shall be suitable for the Fort Davis, McDonald Observatory environment conditions.

4.1.4 Water Accumulation.

The antenna shall be designed to prevent accumulation of water on any active surface.

4.1.5 Leakage.

The antenna shall be designed to prevent any leakage into any exposed equipment or into the antenna interior due to rain.

4.2 Primary operating conditions (Full performance of the antenna):

4.2.1 Temperature.

The antenna shall be capable of operating at temperatures from 20°F to 90°F.

4.2.2 Relative Humidity.

The antenna shall be capable of operating at relative humidity between 0–100%.

4.2.3 Wind Speed.

The antenna shall be capable of operating at wind speeds < 32 km/hr. (20 mi. /hr.) sustained.

4.2.4 Rainfall.

The antenna shall be capable of withstanding rain rates of up to 50 mm/hr. (2 in/hr.) without structural damage.

4.3 Secondary Operating Condition (Degraded performance of the antenna):

4.3.1 Temperature.

The antenna secondary operating temperature shall be10°F to 100°F.

4.3.2 Relative Humidity.

The antenna secondary operating relative humidity shall be 0-100%.

4.3.3 Wind Speed.

The antenna secondary operating wind speed shall be < 48 km/hr. (30 mph.) sustained (or < 99.5-percentile wind speed, if higher).

4.3.4 Rainfall.

The antenna secondary operating temperature shall be rainfall :< 100 mm/hr. (4 in/hr.).

4.4 Survival conditions at stow with negligible structural damage

4.4.1 Temperature.
The antenna survival temperature shall be 10°F to 100°F

4.4.2 Relative Humidity.
The antenna survival humidity shall be between 0-100%.

4.4.3 Wind Speed.
The antenna shall be able to withstand wind speed of < 48 km/hr. (30 mph) sustained.

4.4.4 Rainfall.
The antenna be able to withstand rainfall of < 100 mm/hr.

4.4.5 Hail.
The antenna shall survive one-inch diameter hail in winds of 48 km/hr. (30 mph) without structural damage.

4.4.6 Ice.
The antenna shall be capable of withstanding 19 mm (0.75 in) of ice in winds of 48 km/hr. (30 mph) without structural damage.

4.4.7 Seismic.

The VLBI system shall be designed to International Building Code (IBC) Seismic Design Category (SDC) C and shall not be damaged by earth movement consistent with Seismic Design Category C events.

4.4.8 Snow.

The antenna for elevation angles = 20 degrees shall be capable of withstanding a ground snow load of 30 psf without structural damage or performance degradation

Section 5 Reliability/Maintainability/Availability Requirements

5.1.1 Lifetime.
The antenna mechanical structure aside from motors and gearboxes shall have a lifetime of 20.0 years.

5.1.2 Reliability and Maintainability Report.

The antenna provider shall provide a reliability and maintainability report for the proposed antenna and antenna controller down to the line replaceable unit (LRU). The report shall indicate the top level as well as the LRU, and the MTBF and the MTTR for each. Methods for the calculations shall be based upon MILHDBK- 217F, Notice 2.

5.1.3 Spares Plan.

The antenna provider shall provide a spares lists that identify the recommended spares, the MTBF and MTTR for item in the list and a recommendations as to have the spare part/s locally at the site.

5.1.4 Maintenance Plan.

The antenna provider shall provide a recommended maintenance plan/procedures including maintenance periodicity for all antenna components.

5.1.5 Hand Block and Controller.

The antenna shall have hand block and controller for manual movement of the antenna.

Section 6 Safety Requirements

6.1 Safety Training and Certification.

The antenna provider shall provide applicable safety training or certifications as required and requested. Examples include Crane Operator, Qualified Rigger documentation, Aerial Platform or Powered Industrial Truck Operator certifications, and Fall Protection End User.

6.1.1 Safety Data Sheets.

The antenna provider shall provide a copy of all safety data sheets and receive approval prior to bringing products onsite.

6.2 Safety-Guidance

6.2.1 Federal, State and Local Regulations.

The antenna provider shall comply with federal, state, and local environmental regulations in the design and installation of antenna system.

