9.4M KA ESA
EXTENDED PRODUCT DESCRIPTION

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1.1 Antenna Subsystem

1.1.1 9.4m Antenna Subsystem

The ASC Signal 9.4 meter antenna was designed and introduced to the satellite communications industry over 10 years ago. It has been in production ever since primarily filling the requirements of the C-band to K-band satellite communications market. Prompted by demanding commercial and military requirements, ASC Signal designed and introduced a series of high precision mount designs specifically meant to address large aperture, Ka-Band Gateway earth station applications. The 9.4m antenna design combined with the extended azimuth dual drive precision mount and patented 3 axis subreflector tracker (SRT) technology provide an extremely versatile and reliable gateway antenna solution. Knowing that the ultimate goal of any Ka-band gateway terminal is maximum link availability, the 9.4m design provides the operator with the industry's best feature set available to combat the unique challenges of Ka-band operation.

- Precision stretch formed reflector skins
- Thermally matched all-aluminum reflector construction
- Specially optimized reflector heater systems
- Extended azimuth/hi wind dual drive mount with 26 bit high precision encoders
- Patented (U.S. patent 6,943,750) 3-axis SRT tracking system with adaptive thermal compensation
- NGC 6-axis antenna control with redundant positioning/tracking systems
- All forms of pointing/tracking algorithms available:
    - Ephemeris (INTELSAT, NORAD)
    - Step Track with patented 3 point peaking
    - SmartTrack (Model Track)
    - Monopulse

The primary satellite tracking function is accomplished via small mechanical movements of the subreflector tracking (SRT) assembly. This tracking scheme provides precision satellite tracking over a +/- 0.25 degree range while the main pedestal is in a static/fixed condition. This approach increases operational life and extends time between routine maintenance intervals. The mount motion is primarily utilized to reposition the antenna over >200 degree azimuth range but can also be used as a backup tracking system in case of SRT failure. The antenna control system (based on the ASC Signal NGC controller) commands both the SRT system and the pedestal mount motor drives.

The 9.4m SRT also incorporates a thermal compensation feature that is unique in the industry. Substantial data is available that shows thermally induced reflector distortions dramatically impact the antenna performance for large high frequency structures like the 9.4m. Reflector and mount distortions induced by the sun and anti-ice heater operation will alter beam pointing angles and reduce antenna gain (de-focusing). Beam deflections will automatically be negated while in step track mode. However, the ASC Signal SRT also incorporates a precision z-axis drive mechanism that adaptively re-focuses the antenna system and maintains optimal performance through all weather and anti-ice events.

1.1.2 **Antenna RF Description and Performance**

The 9.4m optical design has been optimized for high efficiency Ka-band performance and providing compliance to all applicable regulatory requirements. The 9.4 Meter Ka-Band antenna is fully compliant (as a minimum) with the following referenced Regulatory Agency specifications:

- Federal Communications Commission Rules and Regulations, Title 47, C.F.R. Part 25.209, as amended.
- ITU-R, S.580-5 and S.465-5 Recommendations for Pattern Performance for 2 degree satellite spacing, as amended

Specifically, the proposed antenna complies with the radiation pattern envelope (RPE) performance for 1 - 180 degrees angles as per ITU-R, S.580-5, S.465-5, and FCC part 25:

Transmit pattern curve

29-25 LOG θ dBi ($1º \leq \theta \leq 20°$)
-3.5 dBi ($20° < \theta \leq 26.3°$)
32-25 LOG θ dBi ($26.3° < \theta \leq 48°$)
-10 dBi ($\theta > 48°$)

Transmit pattern sidelobe excursions

No excursions for $1º \leq \theta \leq 7°$
3dB max excursions for $\theta > 7°$
10% max integr. excursions for $7° < \theta \leq 180°$

Examples of transmit and receive band antenna patterns are shown on the following pages:

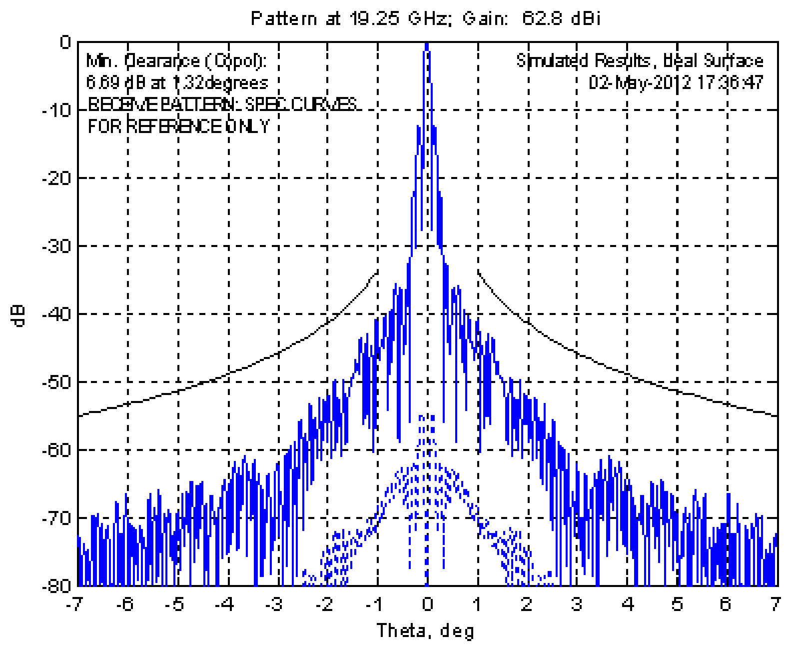


FIGURE 1 ANTENNA PATTERN AT 19.25 GHZ, NARROW CUT

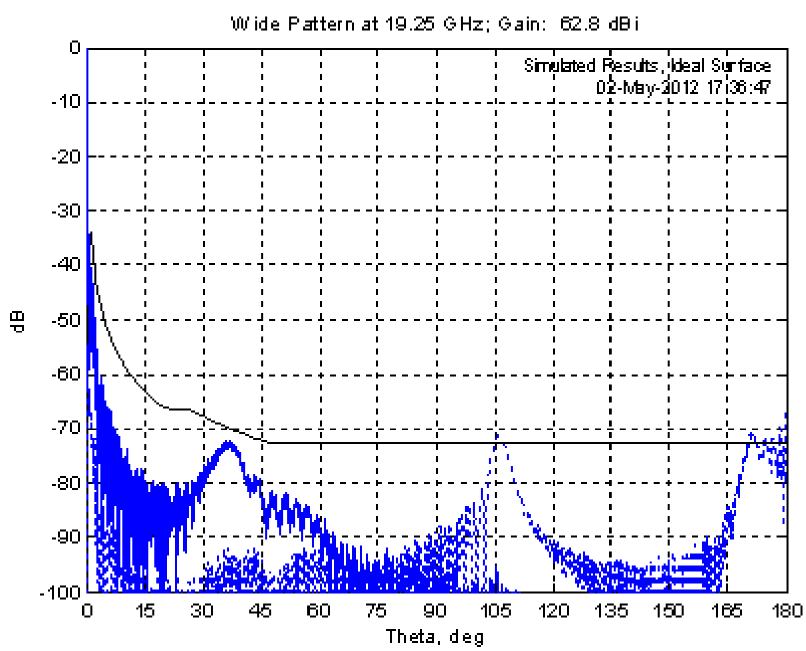


FIGURE 2 ANTENNA PATTERN AT 19.25 GHZ, WIDE CUT

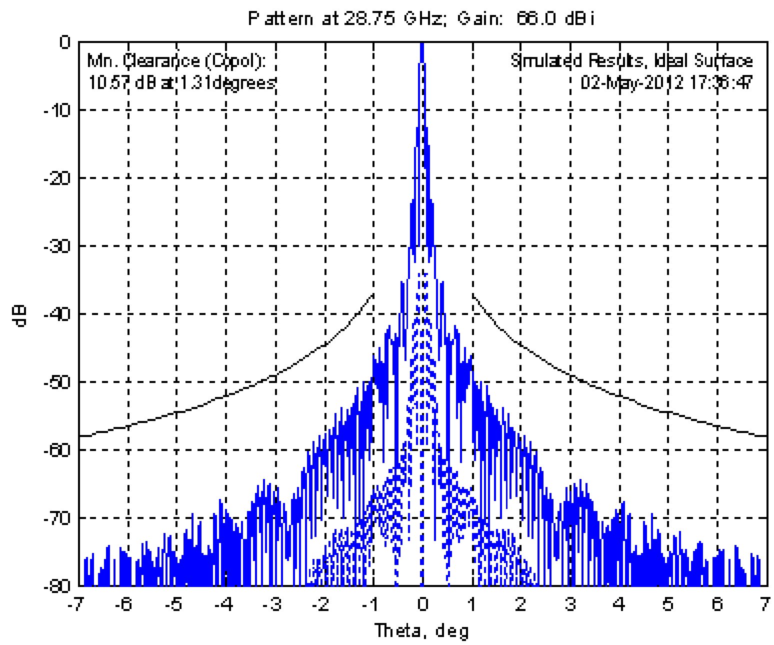


FIGURE 3 ANTENNA PATTERN AT 28.35 GHZ, NARROW CUT

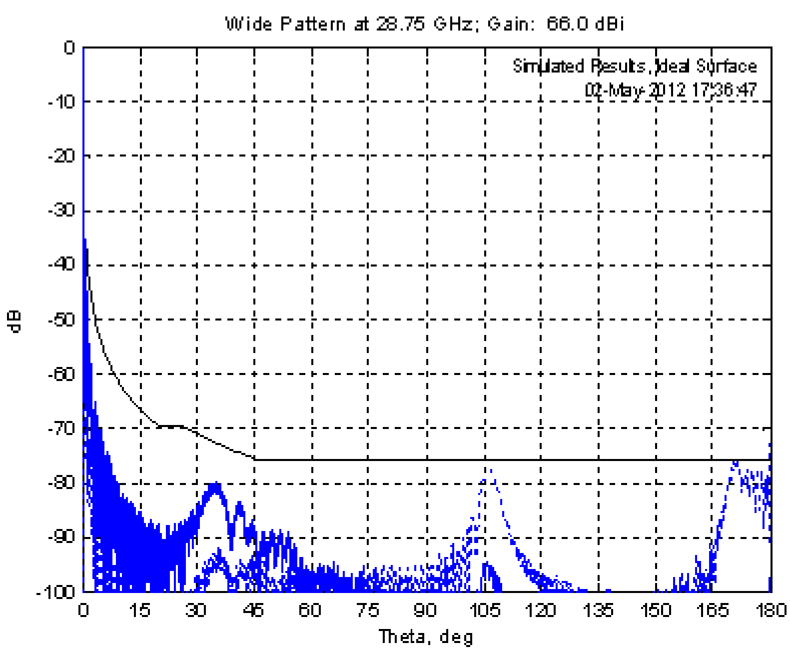


FIGURE 4 ANTENNA PATTERN AT 28.75 GHZ, WIDE CUT

The 9.4m antenna proposed is supplied with a wideband 4-port feed that supports the entire operational bandwidth of the satellite system as well as provides access to all polarizations. The complete RF performance data sheet for the 9.4m Ka-band antenna is given in the attached feed Specification (represented in Table 1 below);

