Technical Brief
For

Vehicle-Mounted Earth Station Licensing

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Revision History

Revision History:	Date	Document Revision Description
Original	08/15/07	N/A
Revision A	10/1/07	Add Antenna Density's

1. TABLE OF CONTENTS

2. INTRODUCTION

The FCC has established guidelines for routinely licensing similar Aeronautical and Vessel Earth Station systems of this land-mobile kind. The FCC requires that the licensee obtain an affidavit from the satellite operator stating that they are aware of and agree to the intended operations of the licensee and that the adjacent operators are also aware of and agree to the intended operations.

Before the FCC In the Matter of IB Docket No. 07-101, Notice of Proposed Rule Making, Amendment of Parts 2 and 25 of the Commission's rules to Allocate Spectrum and Adopt Service Rules and Procedures to Govern the Use of Vehicle-Mounted Earth Stations in Certain Frequency Bands Allocated to the Fixed-Satellite Service.

TracStar Systems is a manufacturer of Vehicle-Mounted Earth Stations and in anticipation of the Acceptance of the Notice of Proposed Rule Changes to Part 2 and 25 the company has filed for an Experimental License to conduct tests with our VMES system to insure proper operation and compliance to FCC Parts 2 and 25.

This document provides technical information regarding the intended operations of the TracStar VMES system. Operations are such that they comply in particular as it relates to FCC Part 25.222.

The systems under test will utilize advanced antenna pointing technology and centralized distributed controls to ensure that interferences to others meet the requirements of the FCC and the ITU.

3. DESCRIPTION

Network Configuration

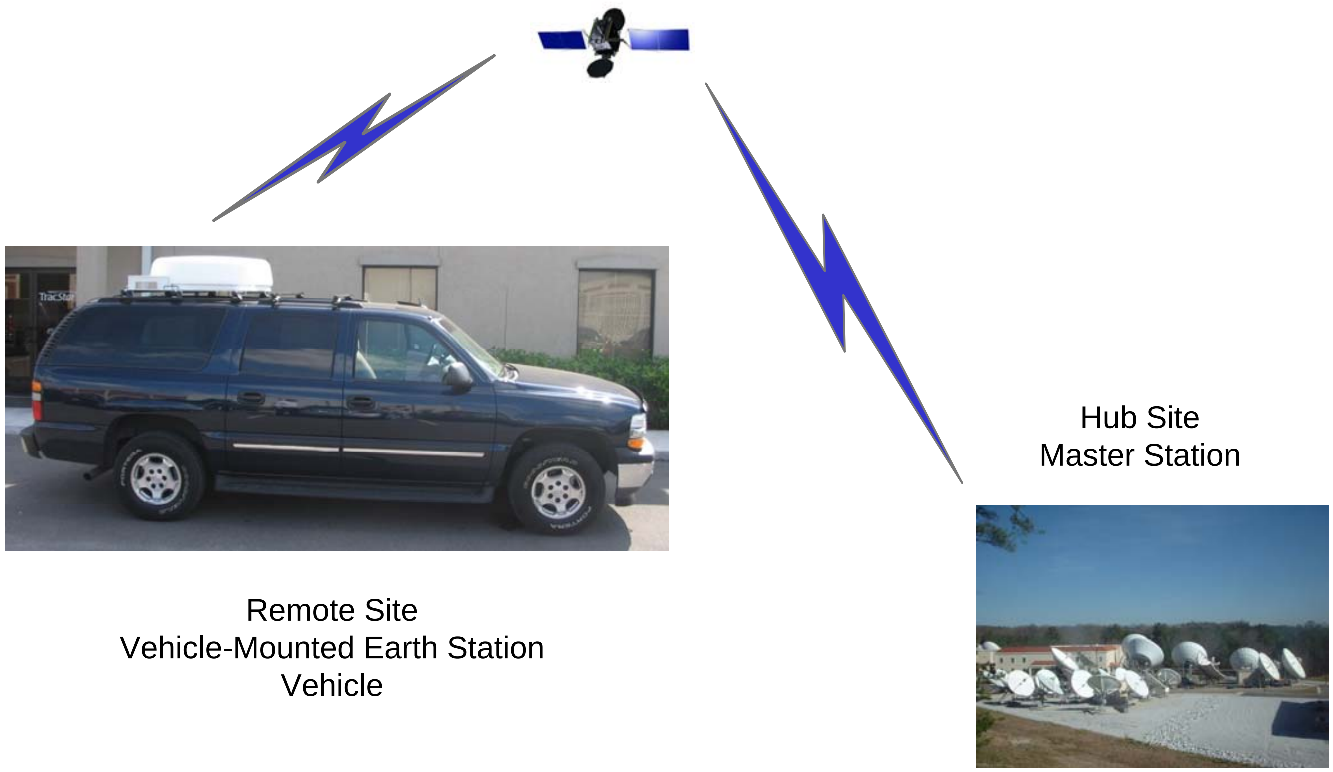
Each network should consist of one or more remote antenna system/s and one hub antenna system providing a point-to-point 64 kbps to 2 Mbps duplex satellite data link while using a small (<1m) antenna operating in a mobile environment.

The network consists of:

- **Remote Site:** These stations should be under continuous (remote) control and monitoring from the NMS. Remote sites should not be able transmit unless they receive the signaling channel from the Network Controller.
- **Geostationary Satellite:** Space segment resources are leased from the available commercial satellite operators.
- **Hub Site**: The Hub and Network Management System (NMS) provides resource management of the leased space segment and continuously monitors and controls the remote site. The network operator should either provide on-site or remote monitoring 24 x 7 support for the NMS. The satellite space segment operations center should be provided with the network operator's phone number for rapid fault resolution.