6.2.2 Lifting Devices and Equipment.

The antenna provider shall meet the requirements of NASA-STD-8719.9, NASA Standard for Lifting Devices and Equipment.

6.2.3 Pressure Vessel Systems -Safety Requirements.

All antenna related pressure vessel systems shall be designed in accordance with **NASA-STD-8719.17**, NASA Requirements for Ground Based Pressure Vessels and Pressurized Systems.

6.2.4 System-Photo Documentation of Key Assemblies.

The antenna provider shall produce closeout photographic documentation of all (key) assemblies during the manufacturing process and of the final integrated configuration.

6.3 Safety-Operations

6.3.1 Control Panel Surface Safe Operating Temperature.

The antenna shall operate at an ambient temperature of 77 degrees Fahrenheit (°F), surface temperature of the control panels and operating controls shall be less than or equal to 113°F.

6.3.2 Aircraft Warning Lights.

The antenna shall have aircraft warning lights and other markings shall be installed. The location shall be at the highest point on the antenna structure and shall be distributed around the outside edge of the primary reflector not interfering with the RF path.

6.3.3 Warning Light-Antenna Start Up.

The antenna shall have warning light installed to notify personnel of antenna activation.

6.3.4 System-Operational Safety-Audible Alarm-Antenna Start Up.

The antenna shall have an audible alarm to notify personnel of antenna start-up.

6.4 Safety-Occupational

6.4.1 Safety Guards.

The antenna guards shall be installed for use as a cover or barrier to prevent access to hazardous equipment so there can be no contact with hazardous voltages, currents, high temperature, moving machinery, etc., during either operation, service, or maintenance.

6.4.2 Sharp Objects.

The antenna equipment shall have no sharp projections on cabinets, doors, and similar parts.

6.4.3 Voltage, Current, Thermal and Physical Hazards.

The antenna shall eliminate or control potential hazards that could result in personnel injury and/or damage to components or facilities through personnel error, component failure, or a combination of the two. For the purposes of this paragraph, specific hazards are defined as voltage, current, thermal, or physical hazards.

6.4.4 Fall Protection.

The antenna shall be designed to protect personnel from falls where working at heights is required. Anchor points and other fall protection engineering shall be installed in accordance with applicable ANSI Z359 Series.

6.5 Safety-Markings and Labels

6.5.1 Markings and Labels.

The antenna guards, barriers, access doors, covers, or plates shall be marked to indicate the hazard that may be reached upon removal of such devices.

6.5.2 Markings and Labels-Danger/Caution Signs.

The antenna shall have danger or caution signs, labels, and markings shall be installed or attached to warn of specific hazards.

6.5.3 Markings and Labels-Electrical Panels.

The antenna electrical panels shall be labeled and marked in accordance with NFPA 70 National Electrical Code and NFPA 70E, Standard for Electrical Safety in the Workplace.

Section 7 Security Requirements

7.1 Security Guidance.

The antenna shall adhere to the technical security control requirements specified in NASA Procedural Requirements (NPR) 2810.1A, Security of Information Technology.

7.1.1 Access Control.

The antenna shall restrict access to antenna related software, information and functions to authorized users.

7.1.2 Password.

The antenna shall require user id and password for access to antenna related software, functions and data.

Section 8 Functions to be performed by the Vendor

8.1 Overview

The Vendor shall design, develop, document, test, deploy, setup and demonstrate operations for each VGOS antenna.

The Vendor requirements for VGOS include the following areas:

- Project Management

- Configuration Management
- Design & Development
- Site Installation and Deployment
- Verification and Acceptance Testing
- Documentation
- Commissioning
- Training and Hand-over to Operations

The antenna provider takes responsibility regarding the technical performance approval of the construction foundation calculations; drawings and integration of the antenna hardware. NASA will supply the receiver, but an appropriate feed cone will be the responsibility of the antenna provider. NASA will also provide the helium compressor and the antenna provider will provide a platform to house the helium compressor.