4 port circular polarized wideband Ka-band feed
9.4m Earth Station Antenna

Operating Frequency	Receive	Transmit	Unit
Circular	17.700-21.200	27.500-31.000	GHz

Gain (1)(+/-0.2dB)	Receive	Transmit	Unit
17.700 GHz	62.0	-	dBi
19.450 GHz	63.0	-	dBi
21.200 GHz	63.9	-	dBi
27.500 GHz	-	66.0	dBi
29.250 GHz	-	66.5	dBi
31.000 GHz	-	66.9	dBi

Beamwidth (typical, mid band)	Receive	Transmit	Unit
3 dB Beamwidth	0.100	0.070	deg
10 dB Beamwidth	0.190	0.130	deg

Noise Temperature (2)	17.700 GHz	19.450 GHz	21.200 GHz	Unit
5° Elevation	149	163	200	K
10° Elevation	129	135	161	K
20° Elevation	115	117	129	K
30° Elevation	109	106	113	K
40° Elevation	106	103	108	K
50° Elevation	106	101	104	K

G/T (3)	17.700 GHz	19.450 GHz	21.200 GHz	Unit
5° Elevation	37.8	38.6	38.9	dB/K
10° Elevation	38.1	39.0	39.5	dB/K
20° Elevation	38.4	39.3	40.0	dB/K
30° Elevation	38.5	39.6	40.3	dB/K
40° Elevation	38.6	39.6	40.4	dB/K
50° Elevation	38.6	39.7	40.5	dB/K

Polarization Isolation	Receive	Transmit	Unit
On axis	1.06	1.06	:1
1dB contour	1.06	1.06	:1

Return Loss	Receive	Transmit	Unit
	1.30	1.30	:1

Power Handling (per port)	Receive	Transmit	Unit
	-	500	W

Port-Port Isolation	Main Band	Unit
Tx -> Rx	85	dB
Tx -> Tx	16	dB
Rx -> Rx	16	dB

Mechanical	Receive	Transmit
Flange Material	Aluminum	Aluminum

Notes:

1. All performance values are referenced to rear output feed flange.
2. 20°C, Clear sky conditions, <7.5 g/m3 water vapor, +/-5K
3. G/T is typical for single thread 110 K LNA connected directly to the feed flange and does not include post LNA contributions.
4. Antenna pattern sidelobes are compliant to ITU-R S.580-6 and ITU-R S.465-5 recommendations, a maximum of 10% of sidelobes may exceed the pattern envelope per recommendation guidelines.

TABLE 1 RF-4CPWWKA-94-206

1.1.3 **Unique 9.4m Features**

The 9.4m incorporates a industry unique very reliable, low maintenance, low cost and low power consumption tracking mechanism that exploits the fact that next generation Ka-Band spot beam satellites must maintain their orbital positions within a small orbital box. For these satellites, accurate station keeping is a necessity in order to keep the multiple tiny spot beams from wandering about, which would cause cross-beam interference and beam edge level degradation.

The ASC Signal Subreflector Tracking (SRT) technology exploits the small orbital box size, by positioning the antenna's main beam constantly toward the satellite by using small controlled movements of the subreflector. This technique can be used when the satellite's AZ/EL pointing angles don't migrate "off axis" from the antenna's mechanical axis by more than three antenna beam widths during tracking. For a 9.4M, at 29 GHz, that translates to ± 0.22 degrees. With the tracking scan angle limited to within this range, there are negligible scan losses, and the cross polarization isolation and the off axis radiation pattern envelope performance remain within all regulatory compliance specifications.

It is important to note that should SRT mechanism fail, the tracking controller in the ASC proposed system will automatically default back to pedestal drive motion to continue with the tracking operation.

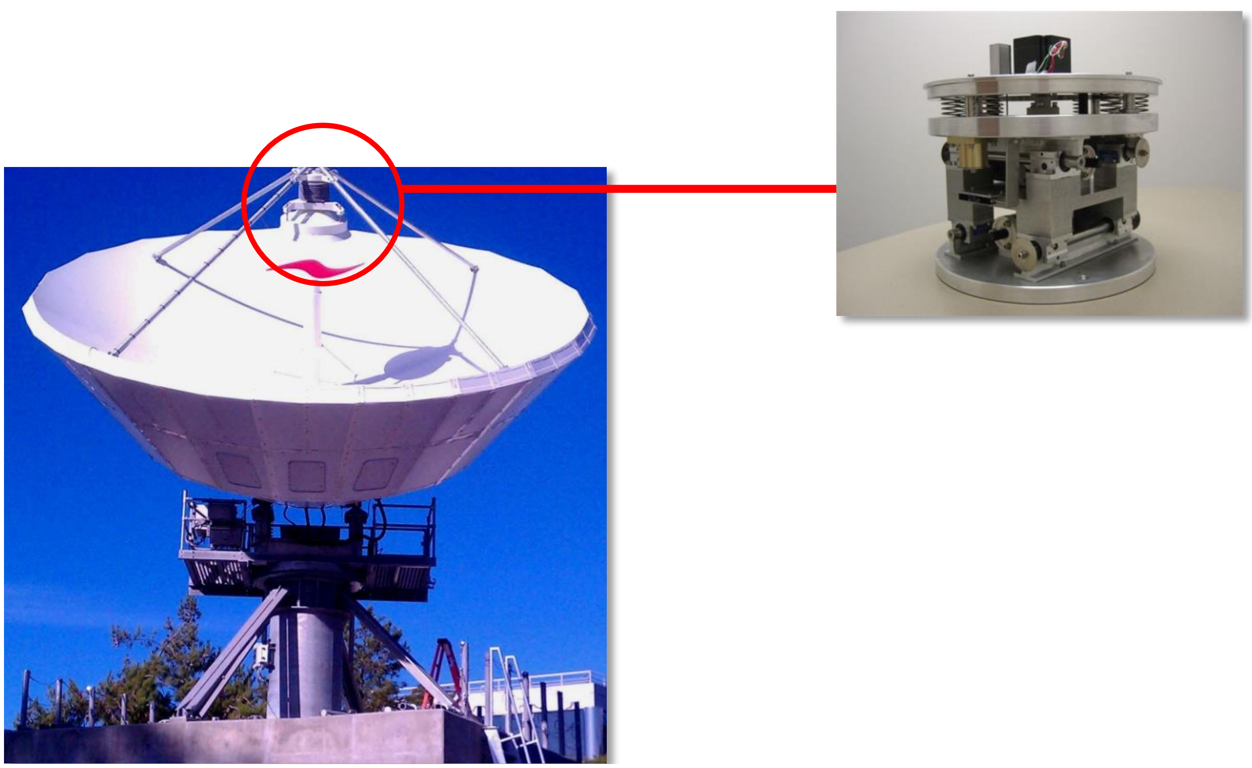


FIGURE 5 KA-BAND GATEWAY ANTENNA WITH 3-AXIS SRT

The ASC Signal 3-axis SRT assembly depicted in Figure 6 above can efficiently track through beam deflections AND adaptively compensate for antenna de-focusing due to antenna heating from de-ice and solar exposure.

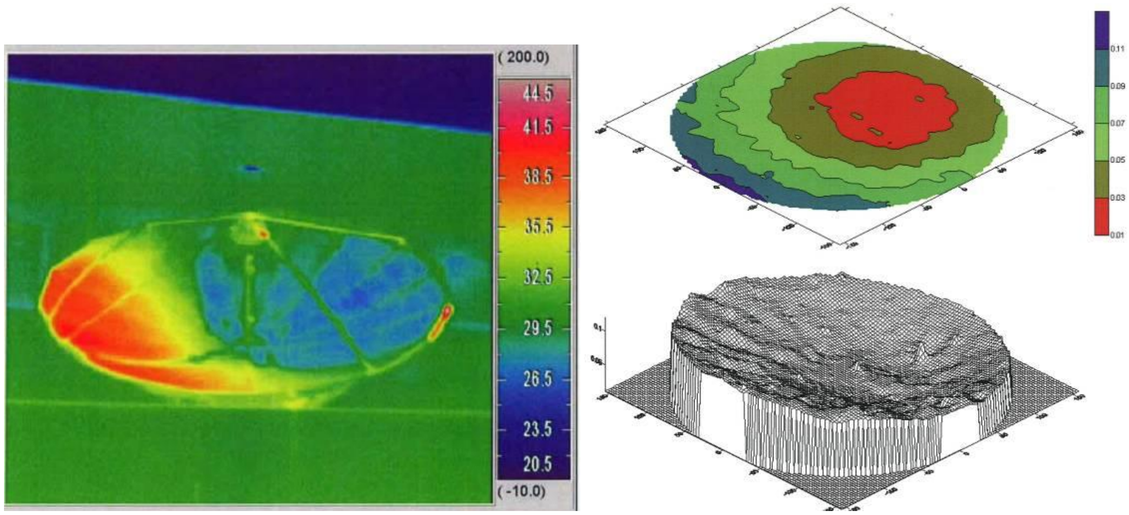


FIGURE 6 MEASURED REFLECTOR DISTORTIONS DUE TO THERMAL LOADING

Figure 7 shows actual measured data (infrared photo left, surface distortions right) of a reflector during afternoon sun induced heating. The vertical scale on the distortion plot is approximately 3 mm peak to peak.

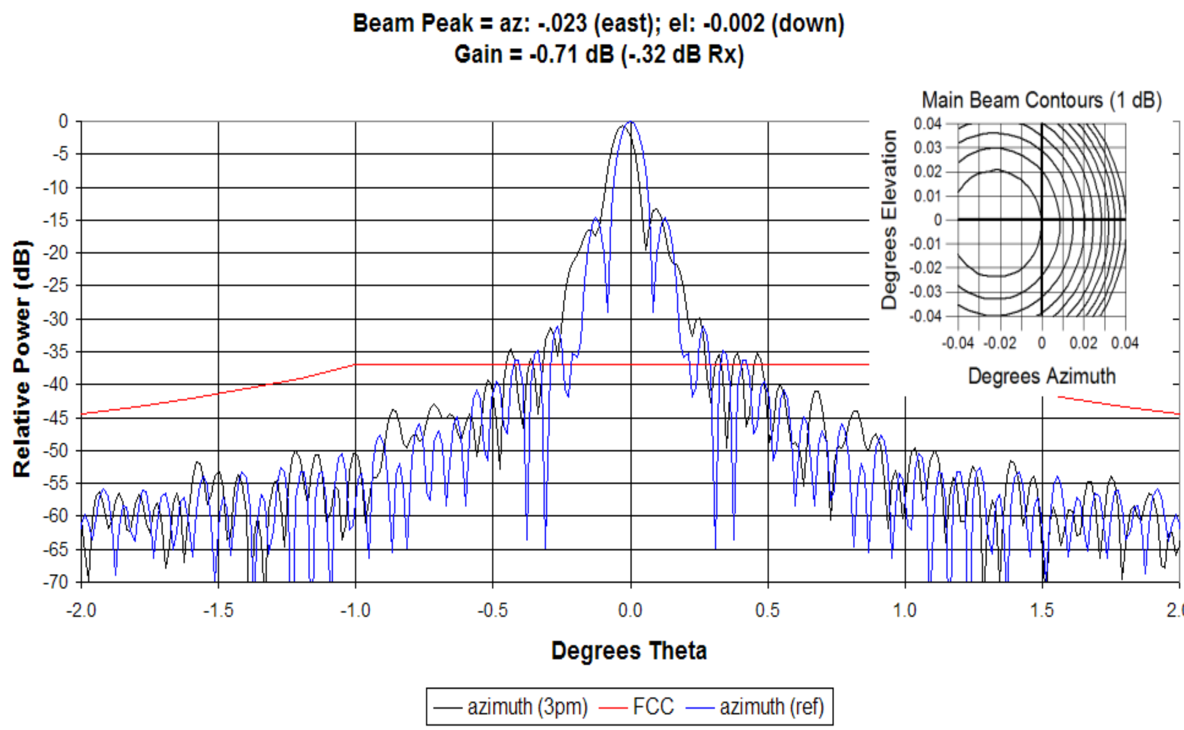


FIGURE 7 EFFECT OF 3-AXIS SRT THERMAL COMPENSATION

Fig 8 shows the antenna performance impact of the 3-axis SRT at Ka-Band. The plot shows an antenna pattern (in black) distorted by sun induced thermal distortions. There is evidence of both a mechanical bias (beam steer) and reflector de-focusing. With the 3-axis tracking engaged (blue), the antenna performance is much improved. Without the adaptive refocusing, these results indicate an uplink (30 GHz) loss in the order of 1 dB or more would occur. A complete description of the 9.4m capabilities along with a complete report on measured distortion and SRT tracking compensation data is available upon request.