Power, Frequency, Timing Control

Modems and frequency converters should be phase locked to an accurate and stable 10 MHz reference. If any converters loose lock, then the transmitter is muted. In addition to managing all remote sites, the NMS monitors and adjusts their power, frequency and timing accuracy.



Typical Network Configuration

Remote Site Configuration

The Remote Site consists of the Antenna Assembly and the Modem.

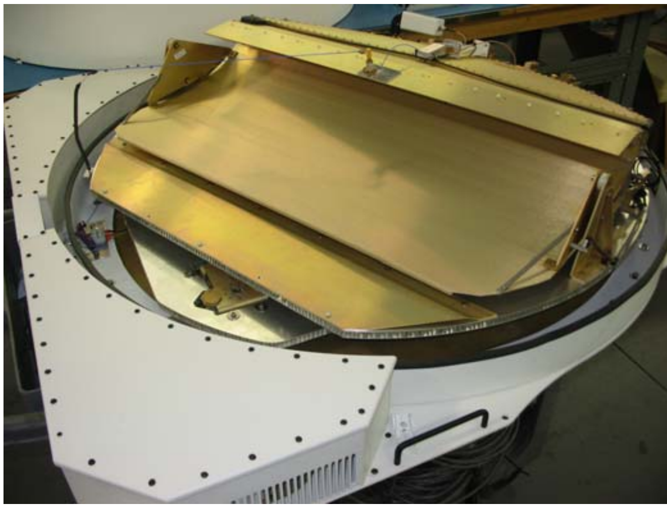
TracStar Systems IMVS450M Antenna Assembly

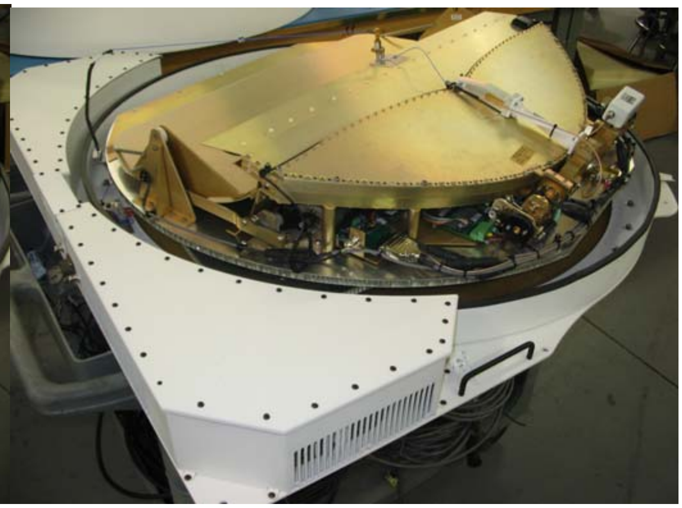
The antenna subsystem consists of:

- Antenna Reflector and Aperture (Mirror and Pillbox)
- Positioner
- Radome
- Linear Cross Polarized Feed
- Solid State Power Amplifier (SSPA)
- L-Band to Ku-Band Block Upconverter (BUC)
- Low Noise Block (LNB) Downconverter
- Antenna Control Unit
- Servo Drivers
- Inertial Sensors
- GPS
- Antenna Power Supply Unit and Graphic Display

The antenna controller utilizes GPS, inertial sensor systems, and satellite position to compute the pointing for the antenna. The TracStar Systems IMVS450M Antenna Assembly is a two axis (Elevation over Azimuth) antenna and Polarization adjusting pedestal. The antenna is wider in its azimuth plane than it is in its elevation plane in order to support minimal height requirements. The wide dimension of the antenna remains level with the vehicle that it is mounted to. The Antenna Reflector, shown below, is approximately 40” x 5.625” (1.02m x 0.14m). The reflector and aperture (mirror and pillbox) is elliptical in shape with an effective parabolic equivalent diameter of 0.45m.