8.2 Project Management

The Vendor shall establish and maintain management processes and controls required to deliver the contract items on schedule and in compliance with the contract requirements. The Vendor shall establish and maintain an integrated management approach to ensure implementation and delivery of the VGOS antenna. The management process shall ensure a disciplined and authoritative approach to the assessment and control of risks, project schedule and costs, and technical performance. The primary functions of the project management interface are to provide timely and accurate project status, risk management, schedule and cost management and export control compliance.

8.2.1 Management Plan (MP)

The Vendor shall prepare, deliver, and maintain a Management Plan (MP). The MP shall serve as the authoritative document providing the management procedures for all activities necessary to meet the requirements of the SOW. The MP shall describe the following at a minimum:

- Vendor's organization and internal lines of communication,
- Assignment of management and engineering responsibilities and duties,
- Project management structure, policies, and procedures,
- Resources plan for contract implementation,
- Decision making processes,
- Risk management process,
- Plan for accommodating system upgrades and version changes.

The Vendor's project management procedures shall describe the use, characteristics, and function of any automated or manual management systems to be used on this project, including, as a minimum, schedule management, resources allocation and management, configuration and data management systems, quality assurance systems, and subcontract management systems (if required).

8.2.2 Management Reporting

The Vendor shall support bi-weekly status and Project Milestone reviews with the SGP Team, via teleconference, for the life of each antenna production.

In addition the Vendor shall support supplementary status reviews as designated by NASA and shall provide written monthly status reports that include: issues, risks and mitigation plans, progress against the established schedule, courses of action to correct schedule departures and problems, and near-term project plans.

8.2.3 Risk Management

The Vendor shall identify programmatic, schedule and technical risks and describe how they will effectively manage/mitigate these risks on an ongoing basis throughout contract performance. The Vendor shall quantify risks with respect to the impact on development, production, integration, testing, performance, delivery, and schedule. The Vendor shall assign a priority to identified risks and develop risk mitigation plans for risks considered medium or high priority. The Vendor shall report on the status and risk mitigation plans in the weekly status reviews and the written monthly reports.

8.2.4 Schedule and Cost Management

The Vendor shall provide their plans and approach for the development and delivery of the task products complying with the major schedule milestones for each task. The Vendor schedule shall be provided in either Microsoft Project format or a format compatible with Microsoft Project. The Vendor shall identify any issues, questions, and/or concerns with meeting these project-level milestones in the weekly status reviews and the written monthly reports.

8.2.5 Safety and Mission Assurance Plan

The Vendor shall develop a Safety and Mission Assurance Plan (SMAP). The SMAP prescribes the Vendor Safety and Mission Assurance plans, roles responsibilities, and activities to be performed during the lifecycle of the contract. The Vendor shall report on the activities outlined in the SMAP in the weekly status reviews and the written monthly reports. The SMAP addresses specific critical SMA disciplines relevant to a non-flight instrument, including:

- Safety per NPR 8715.3, NASA General Safety Program Requirements;
- Quality Assurance per NPD 8730.5, NASA Quality Assurance Program Policy;
- Compliance verification, audit, safety and mission assurance reviews, and safety and mission assurance process maps per NPR 8705.6, Safety and Mission Assurance Audits, Reviews, and Assessments;
- Reliability and maintainability per NPD 8720.1,NASA Reliability and Maintainability (R&M) Program Policy;
- Software Assurance and Software Safety per NASA-STD-8739.8, NASA Software Assurance Standard, and NASA-STD-8719.13, NASA Software Safety Standard;

8.2.6 Logistics and Export Control

The Vendor shall provide preparation for shipping of support systems, repair parts, equipment and supplies utilizing the NASA facilities when available and advantageous. The Vendor shall maintain all government furnished resources to ensure continued service delivery at required Task Order performance levels and reasonable retention of government property value. All shipments shall be accomplished with Commercial Bills of Lading (CBL).

The Vendor shall provide an efficient spares logistics system, which is required for key component parts. Quick response vendor agreements for some COTS and custom hardware components shall be required for critical hardware.