1.1.4 **Mechanical Description and Performance**

The extended azimuth galvanized pedestal mount assembly provides antenna positioning ranges that easily comply with the most program operational requirements. The mount incorporates variable speed dual drives in both axes that provide the necessary stiffness to maintain accurate antenna pointing in high wind conditions.

The 9.4m antenna mechanical design is based on time proven, fielded technology. Established finite element modeling methods backed up by decades of installation experience form the basis of this optimized construction. A similar gateway antenna construction is shown figure 9. Table 3 is a list of some of the key features and performance specifications of the 9.4m antenna and pedestal construction.

Optical Design	Symmetric Gregorian Dual Reflector
Reflector Panels	Precision stretch formed aluminum
Backstructure	Precision thermally matched aluminum
	Stress-free 2 piece rib construction
	Precision eccentric cam adjustment
Reflector Segments	20
Mount Type	Pedestal, Hot dip galvanized steel
Travel Range (continuous)	
Azimuth	>200^{o}
Elevation	0^{o} to 90^{o}
Hub/enclosure dimensions	
Depth	46”
Diameter	84”
Operating Temperature	-40^{o} to 125^{o} F
Seismic	Richter 8.3 or Grade 11
Wind Loading, Survival	125 MPH any position

TABLE 2 9.4M EARTH STATION ANTENNA

FIGURE 8 ASC GATEWAY ESA

The pedestal position drive system incorporates dual opposing gear motors with brakes for precision antibacklash motion and high strength antenna hold performance. The elevation drive consists of mechanically linked dual jack screws for structural stability and low backlash characteristics. The ability to manually reposition the antenna with a handcrank is available for both axes. A close up of the Azimuth drive system is shown in Figure 10.

FIGURE 9 VIEW OF AZIMUTH DRIVE

All ASC antenna constructions utilize galvanized steel, stainless steel and painted aluminum components for superior corrosion resistance and durability. The large maintenance platform provides substantial room for multiple personnel during troubleshooting and maintenance operations and allows access to the antenna hub enclosure even when the antenna is positioned at zenith.

Swept antenna volume drawings shown in Fig. A2.8 and A2.9 incorporate several additional features proposed for the configuration. Note the platform stairway and hub enclosure access door.

ASC also supplies foundation loading requirements and typical foundation drawings. An example foundation specification in shown in Fig. A2.10.

For the typical configuration, ASC has added several features specifically requested. The outline drawing shown in Fig. A2.7 depicts an access ladder and hub rollup door.

1.1.5 **Hub Integration**

Figures A2.5 and A2.6 show preliminary internal hub layouts with the following major electronics:

- Transmit Power Amplifier subsystem
- Low Noise Amplifier subsystem
- Transmit Block Upconverter subsystem
- Receive Block Down Converter subsystem
- Ka/L band frequency converters for Signal Monitoring, Tx Carrier Monitoring and Monopulse Tracking

Other ancillary components listed below will be strategically positioned inside the Hub:

- 10 MHz (passive) distribution subsystem (splitters)
- Tracking LNB, Plate and Block Down Converter
- Signal monitoring RF switch matrix and L-band relay switches

Several access points, space for CFE (Noise Source), test panels and power outlets for testing by the Customer's technical staff will be provided.

Placement of the major subsystem and components is optimized to meet the following objectives:

1. Shortest possible path length for RF connections to minimize loss, with priority given to traffic signal paths, followed by monitoring signal paths
2. Logical grouping
3. Accessibility for maintenance and testing

All internal Hub cable connections, i.e. L-band signals (for traffic, signal monitoring and tracking), 10 MHz reference distribution cables, data communication for control and management (coax, multiconductor or fiber optic) will use internal jumper cables. These will interface at one or more Cable Interconnect Panels inside the hub with the outside IFL cables. The latter are routed through cable access openings below the door, which are weather protected using rubber boots.

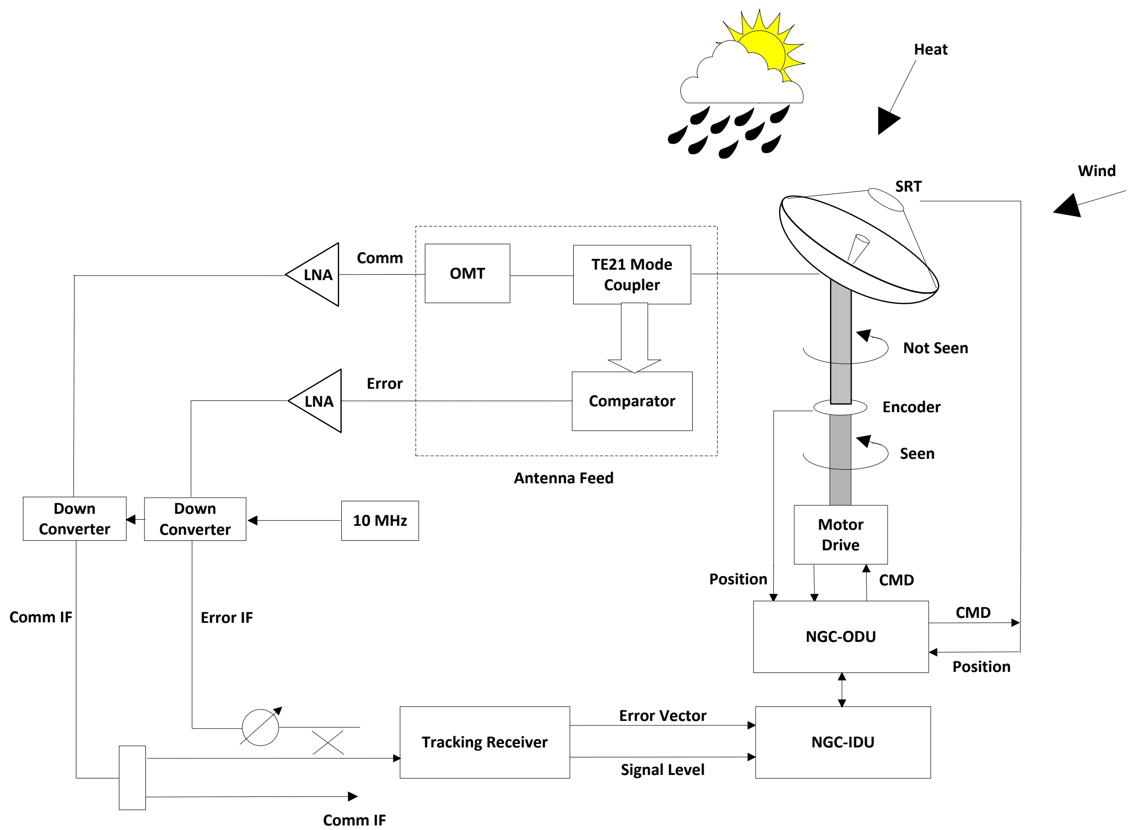
1.1.6 **Antenna Tracking System**

1.1.6.1 **Summary**

The 9.4m antenna design, when combined with the extended azimuth precision dual drive mount and ASC Signal's patented 3-axis subreflector tracker (SRT) technology, provides an extremely versatile and reliable overall gateway antenna solution. The tracking system block diagram shows the basic tracking system (Monopulse) needed for this configuration. This industry unique setup lends itself to also be used to track satellite motions by a variety of other methods. The ASC Signal NGC controller allows for all traditional tracking methods including, but not limited to:

- Ephemeris track (INTELSAT, NORAD, etc)
- Step Track with patented 3 point peaking
- SmartTrack (Predictive Model Track)
- Traditional Monopulse track

The following diagram shows a simplified schematic diagram of the tracking control system.



ASC Signal SRT based Monopulse Block Diagram

FIGURE 10 TRACKING SYSTEM CONTROL

As shown in the block diagram, the ASC Signal tracking system can be used to operate the traditional mount motion drives, AND/OR our patented 3-axis subreflector tracking (SRT) subsystem using a single control system.

The SRT provides a fast, extremely accurate antenna beam steering system, and importantly allows for tracking with significantly reduced mechanical drive wear and maintenance (since the main reflector does not need to move for most corrective tracking steps. Due to the much lesser mass being moved as compared to the mass of the entire reflector system, the SRT consumes far less power – approximately 75W during motion and less than 25W when holding position.

Most importantly this SRT configuration delivers an inherent redundant tracking system feature. The system normally operates with SRT movements, falls back to the conventional main dish alternative upon equipment fault.

In addition to the above redundancy from the antenna mechanics, the NGC also will be configured to offer redundancy in the electronics, as described in the following.

1.1.7 **Antenna Control System Architecture**

1.1.7.1 **Indoor Antenna Control System Equipment**

The ASC NGC indoor unit (NGC-IDU) is a standard ASC Signal product, offered to and used with a variety of options by our customers.

For some proposals Monopulse Tracking implementation, the indoor equipment for the antenna control system will consist of:

- Two (2) NGC-IDU units, configured as a 1:1 redundant pair with automatic reversion, with separate optical fiber links to the NGC-ODU equipment. Each NGC-IDU would be equipped with all necessary software licenses to support all tracking modes (steptrack, predictive track, monopulse).

- Two (2) monopulse-capable tracking receivers, paired with NGC-IDU units. The primary tracking receiver would be configured for monopulse. Which receiver is used would depend on which NGC-IDU was active. The monopulse tracking receiver is connected to a monopulse tracking plate in the hub.

A Cisco Catalyst 2960 switch will be supplied for interconnecting the antenna control system equipment.

The indoor equipment will be linked to the outdoor equipment using optical fiber (for the antenna control IDU-to-ODU units) and coaxial cable (for the tracking receiver to tracking plate interface).