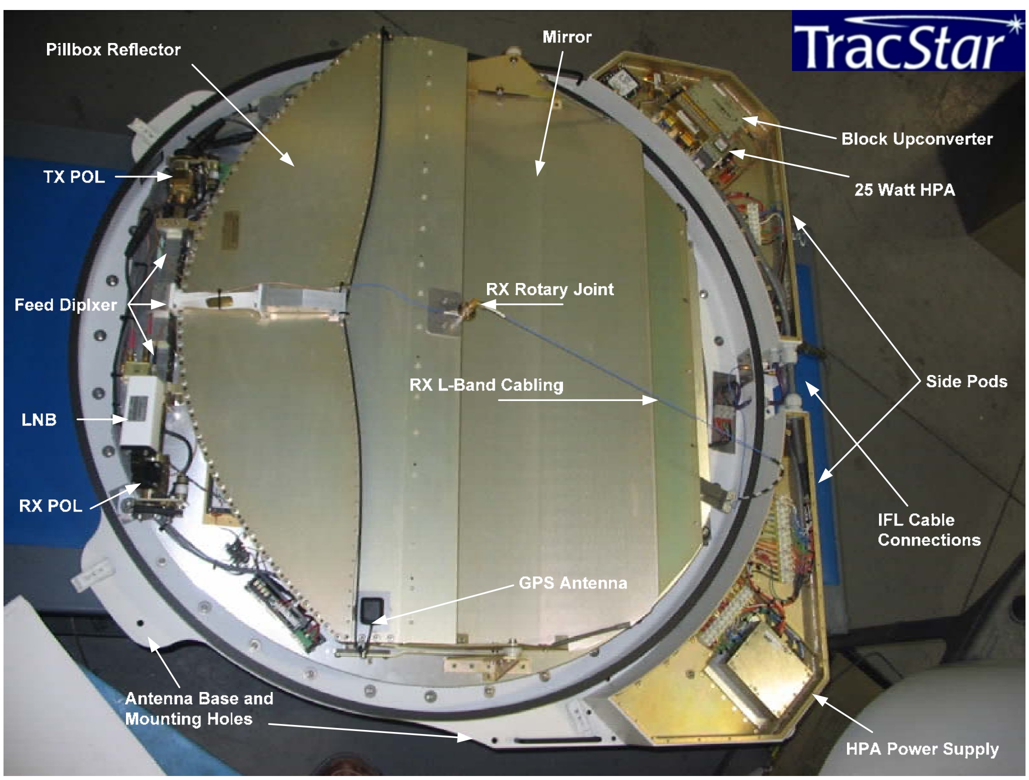
Antenna Assembly





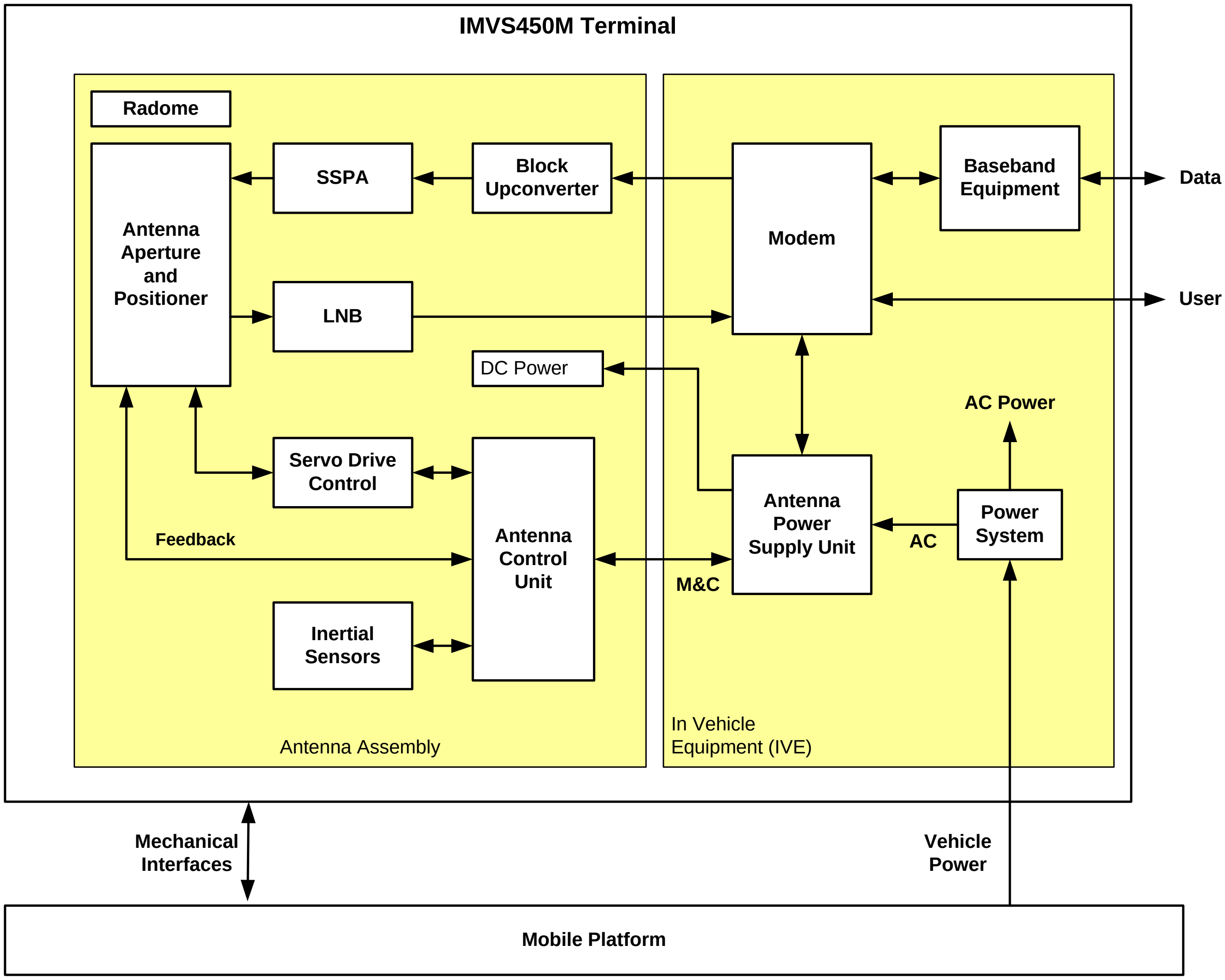
Front View

Side/Rear View



Top View

Functional Block Diagram



Typical IMVS450M System Block Diagram

Theory of Operation

- Acquisition and tracking control software currently is capable of acquiring and then maintaining satellite position while mounted on a land vehicle that is stationary or in-motion.
- Designed to have minimal moving parts to compensate for changes in vehicle platform movement.
- Accelerates at greater than 600 degrees per second squared in both the azimuth and elevation planes.
- Continuously peaks at <0.5 degrees per second on a satellite target.
- Antenna and Control Subsystem tested at 4g's, at speeds in excess of 160 kph, traveled 12 hours straight over a distance of more than 1600 km.
- Operates with an electromechanically steered azimuth, elevation & polarization positioner.