For shipments as a part of each antenna deployment, the Government may direct the Vendor to obtain preservation, packing, crating, labeling, marking, and transportation and shipping services from the GSFC Transportation Management Office, Code 230.

The Vendor shall provide logistics services in support of VGOS activities at the Vendor operated or Operations Contractor locations as required, per contract shipping instructions and coordinated with the NASA-designated point-of-contact. For a foreign export subject to control, the contractor shall provide all activities necessary for the export of these systems (including customs). Since some of the systems are to be delivered and installed, and obtained from locations outside the United States, the Vendor shall be required to perform all activities necessary for the shipping and export/import of these systems. In order to protect the national security and to further U.S. foreign policy objectives, export control laws regulate such transfer activities. Relevant export control laws and regulations include the Export Administration Regulations (EAR), 15 CFR 730-774, and the International Traffic in Arms Regulations (ITAR) 22 CFR 120-130 that are administered by the Departments of Commerce and State, respectively. The Vendor shall be responsible for the all aspects of the export process, including but not limited to the following:

- A plan identifying export licenses required for performance, and exemptions and exceptions that apply
- Determining what items (equipment, software, documentation, information, etc.) require an export license
- Coordinating with the proper government agencies to ensure compliance with the appropriate US export control laws and/or regulations
- Obtaining the required export licenses and Technical Assistance Agreements
- Retaining all required export documentation for the required period of time after exportation
- A status report of licenses obtained, including copies of licenses
- A status report of exports effected against those licenses, including copies of Automated Export System/Shipper's Export Declarations and other related shipping documents.
- The Vendor shall deliver these reports to the NASA Contracting Officer Representative.

The Vendor shall handle the return of any repair/replacement of failed antenna components at foreign/OCONUS sites during the deployment, commissioning and maintenance periods for repair/replacement. The Vendor shall also handle all shipments of repaired/replaced elements to its associated foreign/OCONUS site.

The Vendor shall provide the option of storing an antenna for up to one year in the event that the site preparation is not completed prior to antenna completion.

8.2.7 Property and Logistics Management

The Vendor shall employ a property management system in place, which is approved by a delegated NASA property administrator. The Vendor shall perform property management of all property owned, leased, or acquired by the Government under the terms of the contract. The Vendor shall develop and document an Integrated Logistic Support regimen which addresses at a minimum hardware maintenance; supply support, including re-supply and return; spares re-procurement; technical data and documentation; maintenance tools, test, and support equipment; material transportation and handling; maintenance training; and logistic support performance measurements for the life of the contract. The Vendor shall utilize Maximo ®, latest version, or a suitable equivalent to perform Property and Logistics Management data management.

The Vendor shall provide, implement, and maintain a Government Property & Logistics Management Plan.

The Vendor shall provide research, procurement, shipping, property management and inventory control of property, spare parts, tools and supplies retained for use in support of the systems operation and maintenance, and sustainment requirements. Inventory control shall comply with the requirements of the most current edition of NPR 4100.1, NASA Materials Inventory Management Manual. Storage, transportation and handling of Electro-Static Discharge sensitive items shall comply with the most current edition of NPR 6000.1, Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment and Associated Components.

For all of the locations at which this contract is performed, the Vendor shall comply with all applicable international, Federal, state, and local environmental requirements, environmental Executive Orders, NASA Procedural Requirements, and GSFC environmental directives, procedures, and policies. The Vendor shall submit to the appropriate environmental regulatory agencies any required official correspondence (e.g., permits/permit applications, negotiated agreements, and requests for information from/to regulatory agencies).

8.3 Configuration Management

The Vendor shall establish and implement a Configuration Management (CM) process and baseline for each VGOS antenna. The Vendor shall manage the configuration of the systems throughout the life of each task. The CM process shall ensure that the configurations of hardware, firmware, software, and documentation are in conformance with the contract baselines and specifications for the deliverables.

The Vendor shall manage and control both hardware and data/documentation items associated with antenna elements and configurations as they progress through the design, implementation, integration, test, delivery, and commissioning cycles. The data management shall ensure accurate control and delivery of the following at a minimum:

- Presentation Material,
- Deliverable Documentation,
- Drawings,
- Computer Models (CAD, FEM, etc.),
- Source Code,
- Test and Verification Data.