The M&C system will interface to the control system using the NGC-IDU's SNMP agent. This will include proxy control of the tracking receiver and other equipment attached to the Antenna Control System.

In addition to tracking, the NGC-IDU will also provide the following basic functions:

- Position designate pointing, and jog functions for all five major axes.
- Display of look angles to a default resolution of 0.001°, with optional resolution to 0.0001°.

- Tracking logs including storage of pointing angles every one second to analyze the performance of the monopulse tracking system. Note this requires an optional larger storage card system.

The redundant NGC-IDUs will be configured in an NGC Cluster with the NGC Accessory Controller. This configuration will allow the NGC-IDUs to share configuration information; the backup NGC-IDU will therefore not need to be separately managed. This also allows sharing some operational information, such as signal strength indications and fault statuses.

1.1.7.2 **Outdoor Antenna Control System Equipment**

Outdoor equipment in the NGC architecture includes all motor drive electronics, axis transducers, and limit switches. All axes have both soft and hard movement limits.

The outdoor equipment will consist of:

- The NGC-ODU for the extended azimuth mount, which consists of several small electronics enclosures interconnected by the NGC Bus. These enclosures will include the following electronic components:
- Two (2) MC-7 master control boards, each mated via fiber connection to an NGC-IDU.
- One (1) elevation drive interface, which consists of a Yaskawa V1000-based variable frequency drive, control electronics, a 26-bit Heidenhain ROC 426 optical encoder for the main elevation drive, and the mechanical limit switch package. Dual motors are not necessary in elevation because gravity bias tends to remove backlash from the axis. The motorization of elevation will be jackscrew-based.
- One (1) azimuth drive interface, which consists of two Yaskawa G7-based variable frequency drives, control electronics, a 26-bit Heidenhain ROC 426 optical encoder for the main elevation drive, and the mechanical limit switch package. The azimuth drive uses two AC motors and uses electrical preload (counter-torque) to remove backlash from the axis. The motors will be connected through spur-and-bull-gear to the azimuth axis.
- One (1) three axis SRT drive interface, which can move the SRT in the azimuth (X), elevation (Y), and focus (Z) axis. (The ability of the SRT to refocus the antenna is significant as thermal distortions include shallowing/deepening of focus.)
- For the Main GW, one (1) monopulse tracking plate, which takes the delta signal from the feed and combines it with the sum signal at calibrated phase delays (under control of the tracking receiver) to construct a synchronously amplitude modulated beacon signal. The tracking receiver demodulates this signal to recover the delta amplitude.
- For the Main GW, one (1) tracking down-converter.

The outdoor motorization control system (pedestal positioner and SRT) proposed is substantially identical to one delivered to multiple US sites in the 2010-2012 time period. The NGC-ODU provided will be a standard ASC Signal product available to any customer, and is not expected to be a custom design.

1.1.7.3 **Antenna Control System Redundancy**

With respect to system antenna control, the proposed architecture of the overall Dual Gateway implementation offers multiple redundancy protection levels at several points:

- Spatial diversity. The backup gateway supplies a redundant system.
- Equipment redundancy, i.e., tracking receiver, NGC-IDUs, the fiber links to the NGC-ODUs and an electronics module in the ODUs.

ASC Signal proposes the following to be non-redundant:

- The backup antenna control system will not be equipped with a monopulse tracking plate. ASC Signal believes the combination of a backup gateway and steptrack is adequate for all reasonable scenarios if repair of the monopulse tracking system is required.
- The main reflector motorization subsystem will not be redundant, nor is the SRT, since they effectively back up each other for a geostationary satellite.

1.1.7.4 **Evaluation of Tracking Modes of Operation**

The following is in response to the RFP requirement for evaluating different tracking modes.

The NGC will be capable of operating in the following tracking modes:

i. Monopulse tracking where the tracking receiver continuously supplies a pointing error to the control system without depointing the main beam. This is accomplished by receiving a "delta" output from a specially constructed feed assembly and multiplexing that onto the "sum" signal using phase delays to electronically steer the receive beam. Algorithmically this is the simplest tracking approach: the NGC will develop a new commanded angle based on the pointing error added to the current position, and drive toward that angle. Because the system has two degrees of freedom for each axis, the NGC must allocate the commanded azimuth and elevation to main reflector and SRT commands, which is done by the NGC-ODU. The SRT is normally moved preferentially unless the movement exceeds a user-defined circular limit, in which case the system simultaneously moves both subreflector and main dish to smoothly re-center the SRT. The effect is that the control system minimizes the delta channel ("null seeking") as the main optimization criterion for tracking. The drawbacks to monopulse tracking are:

    (a) the complex receiver electronics necessary to analyze the delta channel from the TE21 mode coupler, and

(b) sensitivity to asymmetry in the reflector that distorts the shape of the "delta" pattern versus the "sum" pattern. Large Ka-band antennas in particular, because of the short wavelength, are subject to significant pattern asymmetries due to solar heating. Under some clear-sky conditions, this effect may make monopulse tracking performance less than desired. In these cases the customer should fall back to step track.

Note that monopulse tracking cannot focus the Z axis of the SRT. This process must be done through an occasional step track process.

ii. Step track¸ where through small depointings of the receive beam, and measurement of the resulting signal loss, peak signal angles are empirically derived. This approach is well-understood and universal.

The main drawback to step track for this application is that de-pointing the receive beam enough to make for a measureable loss will cause a significant loss in the transmit uplink. Smaller step sizes reduce the loss but they also decrease the RMS accuracy due to the lack of resolution in the signal strength. Since the customer requires a 0.3dB max drop (10% of beamwidth), a very small step size (5%) coupled with very long integration times (10-15s) will be required to get reasonable performance. This makes it suitable as a fallback or emergency tracking approach but for normal operation it will have trouble meeting the desired performance.

iii. Orbital prediction or "SmarTrack", where step track is used to construct a mathematical model of the motion of the satellite which is constrained by astrodynamics. Once the model is built, it is used to predict the motion of satellite, and therefore the antenna.

The problem with orbital prediction is it was developed to solve a different problem than the one presented by most large-aperture Ka-band systems. It assumes that the orbital motion of the satellite is the only significant variable in the beam angle. For well-station-kept satellites ($i < 0.1°$) the motion due to astrodynamics is comparable in magnitude to a completely uncorrelated but non-random beam deformation due to thermal distortion of the main reflector under solar load. Since the orbital models all assume that pointing feedback noise is just noise, and since they assume that the filtered pointing angles correspond to true look angles of satellites in Keplerian orbits, the existence of non-random noise makes the orbital prediction process inaccurate. ASC Signal's experience is that no orbital-derivation algorithm is useful for low-inclination Ka-band satellites with large apertures due to these factors.

iv. Ephemeris Predictive track (NORAD/Intelsat elements), where an authoritative set of Keplerian ephemeris parameters is used to predict look angles.

These approaches all suffer from the same issues as orbital prediction, due to the same combination of circumstances as mentioned above.

The following tables show typical performance tracking analysis results of the 9.4m antenna operating in Ka-band for three different tracking methods, using both the SRT and mount motion tracking scenarios under both calm and moderate wind conditions for various frequencies. One of the three methods, “Memory” track, covers ephemeris (NORAD, Intelsat, etc), and predictive track where there is no direct beacon reception feedback required.

Results are provided both in angular tracking error as well as predicted signal tracking losses in both the downlink and uplink. The half power beamwidths for 30 GHz transmit and 20 GHz receive frequencies are 0.072 deg and 0.108 deg respectively.

Each table gives a predicted RMS and a calculated expected peak error based on worst-case assumptions. Peak errors would be transient, RMS errors will be normally present.

For step track in calm conditions, the predicted performance for the main reflector is 0.15dB RMS downlink and 0.33dB RMS uplink loss. The majority of the loss is caused by the step track motion.

For monopulse tracking with the main reflector improvements to about 0.010dB/0.030dB are achieved. This assumes that there is no significant thermal distortion of the main reflector causing asymmetries which would introduce tracking errors to the monopulse mode. When the environmental control system detects significant temperature gradients across the dish, it may be necessary to switch to step track to resume peak-based pointing rather than null-based pointing.

In windy conditions the RMS tracking losses for steptrack increase to 0.19dB and 0.43dB. Note the sharp increases in peak error caused by deflection. Memory track is even worse due to the lack of control system feedback to implement counter measures to unobservable structural wind-up caused by wind force.

In clear skies, SRT tracking for steptrack improves the performance slightly due to the increased accuracy of the subreflector positioner.

STEP TRACK 9.4 m Performance Ka-band	Weather	Calm Clear Sky Conditions				Operational Winds 44.7 gusting to 55.9 mph			
	Dist Type	**Mount Motion Drives**		**SRT**		**Mount Motion Drives**		**SRT**	
		RMS	Peak	RMS	Peak	RMS	Peak	RMS	Peak
Feedback Quantization	Constant	0.0004	0.0007	0.0000	0.0000	0.0004	0.0007	0.0000	0.0000
Deadband	Constant	0.0017	0.0030	0.0006	0.0010	0.0017	0.0030	0.0006	0.0010
Tracking Lag	Sinusoidal	0.0031	0.0044	0.0031	0.0044	0.0031	0.0044	0.0031	0.0044
Scintillation Noise	Gaussian	0.0033	0.0098	0.0033	0.0098	0.0033	0.0098	0.0033	0.0098
Wind Induced Error	Gaussian	0.0013	0.0039	0.0013	0.0039	0.0013	0.0039	0.0013	0.0039
Variable Tracking Error	Mixed	0.005	0.010	0.005	0.010	0.005	0.010	0.005	0.010
Gust Deflection	Gaussian	0.000	0.000	0.000	0.000	0.007	0.020	0.007	0.020
Total Variable Error	Mixed	0.005	0.010	0.005	0.010	0.008	0.021	0.008	0.021
Scan Loss	Absolute	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Total Angular Error deg		0.012	0.015	0.012	0.014	0.014	0.023	0.013	0.023
DL Signal Loss dB		**0.15**	**0.22**	**0.14**	**0.21**	**0.19**	**0.57**	**0.19**	**0.56**
% of HPBW		11.0%	13.6%	10.9%	13.4%	12.6%	21.7%	12.5%	21.7%
UL Signal Loss dB		**0.33**	**0.50**	**0.32**	**0.48**	**0.43**	**1.27**	**0.42**	**1.27**
% of HPBW		16.5%	20.4%	16.4	20.0%	18.9%	32.6%	18.7%	32.5%