- Uses control/pointing code while mounted on a stationary or moving vehicle traveling over improved or unimproved road conditions.
- After initial acquisition, antenna system remains locked and pointed at the satellite even in the event the satellite line of site has been obstructed (aka: blockage) momentarily or for a periods of time up to 30 minutes.
- For momentary blockages minimal scanning is used, where more elapsed time dependent sequences use gradient scale scanning techniques.
- Designed to compensate for changes in either the pitch, roll or yaw direction.
- Travel 360 degrees continuously in the azimuth direction, changes 20 to 75 degrees in the elevation direction and rotates +/-95 degrees linear polarization.
- Antenna controller user interface is configurable for operation on most satellites.
- Performs precise antenna to satellite alignment with the push of a single button.
- Antenna controller provides for automatic acquisition, tracking and manual jog modes.
- User interface is menu driven by front panel or handheld controller buttons, which provide ease of use for command changes and troubleshooting.
- The satellite acquisition method is less than a 1 minute operation. Upon power up and reception of modem communications, the following deployment and acquisition sequence takes place automatically:
  - Antenna acquires GPS for high precision geographic location information
  - Antenna precisely sets elevation angle and sweeps in azimuth through to the selected satellite while looking for and monitoring signal characteristics of the satellite
  - Antenna communicates with antenna controller to obtain the link signal strength provided from the satellite modem
  - Antenna peaks on the satellite until the center of the antenna beam is located and calibrated
  - Antenna then performs a high precision calibration between the pedestal and controller
  - Antenna controller continues communications with satellite modem to obtain the link signal strength provided from the modem serial port
  - Antenna remains peaked while stationary or in motion
  - Antenna controller constantly maintains communication with modem and transmitter until shut off.
  - Antenna controller constantly monitors antenna pointing and position data to insure proper look angles, if antenna misaligns for more than 100ms, the antenna controller will inhibit the modem and transmitter.

Modem

To complete the application a modem with a recommended Direct Sequence Spread spectrum waveform should be considered when engineering the system.

The Modem should consist of:

- Modulator
- Demodulator
- Turbo Codec
- Stable clock, reference, and distribution
- Frequency conversion to/from IF
- Ethernet Interface/Switch
- QOS manager
- Human Machine Interface

Each ground station includes a modem. The modem should provide data conversion, error correction encoding/decoding, and modulation/demodulation. The controller should provide fault, configuration, account/resource, performance, and security management.

Modulation Example

Station modulates using BPSK Spread Spectrum when using an antenna less than 1m in diameter to keep the EIRP density within FCC limits.

The range of data rates include:

Upstream	BPSK (SS):	64kbps to 3.75 Msps
Downstream	QPSK:	64kbps to 11.5 Msps

To ensure that the EIRP density meets FCC limits, typical test date rate will be utilized:

Upstream	BPSK (SS):	384 Ksps
Downstream	QPSK:	512 Ksps

4. REGULATIONS

FCC, ITU Rulings

For Ku band operations, while there are no codified rules regarding allowable off-axis EIRP spectral density, the FCC have specified a minimum gain pattern requirement (25.209) and a maximum power spectral density into the antenna (25.212). The FCC will routinely license antennas that do not meet 25.209, as long as the maximum power spectral density into the antenna (per 25.212) is further reduced by the amount of the non-compliance to 25.209. Later in this document, we will refer to this noncompliance as **"excess gain".**

Another accepted interpretation of the FCC rules is that the allowable off-axis EIRP spectral density may be calculated using the two constraints provided by FCC (25.209 and 25.212). The ITU recommendation, ITU-R S.728-1, provides the Maximum permissible level of off-axis EIRP density from very small aperture terminals (VSATs). The ITU recommendation is identical numerically to FCC 25.209 and 25.212, but instead provides an explicit statement of recommended off-axis emissions.

For non-compliant and mobile antenna operation, the FCC requires that the ground station operator obtain and file affidavits obtained from the satellite operator and its adjacent satellite operators stating that all are aware and in agreement with the intended operation.

Following are relevant extracts from 47 CFR 25, FCC Rulings on Satellite Communications.

47CFR25.209 Antenna Performance Standards

(a) The gain of any antenna to be employed in transmission from an earth station in the geostationary satellite orbit fixed-satellite service (GSO FSS) shall lie below the envelope defined as follows:

(1) In the plane of the geostationary satellite orbit as it appears at the particular earth station location:

$29-25 \log(\theta)$ dBi	$1° < \theta < 7°$
+8 dBi	$7° < \theta < 9.2°$
$32-25 \log(\theta)$ dBi	$9.2° < \theta < 48°$
-10 dBi	$48° < \theta < 180°$

Where:

θ is the angle in degrees from the axis of the main lobe, and dBi refers to dB relative to an isotropic radiator.

For the purposes of this section, the peak gain of an individual sidelobe may not exceed the envelope defined above for θ between 1.0° and 7.0° degrees. For θ greater than 7.0° degrees, the envelope may be exceeded by no more than 10% of the sidelobes, provided no individual sidelobe exceeds the gain envelope given above by more than 3 dB.