As a part of the overall Vendor CM process, the Vendor shall include configuration management of all antenna equipment delivered to each SGP site. The Vendor shall manage the configuration and develop a baseline of all site deliverable antenna items throughout the life of the contract. The CM process shall ensure that the configurations of hardware, firmware, software, and documentation are in conformance with the contract baselines and specifications for each SGP site.

The Vendor shall manage the configuration of all deliverables and ensure that all like elements are of the same configuration level at all times, and/or ensure that any configuration discrepancies are fully documented and approved by NASA. The Vendor shall maintain configuration control of the hardware to the Line Replaceable Unit (LRU) level and software/firmware to the version level. The Vendor shall ensure that the CM of any antenna system is not compromised by any depot maintenance activities.

8.4 Design, Development, and Implementation

8.4.1 Design of the VGOS antenna

The vendor shall design and develop the VGOS antenna that meets the requirements outlined in this RFI. Additional requirements for the second and third antenna may be added to address site specific requirements once those sites are identified.

8.4.2 Technical Interchange Meetings (TIM)

For each antenna, the Vendor shall support Technical Interchange Meetings (TIM) between NASA technical personnel and Vendor personnel. The TIMs shall be conducted within one month of each task award. The primary purpose of the TIM is to review the system design and resolve and issues concerning the development and delivery of the antenna.

While not a formal Review, the TIM is where the Vendor presents their ideas for antenna design and an open exchange between the Vendor and the Government takes place.

8.4.3 Reviews

The Vendor shall be responsible for planning, scheduling and conducting design reviews. Preliminary Design Reviews (PDR) will be held after the first system's TIM when the system design is ready for presentation but is not completely mature. There will only be one PDR. Critical Design Reviews (CDR) will be held when the Vendor has a complete system design and development plan and is ready to start the first build. A full CDR will be required for antenna system #1. Thereafter "delta" CDRs for each system will suffice. At the end of each Factory Acceptance Test (FAT) a Review shall be held. A Pre-Ship Review (PSR) shall be held prior to shipment to the final location. At the end of the Final Acceptance Testing at the final location, a

Site Acceptance Review (SAR) shall be held prior to the integration of the other VGOS subsystems. Finally, the Vendor shall support an Operational Readiness Review once the fully integrated VGOS station has completed its commissioning period.

8.4.3.1 Preliminary Design Reviews (PDR)

A PDR shall be held after the first system's TIM when the system design is ready for presentation but is not completely mature. The Vendor shall present a clear, consistent design that addresses all of the VGOS antenna requirements and demonstrates that the system meets all requirements. A PDR is only required for the first system.

8.4.3.2 Critical Design Review (CDR)

The CDR shall be held prior to the build of the first antenna system with delta CDRs held for each of the other systems. The Vendor shall present a clear, consistent design that addresses all of the VGOS antenna requirements and demonstrates that the system meets all requirements.

8.4.3.3 Factory Acceptance Test (FAT) and Review (FATR)

The FAT shall be performed at the Vendor's factory, by Vendor personnel with the Vendor's test equipment. A formal FAT Plan shall be generated by the Vendor with NASA input that will specify each test to be performed, what is required to pass, and who performs the test. A NASA representative must be present for a majority of FAT testing. NASA concurrence will be required to determine pass/fail on each FAT according to criteria in the FAT Plan.

A FAT Review (FATR) will be held after the FAT on each antenna and NASA SGP personnel have had time to review the test results (approximately one week).

8.4.3.4 Pre-Ship Review (PSR)

A PSR will be held after the FATR on each antenna prior to shipment of the antenna to the SGP site. Any open actions identified at the FATR should be closed by the PSR or have a NASA approved plan for closure.