TABLE 3 STEP TRACK SYSTEM PERFORMANCE

MEMORY TRACK 9.4 m Performance Ka-band	Weather	Calm Clear Sky Conditions				Operational Winds 44.7 gusting to 55.9 mph			
	Dist Type	**Mount Motion Drives**		**SRT**		**Mount Motion Drives**		**SRT**	
		RMS	Peak	RMS	Peak	RMS	Peak	RMS	Peak
Feedback Quantization	Constant	0.0004	0.0007	0.0000	0.0000	0.0004	0.0007	0.0000	0.0000
Feedback Repeat.	Gaussian	0.0033	0.0100	0.0003	0.0010	0.0033	0.0100	0.0003	0.0010
Deadband	Constant	0.0017	0.0030	0.0006	0.0010	0.0017	0.0030	0.0006	0.0010
Prediction Error	Gaussian	0.0023	0.0069	0.0023	0.0069	0.0023	0.0069	0.0023	0.0069
Total Tracking Error	Mixed	0.004	0.012	0.002	0.007	0.004	0.012	0.002	0.007
Wind Deflection	Gaussian	0.000	0.000	0.000	0.000	0.018	0.054	0.018	0.054
Total Angular Error deg		0.004	0.012	0.002	0.007	0.019	0.055	0.018	0.055
DL Signal Loss dB		**0.02**	**0.15**	**0.01**	**0.05**	**0.36**	**3.18**	**0.34**	**3.09**
% of HPBW		4.1%	11.0%	2.2%	6.4%	17.3%	51.5%	16.9%	50.8%
UL Signal Loss Db		**0.05**	**0.33**	**0.01**	**0.11**	**0.81**	**7.16**	**0.77**	**6.96**
% of HPBW		6.2%	16.6%	3.4%	9.7%	25.9%	77.3%	25.4%	76.2%

TABLE 4 MEMORY TRACK SYSTEM PERFORMANCE

MONOPULSE 9.4 m Performance Ka-band	Weather	Calm Clear Sky Conditions				Operational Winds 44.7 gusting to 55.9 mph			
	Dist Type	**Mount Motion Drives**		**SRT**		**Mount Motion Drives**		**SRT**	
		RMS	Peak	RMS	Peak	RMS	Peak	RMS	Peak
Feedback Quantization	Constant	0.0004	0.0007	0.0000	0.0000	0.0004	0.0007	0.0000	0.0000
Deadband	Constant	0.0017	0.0030	0.0006	0.0010	0.0017	0.0030	0.0006	0.0010
Tracking Lag	Sinusoidal	0.0023	0.0032	0.0023	0.0032	0.0023	0.0032	0.0023	0.0032
Variable Tracking Error	Mixed	0.003	0.004	0.002	0.003	0.003	0.004	0.002	0.003
Gust Deflection	Gaussian	0.000	0.000	0.0000	0.0000	0.007	0.020	0.007	0.020
Total Variable Error	Mixed	0.003	0.004	0.002	0.003	0.007	0.018	0.007	0.018
Bias Error	Absolute	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Angular Error deg		0.004	0.005	0.003	0.004	0.007	0.019	0.007	0.019
DL Signal Loss dB		**0.01**	**0.02**	**0.01**	**0.02**	**0.06**	**0.36**	**0.05**	**0.36**
% of HPBW		3.3%	4.6%	3.0%	3.7%	6.9%	17.3%	6.7%	17.3%
UL Signal Loss dB		**0.03**	**0.06**	**0.02**	**0.04**	**0.13**	**0.81**	**0.12**	**0.81**
% of HPBW		5.0%	6.8%	4.4%	5.6%	10.4%	25.9%	10.1%	25.9%

TABLE 5 MONOPULSE SYSTEM PERFORMANCE

1.1.8 Environmental Controls

1.1.8.1 Dehydration Subsystem

The dehydration subsystem will use the ETI ADH NETCOM automatic dehydrator. This automatic dehydrator supplies low pressure dry air to keep waveguide and coaxial cable dry. "Snap On" type air leakage valves will be implemented along with quick release couplings Norgren Series 233 with type G ¼ connection for monitoring and testing the system. For easier management, operation, and maintainability this unit will be housed in an outdoor rated unit mounted on the antenna pedestal and will incorporate an Ethernet interface for integration to the M&C System.

1.1.8.2 Plenum Based Environmental Management

To help manage thermal distortion the 9.4m antenna subsystem can be integrated with a reflector enclosing plenum system. Normally reserved for colder climates with significant snowfall, this system has been designed to "manage" ambient temperature within the plenum behind the reflector by monitoring multiple points behind the reflector sense temperature differentials and responding as needed. These techniques result in a more uniform ambient temperature around the reflector. This management results in more improved performance of the reflector. ASC Signal has conducted extensive measurements both characterizing and optimizing plenum systems for Ka band ESA applications. A full measurement report on this activity is available upon request.

1.1.8.3 **Anti Dew Systems**

The 9.4m antenna subsystem also incorporates a feed anti-dew system designed to ensure the external surface of the feed window does not experience any dew-point condensation which could otherwise completely attenuate operational emissions.

1.1.8.4 **Rain Diverter**

ASC also uses rain deviator (feed blower) for rain events. Triggered by seninsing the presence of rain the system is designed to target a high velocity stream of air around the feed horn to vaporize any moisture near the vicinity of the feed horn window before. While this cannot mitigate far field attenuation in the path due to moisture, localized moisture around the feed no longer has the chance to hit the feed window surface and otherwise degrade the signals.

1.1.9 **Hub air conditioning**

As required dual air conditioning system will be installed to control the antenna hub temperature. The antenna hub will be sealed from leakage and insulated accordingly. The TWT exhaust will be connected to louvers ported out of the hub, venting excessive the heat from the hub and enabling more efficient operation. The air conditioning units will be sized sufficiently so that each individual air conditioning unit will be able to appropriately cool the equipment, hence the system, is redundant in respect that both are operable however in the vent of failure of a single unit the overall cooling operation will not be hampered. In addition, in the unlikely event both units fail the fan vent systems will activate for cooling the hub equipment.

1.2 G/T Analysis

A detailed analysis of the Gateway G/T has been performed. The detailed worksheet appear in Appendix C, and are summarized in the Table below. Ka Band G/T analysis is differs from Ku or C Band analysis due to monotonically increasing noise temperature with frequency due to the atmospheric absorption characteristics. This phenomenon is presented in the antenna's noise temperature Table of values below.

ELEVATION	*Antenna Temp (K)* *FREQ (GHz)*		
ANGLE (deg)	**20.2**	**20.7**	**21.2**
5°	172	184	195
10°	141	150	159
20°	120	124	128
30°	107	11	112
40°	104	106	108
50°	101	102	104

TABLE 6 9.4M NOISE TABLE

The G/T is degraded by tracking error, wind deflection and optical deformation and at Ka Band it is very important to consider solar defocusing. All antennas, no matter their design, are affected by solar defocusing to some extent. ASC has carefully characterized this degradation and has devised an industry unique form of mitigating this inherent gain reduction characteristic by adding a "Z-Axis" to the optics which effectively corrects the effects of solar optical distortion. Without the "Z-Axis" correction, an antenna can and does lose up to 1.4 dB of receive gain (even extremely robust structural designed antennas) in the presence of intense solar radiation. The ASC SRT Z-Axis correction reduces the solar defocusing affect to less than 0.25 dB! This is a critical element to consider when analyzing overall Gateway Terminal performance both at Transmit and Receive.

The following Table summarizes the G/T calculated for three various environmental conditions and for three separate hardware configurations. The three configurations are: (1) SRT Step Track, (2) SRT Mono Pulse, and (3) Mono Pulse Mount Motion. The three environmental conditions are: (1) Ideal Conditions, i.e., no wind and no sun, (2) Solar Defocus and no wind, and (3) Solar Defocus and wind simultaneously. The take-a-way from this data is simply that Mono Pulse tracking buys very little return for its complexity and cost and by mitigating the solar defocusing rather substantial gains are made. The data in the data is a little more meaningful when see graphically as illustrated in the following chart.

The proposed antenna and tracking system design affords a cost effective and less complex engineering solution that achieves a G/T within a small variance from the specification!

CONFIGURATION	G/T (dB/K)
SRT Mono Pulse ideal condx	38.66
Mount Motion Mono Pulse ideal condx	38.66
3-axis SRT ideal condx	38.53
SRT Mono Pulse Solar Defocus	38.41
3-axis SRT Solar Defocus	38.28
SRT Mono Pulse Solar and Wind	38.24
3-axis SRT Solar and Wind	38.11
Mount Motion Mono Pulse Solar Defocus	37.26
Mount Motion Mono Pulse Solar and Wind	37.09