47CFR25.212 Narrowband transmissions in the 12/14 GHz GSO Fixed-Satellite Service

In the 14 GHz band, an earth station with an equivalent diameter of 1.2 meters or greater may be routinely licensed for transmission of narrowband analog services with bandwidths up to 200 kHz if the maximum input power density into the antenna does not exceed -8 dBW/4 kHz and the maximum transmitted satellite carrier EIRP density does not exceed 13 dBW/4 kHz, and for transmission of narrowband and/or wideband digital services, if the maximum input power density into the antenna does not exceed **-14 dBW/4 kHz** and the maximum transmitted satellite carrier EIRP density does not exceed +6.0 dBW/4 kHz.

Small Antenna Performance

An antenna smaller than 1m will typically have an antenna gain profile that exceeds the FCC ruling 25.209. FCC will routinely license antennae that do not meet 25.209 if the operator reduces the Power Spectral Density (PSD) into this antenna from **-14 dBW/4 kHz** by the amount that an antenna exceeds 25.209 (described in this document as **excess gain**). The power spectral density may be reduced by dropping the carrier power or by adding or increasing spectral spreading.

Experience shows that the typical EIRP spectral density can be achieved by lowering the Power Spectral Density into the antenna. The combined result of the antenna and the reduced PSD of the transmitted carrier can provide an EIRP spectral density that meets the intent of FCC 25.209 and the ITU recommendation, ITU-R S.728-1.

5. ANTENNA POINTING ERROR ANALYSIS

The TracStar IMVS450M Antenna Assembly controls pointing of the antenna through the use of advanced control systems utilizing GPS, inertial navigation systems, signal tracking assistance, and rate and attitude sensors. This antenna pointing technology has been engineered over several years and has been verified in both lab and operational environments.

For the military and commercial applications foreseen, vehicles may be subjected to a worst case environment described as the Churchville B test course (extreme rugged terrain). The TracStar Systems IMVS450M Antenna Assembly meets or exceeds its pointing objectives while subjected to the shock and vibration of this test course. It should be noted that while the system is designed and tested to this environment, vehicles will typically be subjected to a substantially less severe environment (paved or dirt roads) and as such the antenna pointing system will typically maintain pointing to tighter tolerances.

Antenna pointing errors arise from:

- S = Signal Tracking Assistance Errors – A signal tracking mechanism will measure signal strength and peak the antenna signal strength using receive signal strength measurements resulting from dynamic motion or dithering. Tracking error is +/-0.1° and this eliminates Antenna Static errors (A) and Navigational errors (N).

- A = Antenna static errors due to mechanical alignment of the feed, reflector, and its relation to the inertial navigation system. Typically this error is +/-0.2°, but this is +/-0.0° through the use of signal tracking assistance.

- N = Navigational system dynamic errors due to the motion of the inertial navigation system. Typically this error is +/-0.25°, but this is +/-0.0° through the use of signal tracking assistance.

- D = Dynamic pointing errors between the desired pointing angle and the antenna pointing while in motion. (+/-0.19**°,** 95%)

Total Error E = expected value of the uncorrelated events (S, A, N, D)
= square root($S^2 + A^2 + N^2 + D^2$)
= square root($(0.1)^2 + 0^2 + 0^2 + (0.19)^2$)
= **+/-0.2°**

Beyond **+/-0.2°** the transmitter is muted in less than **100 mSec** (47cfr25.222 requirements).

Antenna/Vehicle are NOT in motion	E<0.1°, 100% of the time Transmitter is Enabled
Antenna/Vehicle are in motion (paved or dirt roads)	E<0.2° Transmitter is Enabled
Extreme Terrain Off-road mobile vehicle conditions	E<0.2°, 85% of the time Transmitter is Enabled
Antenna/Vehicle are in motion	E>0.2° Transmitter is **MUTED**

6. MAXIMUM POWER SPECTRAL DENSITY

6.1 Maximum Power Spectral Density - Elevation

Maximum Antenna Gain in Excess of FCC 25.209

Antenna plots of the TracStar Systems IMVS450M Antenna Assembly have been examined for the maximum gain in excess of the FCC 25.209 profile. The maximum allowable transmit carrier energy density will be reduced by the excess gain.

The Antenna Reflector is approximately 40” x 5.625” (1.02m x 0.14m). The reflector and aperture (mirror and pillbox) is elliptical in shape with an effective parabolic equivalent diameter of 0.45m.

The maximum excess gain is 12.0 dB and occurs at 14.5 GHz, vertical polarization, elevation profile (see the attached Antenna Gain Plotted against FCC Antenna Performance Standards 25.209).

Frequency 14.25 GHz Antenna 5.6"x40" (0.45 m)
Polarization VERT Peak Gain 32.5 dB

Plane E Max Difference between antenna and FCC25.209 12.0 dB

Since small antenna pointing errors will occur as a result of the antenna dynamics, we have examined the maximum excess gain resulting from pointing errors (note that the transmitter is MUTED if the antenna exceeds the pointing error threshold).

The maximum excess gain is 13.3 dB and occurs at 14-14.5 GHz, vertical polarization, elevation profile with a 0.2° degree pointing error.

Maximum Power Spectral Density Allowed To Meet FCC Rulings

For an FCC 25.209 compliant antenna, the maximum input power density into the antenna shall not exceed -14 dBW/4 kHz.