8.4.3.5 Site Acceptance Testing (SAT) and Site Acceptance Review (SAR)

After passing the PSR, the vendor shall transport and install the antenna system to the corresponding SGP site. The Vendor shall perform SAT verification with NASA support after installation of each antenna system delivery at each SGP site. The SAT is expected to be a subset of the tests demonstrated at the FAT. The Vendor shall conduct the SAT verification testing and provide NASA with the data and their analysis of the system performance. The Vendor shall generate the SAT Test Plan that will define the testing to be performed. NASA will generate the requirements for passing. NASA concurrence will be required to determine pass/fail on each system according to criteria in the SAT Test Plan. Integration with the signal chain will begin with the successful completion of the SAR.

8.4.3.6 Operational Readiness Review (ORR)

The Vendor shall support an ORR after the final integration of the other VGOS subsystems and a commissioning period of no less than 3 months.

8.4.4 Site Installation and Deployment

NASA or the site owner will be responsible for the preparation of the SGP site prior to delivery of the antenna. These responsibilities include installation of the antenna foundation and power and communications hookups.

The Vendor shall review and approve the site plans related to the VGOS antenna, including the construction foundation calculations and interface drawings.

The Vendor shall break down and pack the antenna and ship it to its final location where the Vendor shall then reassemble the unit and begin functional testing.

The Vendor shall be knowledgeable and abide by all local laws and regulations related to the site installation, system installation, safety and operations.

The Vendor shall support the unpacking, installation and checkout for all of the antenna deliverables at each SGP site, including OCONUS sites. The Vendor shall perform the installation and checkout of the antenna system at each SGP site.

The installation and checkout for each site equipment delivery shall be in accordance with the site-specific schedules for each SGP site per the task Deliverables tables.

8.4.5 Verification Planning

The Vendor shall develop and deliver a single Acceptance Test Plan (ATP) for each antenna system. The ATP shall describe the methodology for verifying, evaluating, and accepting each antenna system. The ATP shall include plans for both the FAT and the SAT.

The ATP shall identify how all VGOS antenna requirements will be verified either during the first article (FA) testing, the FAT and/or the SAT for each site. A Requirements Verification Matrix (RVM) that depicts each requirement, the associated verification methodology (e.g., Test, Demonstration, Analysis, Inspection) for each requirement, and where each requirement is verified (i.e., FA, FAT, SAT or combinations) shall be provided as part of the ATP.

Updates to the ATP shall be provided prior to each CDR as required. The ATP must be reviewed and approved by NASA prior to the start of any formal verification.

The Vendor shall develop and deliver Acceptance Test (AT) Procedures. Separate AT Procedures documents shall be provided for each of the levels/phases of verification (i.e., FA, FAT, and SAT) for each antenna system. The test procedures shall provide detailed procedures/steps required to adequately demonstrate the verification of all requirements as specified in the ATP for the associated verification level/phase.

Each AT Procedures document shall include an updated version of the Requirement Verification Matrix (RVM) from the ATP. The updated RVM shall delineate traceability of each specific requirement to the test procedure and verification step within the AT Procedures document. The RVM shall, at a minimum, include the following for each requirement entry: the associated verification level (FA, FAT, SAT, or combinations), the verification method(s), and identification of the specific test procedure section and verification step. NASA shall approve each AT Procedures document prior to the start of any verification sessions.

8.5 Documentation

The Vendor shall prepare and deliver documentation covering the design, build, test, operations, and maintenance of each antenna system. This includes:

- Antenna specifications
- Foundation Interface drawings with maximum loads and foundation stiffness requirement
- System drawings
- Vendor supplied documentation and drawings
- Parts list (with costs of items that will require Government property tags at delivery)
- System alignment documentation
- System maintenance documentation
- Project Activity Reports
- Review Packages
- Vendor Provided Spare Parts List (VPSPL)
- Acceptance Test Plan/Procedures
- Acceptance Test Reports
- Installation Documentation
- Management Plan (MP)
- Configuration Management Report of system changes
- Technical System Documentation
- Subsystem documentation and test reports from the manufacturers
- Training Package
- Operations Manual for each system
- Antenna Hardware Overview Manual
- Software Manual (Programmer's Reference Manual)
- Software User's Guide.
- Safety Plan
- Weekly and Monthly Status Reports and Monthly Milestone Reports
- Safety and Mission Assurance Plan (SMAP)

NASA or the NASA designated personnel shall have the right to copy vendor-provided documentation for the sole limited use of this contract.