TABLE 7 G/T TABLE

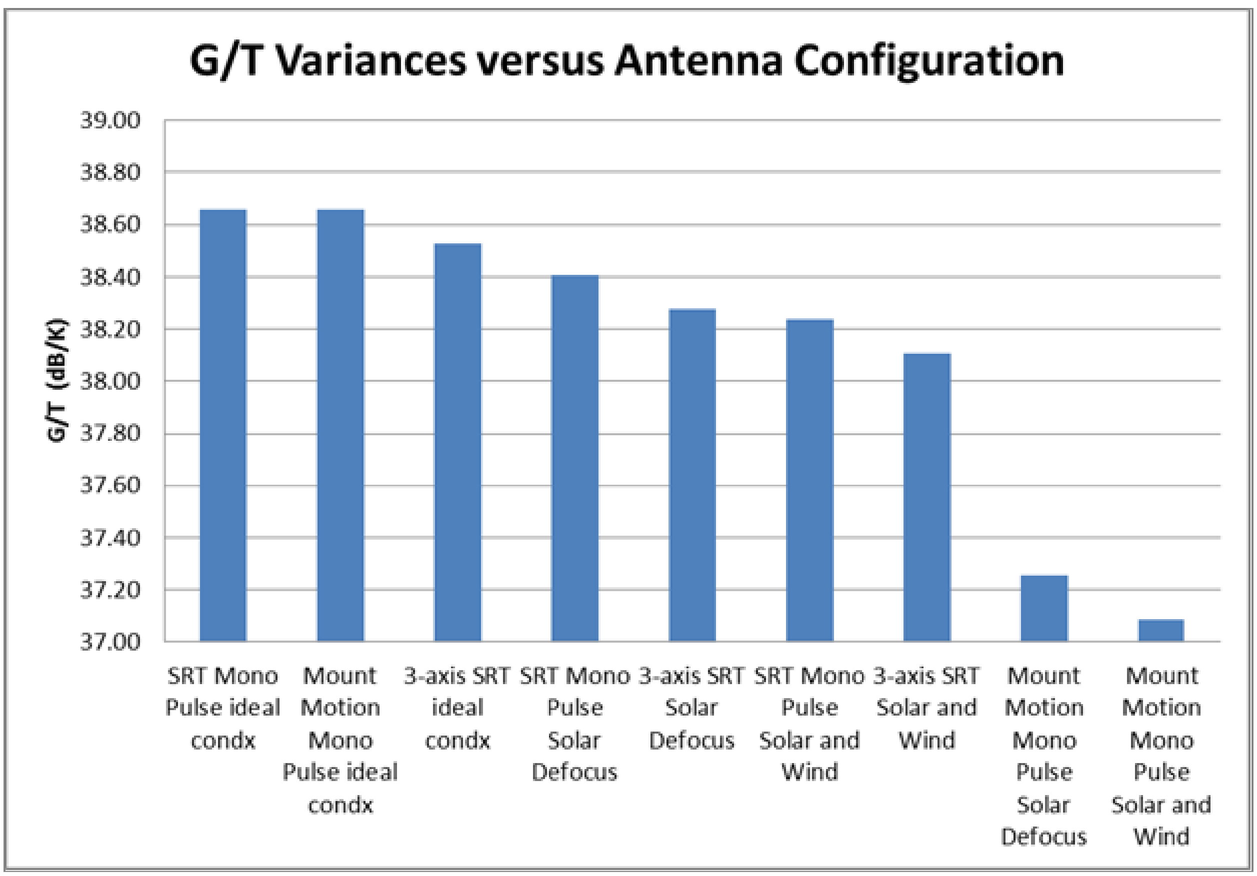


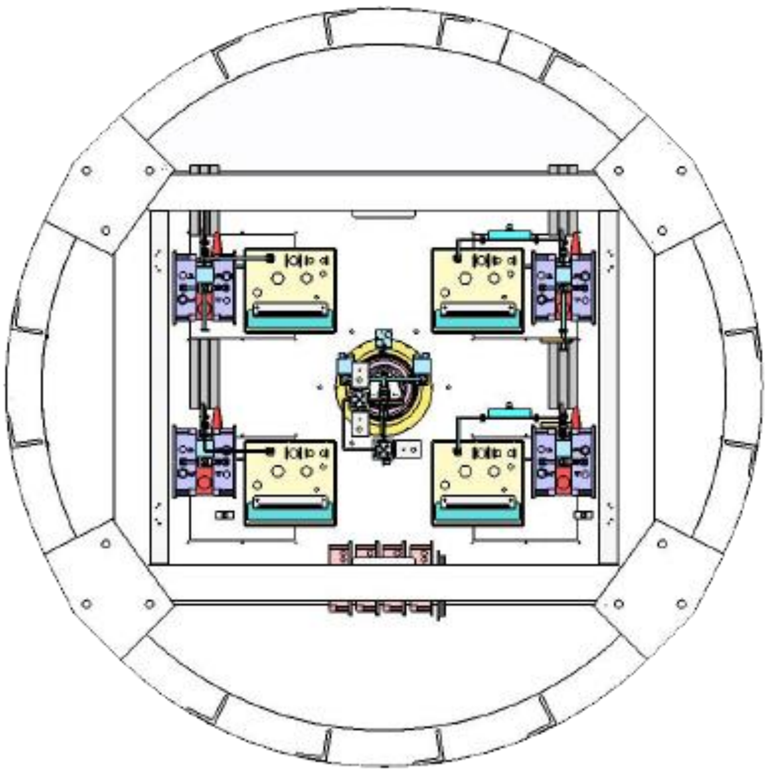
FIGURE 11 G/T CONFIGURATION VARIANCE

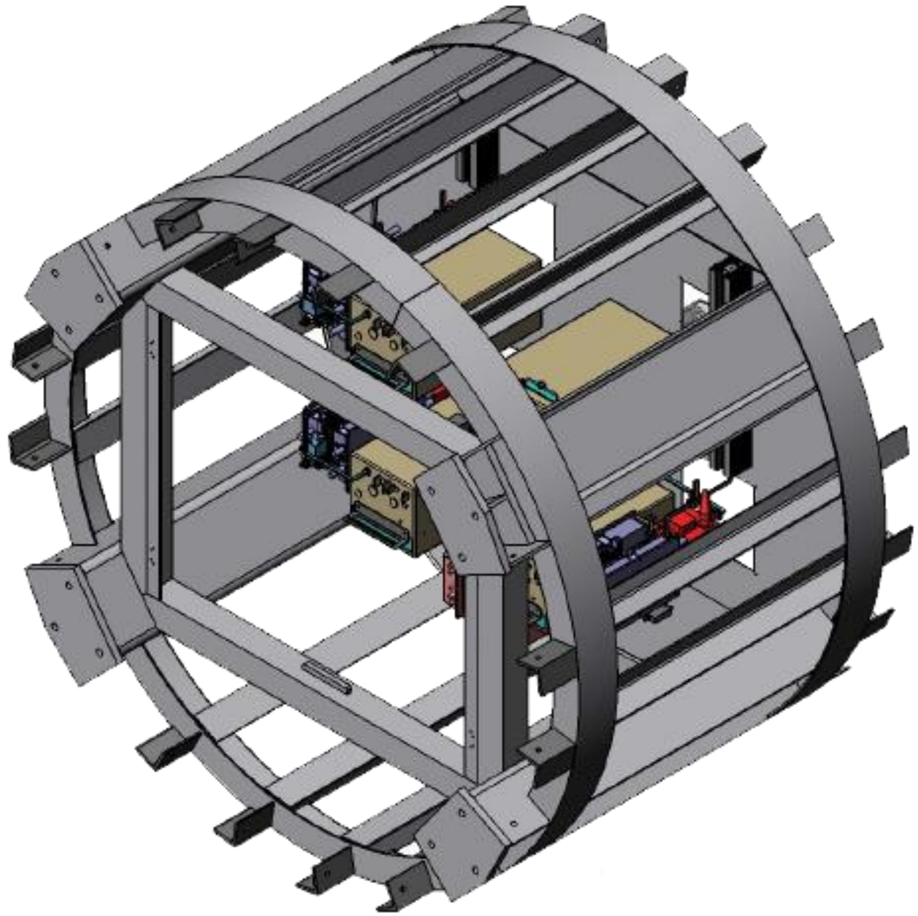
G/T CALCULATIONS	38.24	dB/K
SRT Step Track Antenna Parameters		
Antenna Type	9.4	M
Antenna Efficiency	53	%
Solar Defocusing with 3-axis SRT	0.25	dB
RMS Pointing Error Winds 45MPH gusts to 65MPH	0.18	dB
Effective Operational Antenna Gain @ Op Freq & Environ Condx	63.0	dBi
Antenna Noise Temp @ Op EL & Op Freq & Atmos water vapor =7.5 g/m^3	124.0	K
Combiner VSWR	1.3	:1
Antenna Op Elevation Angle	20.0	°
Op Frequency	20700	MHz
Analysis Ambient Temperature	23	C
LNA/LNB Subsystem		
Feed to Plate W/G Loss + Filter	0.438	dB
1:2 LNA Switch Plate w/cplr Loss	0.26	dB
LNA Temperature @ 23 C	100	K
LNA Gain @ 23 C	50	dB
LNA Input VSWR	1.25	:1
LNA Output +1 dB Comp Pt	10	dBm
System Analysis		
Net System Gains		
Antenna	63.0	dBi
W/G Connection	-0.44	dB
W/G Switch	-0.26	dB
LNA Mismatch	-0.05	dB
Net Gain	62.24	dBi
Net System Noise (Referenced at LNA Input)		
Ambient Temperature	23	° C
LNA	100	K
Antenna	104.29	K
TRF	26.42	K
W/G Switch	16.99	K
LNA Reflec. Noise	3.61	K
RF Cable/CPLR Loss	0.00	K
1:2 Switch Loss	0.00	K
BDC	0.22	K
100 M IFL	0.01	K
Net System Temp	251.53	K

Table 8 Sample G/T Calculation Monopulse SRT with Solar Defocusing

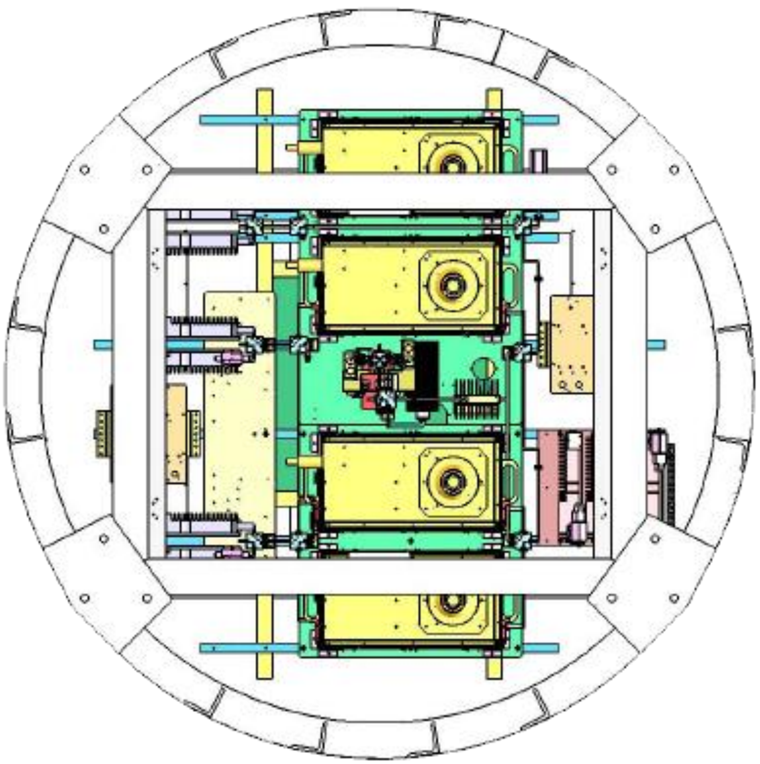
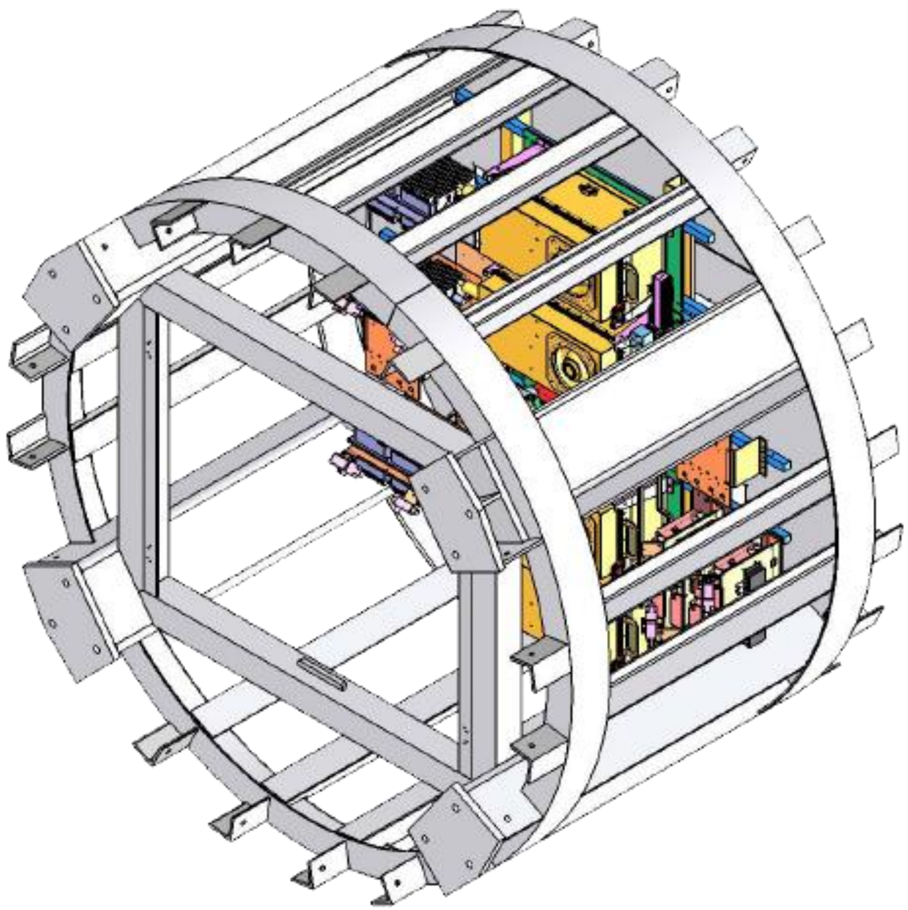
and 45 MPH Wind gusting to 60 MPH