This energy density must be reduced by the maximum excess gain of the "non-compliant" antenna. FCC 25.209 compliant antenna -14 dBW/4 kHz maximum excess gain of the "non-compliant" antenna 13.3 dB

Maximum Power Spectral Density – Elevation allowed into the "non-compliant" antenna -27.3 dBW / 4 kHz

6.2 Maximum Power Spectral Density - Azimuth

Maximum Antenna Gain in Excess of FCC 25.209

Antenna plots of the TracStar Systems IMVS450M Antenna Assembly have been examined for the maximum gain in excess of the FCC 25.209 profile. The maximum allowable transmit carrier energy density will be reduced by the excess gain.

The Antenna Reflector is approximately 40" x 5.625" (1.02m x 0.14m). The reflector and aperture (mirror and pillbox) is elliptical in shape with an effective parabolic equivalent diameter of 0.45m.

The maximum excess gain is 0.0 dB and occurs at 14-14.5 GHz, horizontal polarization, azimuth profile (see the attached Antenna Gain Plotted against FCC Antenna Performance Standards 25.209).

Frequency 14.25 GHz Antenna 5.6"x40" (0.45 m)
Polarization HORIZ Peak Gain 32.5 dB
Plane E Max Difference between antenna and FCC 25.209 0.0 dB

Since small antenna pointing errors will occur as a result of the antenna dynamics, we have examined the maximum excess gain resulting from pointing errors (note that the transmitter is MUTED if the antenna exceeds the pointing error threshold).

The maximum excess gain is 0.0 dB and occurs at 14-14.5 GHz, vertical polarization, azimuth profile with a 0.2° degree pointing error.

Maximum Power Spectral Density Allowed To Meet FCC Rulings

For an FCC 25.209 compliant antenna, the maximum input power density into the antenna shall not exceed -14 dBW/4 kHz.

This energy density must be reduced by the maximum excess gain of the "non-compliant" antenna. FCC 25.209 compliant antenna -14 dBW/4 kHz maximum excess gain of the "non-compliant" antenna 0.0 dB

Maximum Power Spectral Density – Azimuth allowed into the "non-compliant" antenna -14 dBW/4 kHz

6.3 Maximum Power Spectral Density - Combined

The TracStar Systems IMVS450M Antenna Assembly is a two axis (Azimuth, Elevation) antenna and Polarization feed adjusting pedestal. The antenna is wider in its azimuth plane than it is in its elevation plane in order to support military size requirements. The wide dimension of the antenna remains level with the vehicle. In general the wide dimension of the antenna will not be tangent to the geostationary arc for the desired satellite. To a first order approximation, the actual illumination on the geostationary arc is the vector addition of the azimuth and elevation gain profiles adjusted by the angle between the wide dimension of the antenna and the geostationary arc (relative rotation).

At 0° relative On-Axis rotation, the illumination on the geostationary arc is the azimuth gain profile. At 90° relative On-Axis rotation, the illumination on the geostationary arc is the elevation gain profile. As seen in the previous two sections, the worst case gain difference between azimuth and elevation excess gain is 13.3 dB.

We have examined the relative On-Axis rotation from locations in CONUS vs. the satellites of interest (listed below) and have found the relative rotation 1.6° (Miami to AMC-9) to 59° (Seattle to T-14).

Satellite	Longitude	CONUS	Locations
AMC-4	101W	Seattle, WA	48.7N, 122.3W
AMC-9	83W	Portland, MN	43.6N, 70.2W
AMC-6	72W	Miami, FL	25.7, 80.4W
Telstar-14	63W	San Diego, CA	32.7N, 117.2W

Excess gain increases as a function of relative rotation are shown below. Thus it is conservative to utilize the azimuth antenna pattern, reduced by the increase in excess gain to determining the allowable PSD into the antenna.

TABLE 6.3
Excess Gain and PSD vs. Relative Rotation (Note 1)

Relative Rotation (Degrees)	Increase in Excess Gain (dB)	Maximum Power Spectral Density allowed into the "noncompliant" Antenna (dBW/4kHz)

0	0.0	-14.0
1 to 10	0.0	-14.0
11 to 20	0.9	-14.9
21 to 30	1.6	-15.6
31 to 40	2.2	-16.2
41 to 50	4.5	-18.5
51 to 60	6.1	-20.1
61 to 70	7.4	-21.4
71 to 80	10.3	-24.3
81 to 90	13.6	-27.3

Note 1: The LP antenna radiation patterns have a different AZ and EL half power beamwidth (HPBW) due to its asymmetric reflector. As the reflector has an approximately elliptical shape, to a first approximation so also does the resulting antenna main beam. The resulting radiation pattern E(Φ) is given by:

$$E(\Phi) = F_{EL} * \sin(\Phi) + F_{AZ} * \cos(\Phi)$$

where F_{EL} is the elevation pattern and F_{AZ} is the azimuth pattern

This is the parametric equation for a perfect ellipse. The resulting pattern amplitude at any arbitrary pattern cut at angle Φi is given by:

$$I\ E(\Phi i)\ I = \sqrt{[F_{EL}^{2} * \sin^{2}(\Phi i) + F_{AZ}^{2} * \cos^{2}(\Phi i)]}$$

6.3.1 Outbound On-Axis Uplink Power Density

Section 25.134(a) of the Commission’s rules specifies the maximum routinely authorized outbound uplink power density into an antenna to be –14 dBW/4 kHz.

Including the antenna back-off, Δ, as described in Section 6, the equation describing the maximum routinely authorized aggregate Return link uplink PSD is:

$$PSD = -14 - \Delta = PSD_{max} \text{ dBW/4kHz}$$

Where Δ is Excess Gain Relative to On-Axis Rotation as Stated in Table 6.3.