8.6 Models and Test Data

The Vendor shall deliver to NASA hardware specific models and test data in the electronic format in which they were generated including:

- CAD Drawings and high fidelity mechanical models
- Finite Element Models,

- Test Data.

The Vendor shall prepare and deliver a Finite Element Analysis (FEA) model and a structural design report showing compliance with environmental requirements and the requirements for Reference Point Stability and the Path Length Stability. The FEA will model multiple static loading and thermal loading scenarios under various environment conditions and pointing positions.

8.7 System/Product Support

8.7.1 Overview

The Vendor shall be responsible for providing Software Licenses, Spares and Parts Repair, Maintenance Programs, Training, Documentation, and optional Additional System Support.

Vendor software licenses, and hardware, firmware, and software maintenance agreements acquired by NASA with the antenna products shall contain provisions for optional reassignment or transferability to NASA designated support contractors at no additional cost.

8.7.2 Software Licensing

The Vendor shall provide software licensing agreements for each element of the antenna deliverables, as applicable, purchased in this contract. These agreements shall license all deliverable software separately and cover all antenna systems purchased under the contract on a site-by-site basis. The Vendor shall ensure that licenses for all COTS products are properly passed from the Vendor to NASA with the delivery of the antenna systems. Each agreement shall be provided as a "one-time fee" license and commence with the receipt on-dock of the antenna system for each SGP site. The Vendor shall support the transition, if necessary, of all licenses and support agreements from NASA to NASA-designated support contractors if required during the lifetime of the contract.

In addition to the required number of software licenses for each antenna system, the Vendor shall provide four (4) physical copies (separate media) of each software package for each antenna system. The software media shall be provided with the initial equipment delivery at each SGP site. The software media shall be in a format compatible with the antenna equipment installation capabilities.

With the exception of software that comes with COTS components, all source code for all software is a required deliverable with each antenna system.

8.7.3 Logistics Spares and Repair Parts

The Vendor shall provide a Vendor Provided Spares Parts List (VPSPL), for the SGP as a whole taking into account the planned methodology for local and depot maintenance support of the delivered equipment and the performance requirements. The VPSPL shall provide the following data for each Line Replaceable Unit (LRU):

1. LRU part number
2. LRU nomenclature

3. LRU Mean Time Between Failures (MTBF)
4. LRU Mean Time To Service Restore (MTSR)
5. Quantity of operational LRUs on a per site basis (i.e., quantity of each LRU within the delivered system)
6. Quantity of vendor provided spares for each LRU on a per site basis

The Vendor shall provide a complete list of all major elements in the deliverables for each site and identify the LRUs for each element.

MTBF and MTSR estimates shall be provided for each LRU. The LRU MTBF estimates shall be derived from operational history or by a standards-based methodology typically used by the vendor. The MTSR shall be determined as the time for trained maintenance personnel to restore operational capabilities assuming availability of on-site replacement LRUs. NASA personnel trained by the Vendor for LRU level troubleshooting and replacement will provide the on-site maintenance with the support of the Vendor during the commissioning period. The Vendor shall provide the methodology/analysis approach used to develop the vendor provided spares quantities, as well as the LRU MTBF and MTSR estimates.

8.7.4 Maintenance Program

8.7.4.1 Maintenance Program Overview

The Vendor shall provide a Maintenance Program for support of all deliverables at each SGP site. The maintenance program shall provide coverage for all hardware, firmware, and software delivered on a per site basis. This shall include all deliverable equipment, including all spares (initial procurement and additional procurements under contract options), all deliverable miscellaneous equipment (e.g., equipment enclosures, etc.), and all deliverable software (application software, utility software, and operating system software).

The Vendor shall continue to manage the configuration of all deliverables under the Maintenance Program. The Vendor shall ensure that all like elements are of the same configuration level at all times, and/or ensure that any configuration discrepancies are fully documented and approved by NASA. The Vendor shall maintain configuration control of the hardware to the LRU level and software/firmware to the version level. The Vendor shall ensure that the CM of any antenna system is not compromised by any depot maintenance activities.