ANNEX 2: DRAWINGS

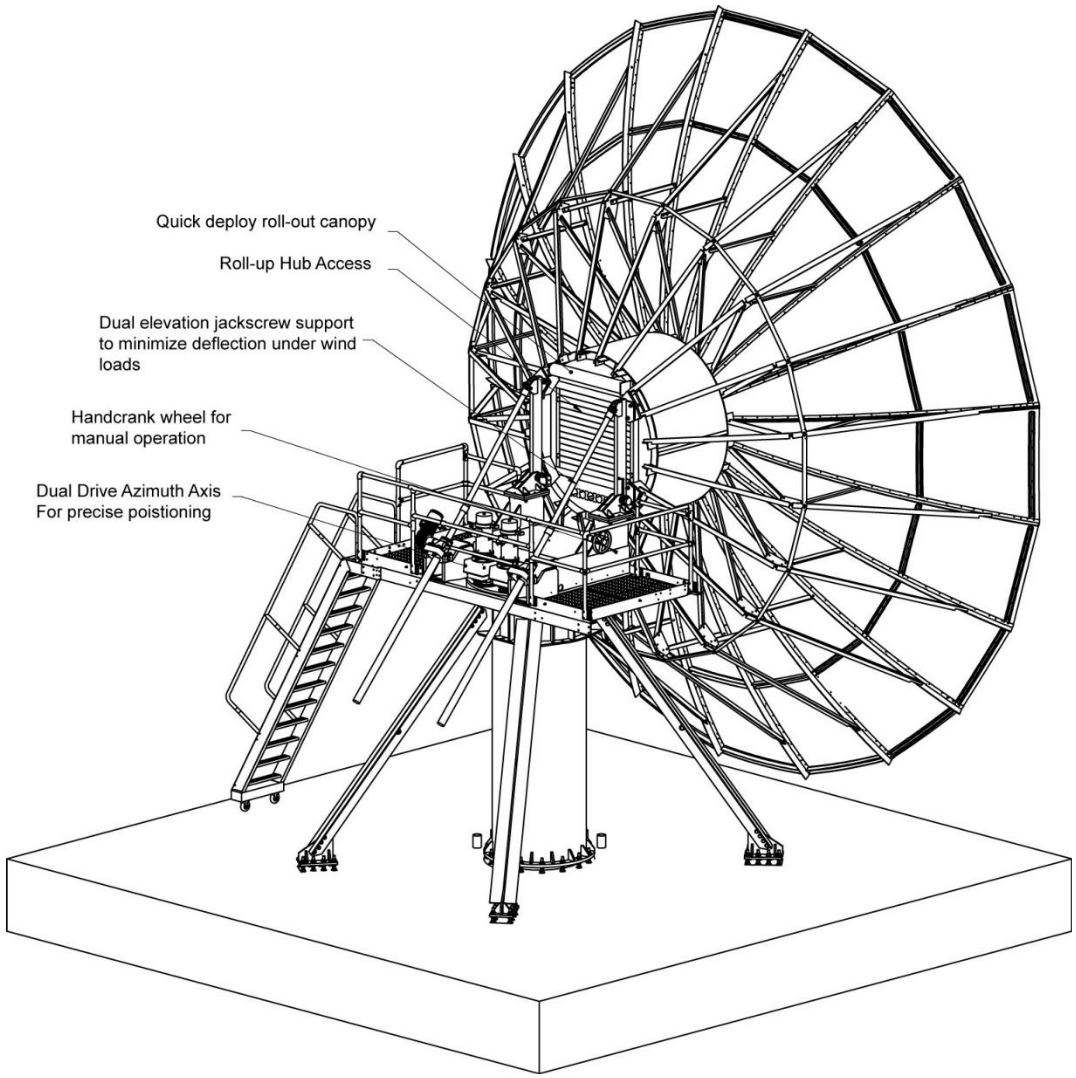




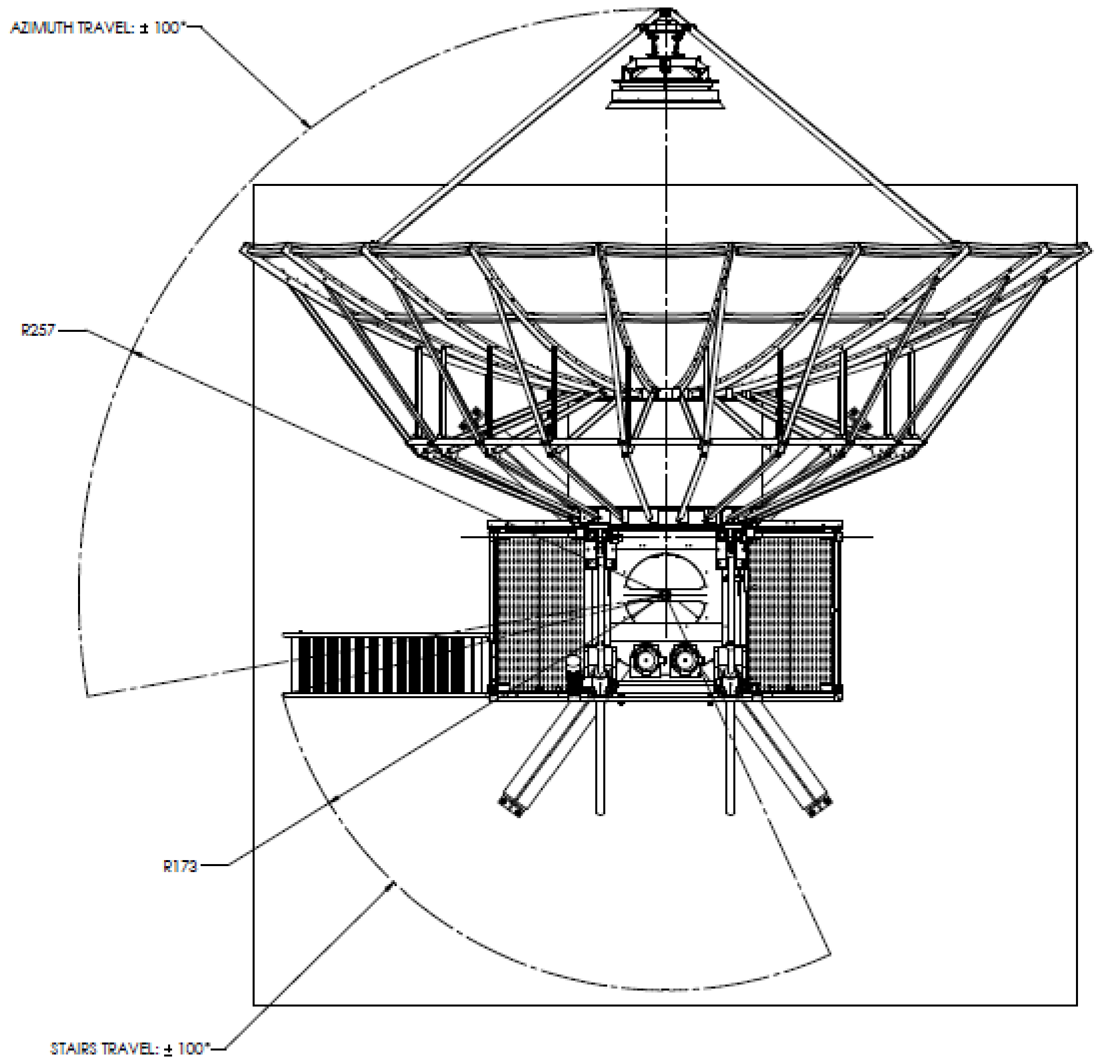
A2.5 - EXAMPLE HUB CONFIGURATION #1

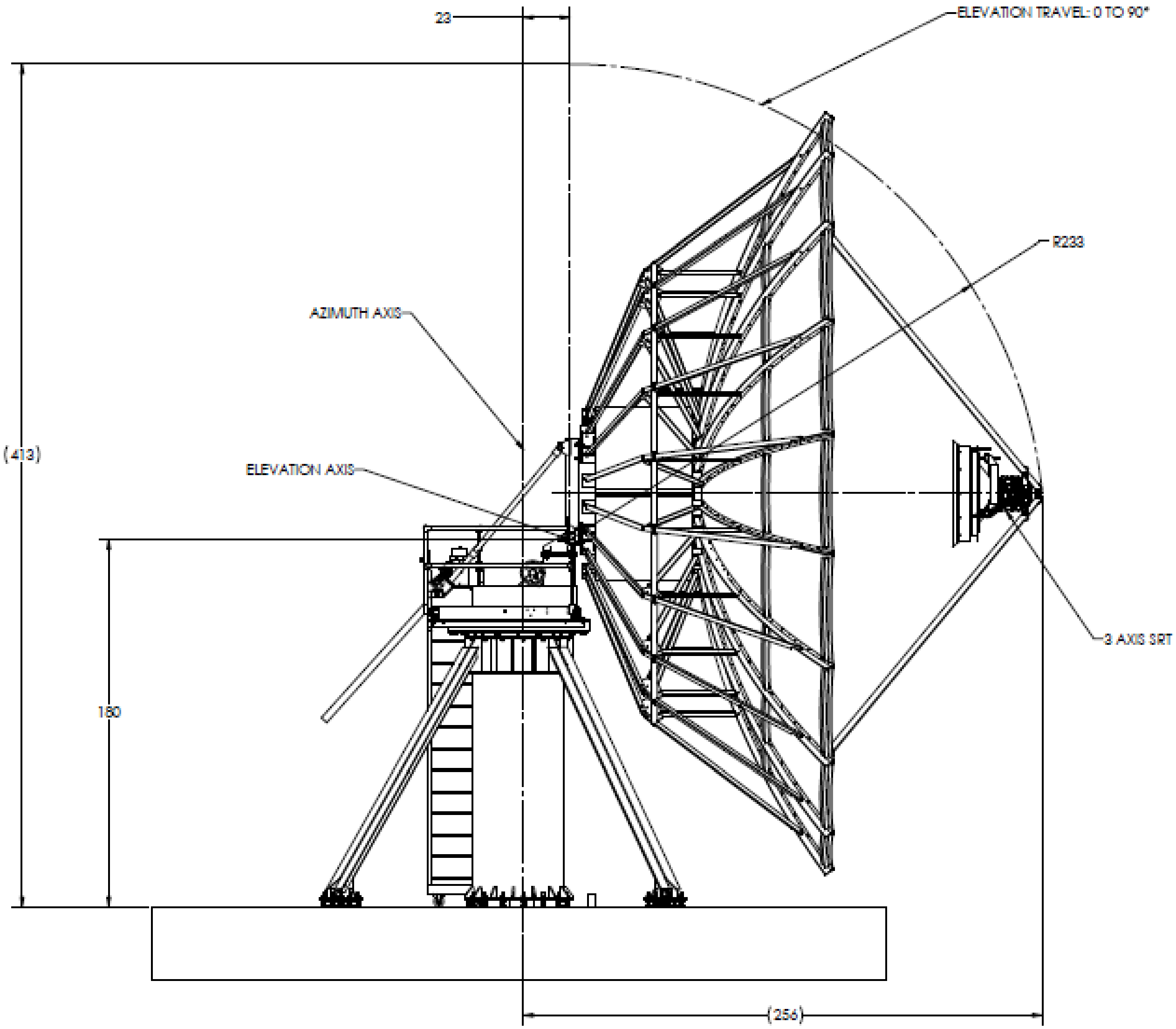
A2.6 - EXAMPLE HUB CONFIGURATION #2



A2.7 - 3-D ANTENNA MODEL



A2.8 - ANTENNA MOUNT, AZIMUTH SWEPT VOLUME

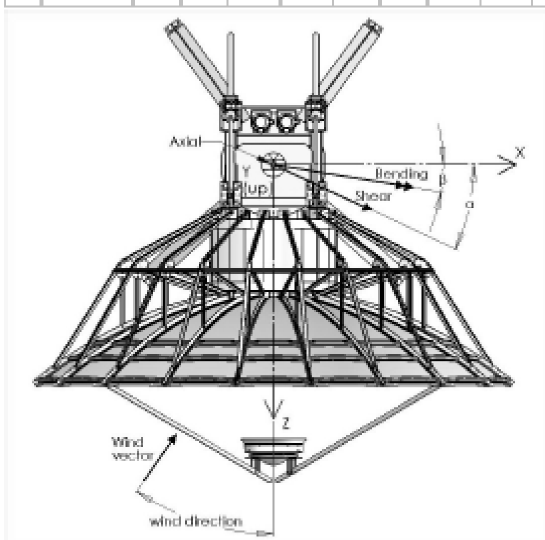


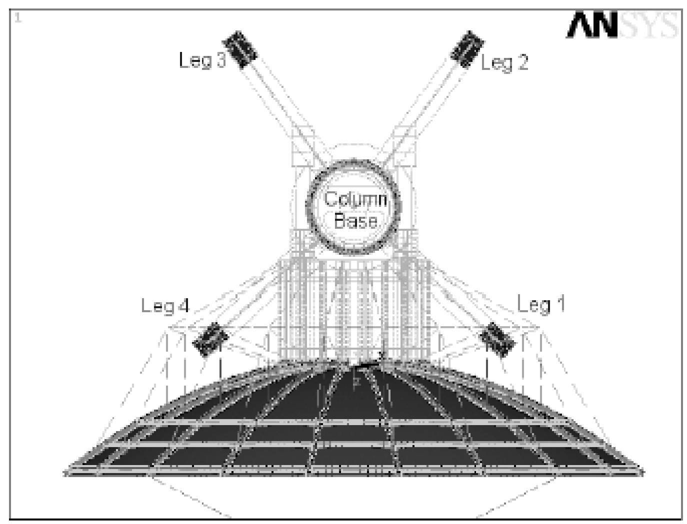
A2.9 - ANTENNA MOUNT ELEVATION SWEPT VOLUME

Foundation Loads (on axis)

Wind speed = 125 mph

	Loads	0° elevation				30° elevation				60° elevation				90° elevation				Max Loads
		0°wind	60°wind	120°wind	180°wind	0°wind	60°wind	120°wind	180°wind	0°wind	60°wind	120°wind	180°wind	0°wind	60°wind	120°wind	180°wind	
Column Base	Fx (Lbs)	-49	-915	1806	56	64	694	-1952	-33	1	-616	-4292	1	17	-6480	-6895	-15	- 6895
	Fy (Lbs)	-6710	-7570	-13948	-15745	-23770	-20031	-10874	-9847	-33721	-20137	-9160	-9020	-7325	-8107	-9585	-10480	- 33721
	Fz (Lbs)	2005	1013	-3729	-4855	-3132	-1776	-4777	-7143	-5923	-304	-6552	-9596	7374	3780	-3441	-7067	- 9596
	Mx (Lbs-in)	59712	52171	-22378	-44918	40252	32927	-23750	-35049	13165	9088	-14190	-35802	13960	6946	-7790	-15201	+ 59712
	My (Lbs-in)	-63	1390	-2180	-61	36	572	-1679	-37	-23	-164	-641	-18	11	3	-14	-15	- 2180
	Mz (Lbs-in)	791	-9596	20383	1295	-792	-8741	25297	679	242	4833	24555	186	-62	19690	20029	216	+ 25297
Leg 1	Fx (Lbs)	-7284	-6609	4021	6309	-4341	-4106	4875	5087	-405	-216	4594	4196	-1309	1526	3854	2620	- 7284
	Fy (Lbs)	9597	8672	-5798	-8918	5975	5260	-8976	-7261	211	-33	-6800	-6057	1536	-2407	-5594	-3945	+ 9597
	Fz (Lbs)	-6555	-5404	3591	5670	-3909	-3691	4367	4576	-389	-196	4130	3776	-1941	1375	3473	2357	- 6555
	Mx (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	My (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	Mz (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