7. SPECTRUM MANAGEMENT

Managing Transmit Power Spectral Density

TracStar Systems has developed methods to protect adjacent satellite operations. These methods have taken several years to develop and refine and have been verified in laboratory and operational conditions. A conservative analysis has been performed and has and will continue to be used to protect adjacent satellite operations.

Power Spectral Density (PSD) into the antenna shall be managed within the required FCC limits by limiting transmit power and/or utilizing spread spectrum modulation. The actual power required in order to achieve a reliable data link will depend on the site location within CONUS, the associated weather conditions, the satellite performance, and the receiving station performance. If the communications link requires more power, additional spreading will be required. If the communications link requires less power then the spreading factor may be reduced.

The TracStar Systems IMVS450M Antenna Assembly controls pointing of the antenna through the use of advanced control systems utilizing GPS, inertial navigation systems, signal tracking assistance, and rate and attitude sensors. This antenna pointing technology has been engineered over many years and has been verified in both lab and operational environments.

Interference effects will be less than or equal to those of an FCC 25.209 compliant antenna.

The earth station will be operated within CONUS such that the PSD into the antenna will be less than -14.0 dBW/4 kHz and will be further reduced to account for the relative rotation of the non-circular antenna with the geostationary arc (per paragraph 6.3).

Antenna pointing will be maintained within +/-0.2°. Under extreme mobile environments, the transmitter will be MUTED within 100ms while pointing error exceeds +/-0.2°.

8. ADJACENT SATELLITES

Typical VMES antennas have a poor radiation performance in the direction of the Geostationary Satellite Orbital (GSO) arc. Figure 1 illustrates the VMES illuminating radiations to/from the satellites spaced between about 2° to 3° on the GSO arc. The zone of interest is usually within a span of ±10° from the wanted satellite and within ±3° of the GSO arc. The Half Power Beamwidth (HPBW) of an antenna is inversely proportional to its aperture which results in poor directivity as the aperture gets smaller. Further, the sidelobe performance of these antennas typically violate the standard 29-25*log (θ) FCC off-axis envelope. In addition these antennas continually track the satellite often resulting in a (unavoidable) typical pointing error of ±0.5° that shifts the antenna pattern accordingly. With 2° spacing between adjacent satellites on the GSO arc and with such antenna performance constraints, transmissions from the VMES remote invariably results in interference to neighboring satellite systems and signal reception to it (from the wanted satellite) is affected by interfering energy from its neighbors.