The Maintenance Program shall provide coverage for up to one (1) year for each antenna system commencing with the successful completion of the ORR. NASA will have the option to write a separate task to increase the maintenance period for any of the systems before that system's one year Maintenance Period ends. The Maintenance Program shall be transferable from NASA to a NASA designated support contractor if required.

If the Vendor declares End of Life (EOL) or fails to provide required support for a delivered product, NASA shall have access to the Vendor-provided escrow account information as defined in the VGOS Antenna contract.

8.7.4.2 Hardware Maintenance

The Vendor shall provide depot level maintenance support during the Maintenance Program time frames. The Vendor shall be responsible for providing initial spares (as defined in the VPSPL) and replenishing spares as required on a per site basis. The spares shall be properly packaged and marked for use at each SGP site.

Under this program, each SGP site will manage the on-site spares based on the VPSPL. NASA Logistics personnel will receive, store, and inventory the antenna spares for each site. NASA maintenance personnel will identify, remove and replace a defective LRU with the support of the Vendor during the Commissioning and Maintenance periods. When an onsite maintenance action is completed, NASA maintenance personnel will package and ship the defective LRU to the Vendor's designated depot.

The Vendor shall repair or replace all broken, malfunctioning, or defective LRUs and any LRUs that otherwise fail to perform in accordance with the specifications, regardless of cause, and ship the repaired/replacement spares back to the NASA designated site. The repaired/replacement spare shall arrive at the NASA designated site within ten (10) calendar days of the initial notification from NASA of the failure. The Vendor shall pay for all shipping costs to return the replacement or repaired spare to the NASA designated site. The Vendor shall provide 5 days/week, 8 hours per day support for NASA to notify the Vendor of a failure requiring repair/replacement. The Vendor shall verify and ensure to NASA that replacement parts are equal to or better than the original parts and compatible with current system configurations, such that no degradation in performance or quality will result from maintenance services performed.

8.7.4.3 Software Maintenance

The Vendor shall provide software maintenance support for each SGP site as a part of the overall Maintenance Program.

The Vendor shall provide four (4) physical copies (separate media) of each software release for each antenna system. The software media shall be in a format compatible with the antenna equipment installation capabilities.

The Vendor shall provide an automatic notification, via email or phone, to the designated NASA Point of Contact (POC) or designated appointee for each SGP site, when a software or firmware upgrade, revision, update or patch is released.

8.7.4.4 Field Change Orders and Engineering Change Orders

After the ORR, modifications resulting from Vendor recommended Field Change Orders (FCOs) and/or Engineering Change Orders (ECOs) to enhance performance or correct problems shall be implemented only with NASA concurrence. This shall include any "technology refresh" (hardware, firmware, or software) upgrades recommended by the Vendor. The Vendor shall verify and ensure to NASA that replacement parts are compatible with current system configurations and equal to or better than the original parts, such that no degradation in performance or quality will result from maintenance services performed as a result of any FCOs or ECOs.

8.7.5 Training

The Vendor shall develop and provide operator and maintenance training to NASA designated personnel, including on-the-job training. As a part of each site-specific CDR, the Vendor shall provide a brief description of the planned training course(s) for engineering, operations, and maintenance personnel.

The Vendor shall provide separate training sessions for each antenna system in English, which is to include each of the following courses:

- Maintenance Training Course - antenna equipment maintenance training including: troubleshooting techniques and LRU replacement.
- Antenna System Operations Training Course - antenna system operations training including: configuration, reconfiguration, control, statusing, and system administration functions.

Each training course shall be conducted at a NASA designated location for each antenna system. The training courses shall be scheduled in advance by the Vendor with each NASA SGP site and will be based on the availability of the NASA designated personnel to receive the training as well as the availability of adequate facilities/resources.

All course package material shall be provided in an electronic format that is reproducible such that NASA personnel can provide equivalent training to additional users for "self-training" as necessary.