Leg 2	Fx (Lbs)	7938	6749	-2133	-5405	5579	4322	-1515	-4538	2244	2076	-383	-3737	2533	2868	611	-2040	+ 7938
	Fy (Lbs)	-13967	-11885	3261	8960	-8612	-7719	2208	7510	-4185	-3905	255	6141	-4700	-5243	-1309	3211	- 13967
	Fz (Lbs)	-10921	-9053	2886	7438	-7678	-5808	2045	6241	-3090	-2882	476	5140	-3484	-3882	-847	2805	- 10921
	Mx (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	My (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	Mz (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
Leg 3	Fx (Lbs)	-7851	-7081	3044	5487	-5959	-5274	3676	4576	-2248	-1523	2244	3735	-2543	101	2367	2048	- 7851
	Fy (Lbs)	-13834	-12597	5827	9141	-10038	-9083	6115	7579	-4170	-2929	5341	6139	-4719	-131	3842	3227	- 13834
	Fz (Lbs)	-10803	-9791	4233	7551	-7777	-6896	5096	6296	-3080	-2090	4484	5139	-3496	145	3303	2817	- 10803
	Mx (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	My (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	Mz (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
Leg 4	Fx (Lbs)	7414	6087	-2647	-6175	4228	2932	-1486	-5024	406	1098	-37	-4197	2021	3272	959	-2805	+ 7414
	Fy (Lbs)	9771	7970	-3808	-8737	5403	3858	-2347	-7173	312	1173	-352	-6057	3443	4159	994	-3883	+ 9771
	Fz (Lbs)	-6671	-5494	2409	5558	-3808	-2546	1358	4520	-369	-690	33	3776	-1817	-2944	-864	2343	- 6671
	Mx (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	My (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0
	Mz (Lbs-in)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 0





A2.10 - SAMPLE FOUNDATION DRAWING

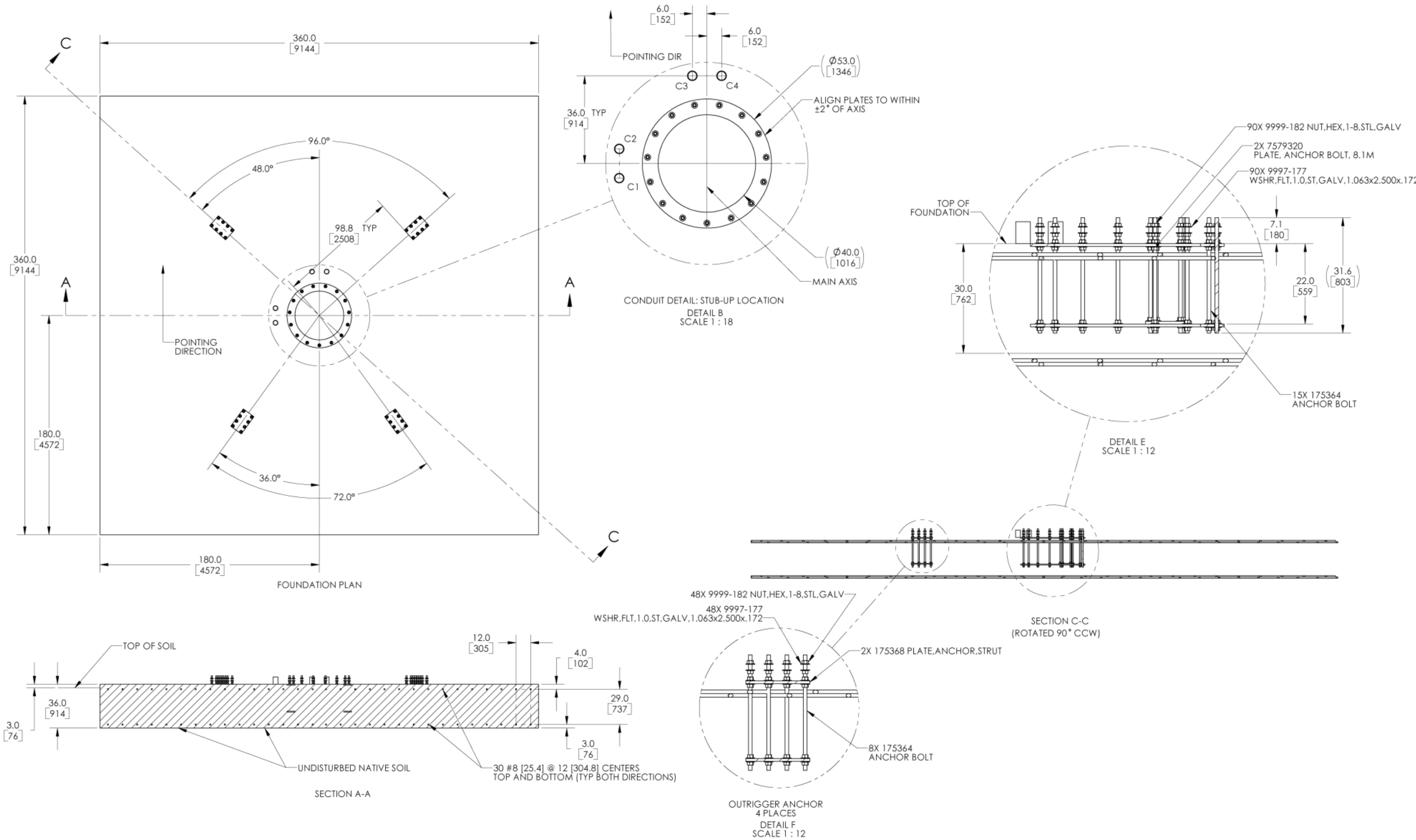


TABLE 1				
SOIL BEARING CAPACITY	MODULUS OF SUBGRADE REACTION	FOOTING THICKNESS	VOLUME OF CONCRETE	WEIGHT OF REINFORCING
2000 Psf [100kPa	100 KIPS/ft3 [15000 Kn/M3]	36.0 [914]	144 CUBIC YARDS [110 CUBIC METER]	4.70 TONS [4.3 METRIC TONS]

A2.11 - EXAMPLE FOUNDATION DRAWING