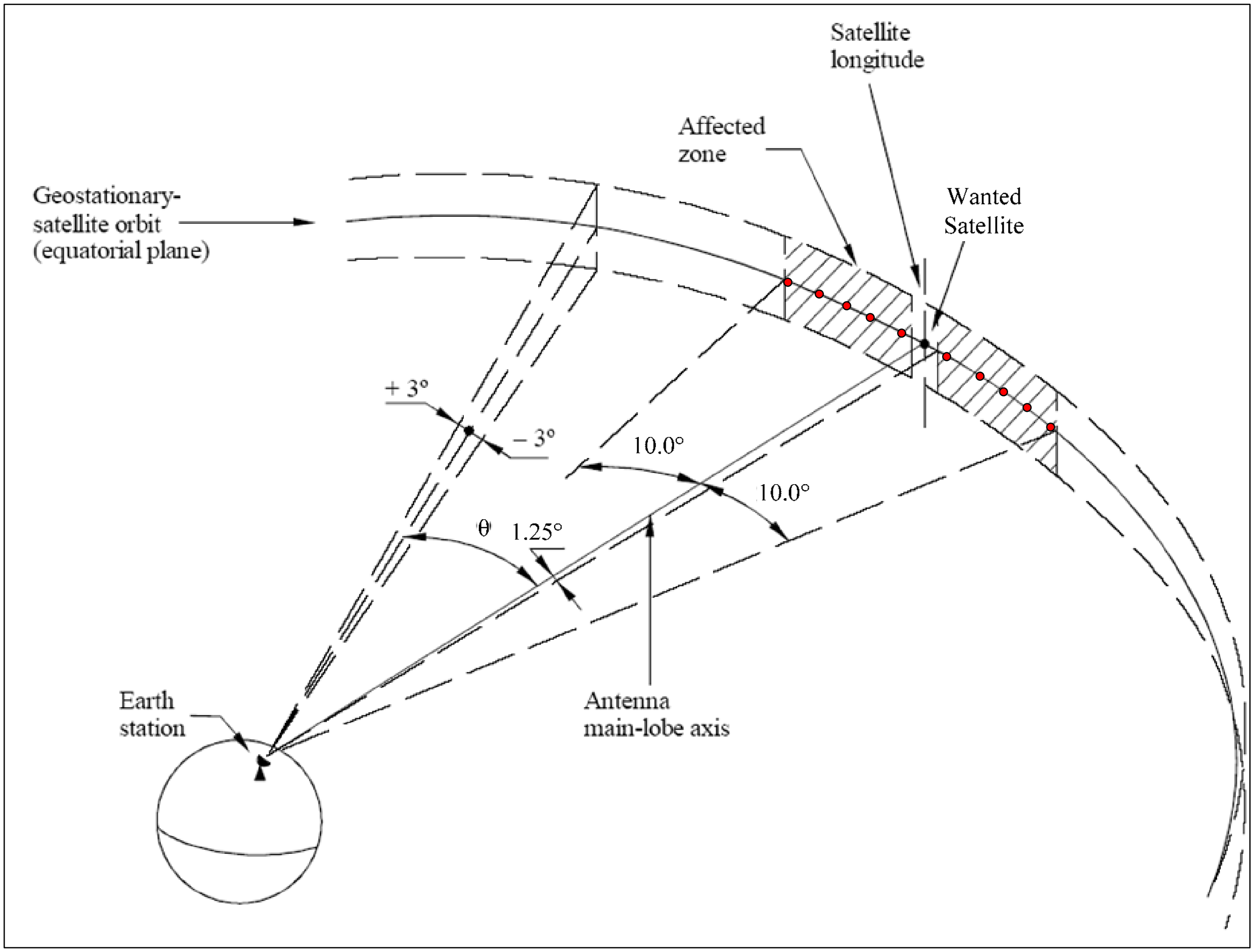


Figure 1: USAT Earth Station Illuminating the GSO Arc

The use of a DSSS waveform system provides the powerful capability of enabling communications to the noise and interference dominated link by spreading the signal at the transmitter and achieving 'processing gain' by de-spreading the same back at the receiver. The Spread SCPC downstream waveform operates at low thresholds close to the expected worst case of $C/(N+I_{ASI})$[1] in the link. The Spread TDMA upstream waveform combined with the decrease in Excess Gain provides the means to limit the off-axis EIRP density from the VMESs by reducing the overall input power spectral density into the antenna.

[1] Carrier to Noise plus Adjacent Satellite Interference Ratio. The worst case of broadband interference (interference bandwidth set equal to the signal bandwidth) is assumed and considered statistically similar to pure AWGN (thermal noise)

The following chart shows the adjacent satellites to the typically **desired** operational satellite.

Telstar-14	63°W	11
Nahuel-1A	71.8°W	0.2
AMC-6	**72°W**	**0**
DirecTV-1R	72.5°W	0.5
SBS-6	74°W	2
Echostar-4	77°W	5
AMC-5	79°W	7
AMC-9	83°W	11

9 Protection of Fixed Satellite Service Users

9.1 Protection of Users of the 11.7-12.2 GHz Band

For the VMES system, the EIRP spectral density levels will be equal to or less than those previously coordinated for a typical satellite.

9.2 Protection of Users of the 14.0-14.5 GHz Band

Fixed Satellite Services
Based on the link budgets, the maximum Forward link downlink EIRP density dominates the transponder emissions compared to the Return link. Thus the Forward link emissions determine the EIRP density performance relative to 25.134(b). The worst case Forward link EIRP is 51.5 dBW. This power is spread over the noise bandwidth (*Bn* **=** *xx.x MHz*) of the Forward link signal with EIRP density of x.x dBW/4 kHz.

The International Telecommunications Union (ITU) 2003 World Radio Conference (WRC-03) adopted a draft new Recommendation—Recommendation-RM.1643—that specifies how VMES operations should protect FSS networks. The Recommendation specifies that:

> VMES networks should be designed, coordinated and operated in such a manner that the aggregate off-axis EIRP levels produced by all co-frequency VMESs within LMSS networks are no greater than the interference levels that have been accepted by other satellite systems.

The design of the LMSS system conforms to this ITU requirement.

TracStar will protect GSO FSS satellites by controlling the aggregate off-axis EIRP density along the GSO arc to the level required for routinely processed VSAT applications.

To avoid harmful interference to other FSS systems from the Return link, the VMES system will manage the aggregate EIRP spectral density of the VMESs in the plane of the GSO arc to the levels described in Section 6.3.1.

Off-Axis Antenna Gain Patterns

Off-axis emissions requirements are defined by Section 25.209(a)(1). The VMES system utilizes an 18” equivalent parabolic reflector for the Return link antenna. Due to the small diameter, the antenna by itself cannot meet the requirements of Section 25.209(a)(1). However, by limiting the on-axis aggregate EIRP density to **6.4 dBW / 4 kHz**, the system will operate below the EIRP mask and meet the intent of the requirement.

In addition, as specified in the Recommendation, TracStar has taken the various factors that can cause the aggregate off-axis EIRP levels to vary (*i.e.*, mispointing of VMES antennas, variations in the antenna pattern of VMES and variations in the transmit EIRP from VMES) into account. In terms of pointing accuracy, the ACU corrects for land-vehicle attitude changes based upon INS data, without waiting for degradation in received signal strength.

Further, as recommended, the VMES antennas, which use both open loop pointing to the satellite and a receive signal lock indication from the demodulator for pointing verification, are inherently resistant to capturing and tracking adjacent satellite signals and immediately will cease transmission if they detect that unintended satellite pointing has occurred or is about to occur.

9.3 Terrestrial Services

Others have conducted a search of the 14.0 to 14.5 GHz band to determine if there are any terrestrial services within North America licensed in this band and found none with which its LMSS Service would conflict. In any event, it is highly doubtful that a land-vehicle that can transmit only when they are securely locked onto a GSO satellite would be able to transmit in the direction of a land-based service within the latitudes of CONUS. Nonetheless, TracStar has ensured that its VMESs comply with the maximum power-flux density (PFD) limits contained in Recommendation ITU-R M.1643. These limits are: $-132 + 0.5 \cdot \Theta$dB(W/m2)/1 MHz for $\Theta < 40º$; and -112 dB(W/m2)/1 MHz for $40 < \Theta < 90º$. The VMES system complies with the recommendation when the land-vehicle antenna is pointed 15º above horizontal (worst case for CONUS).

9.4 Land and Maritime Mobile Satellite Services

Both the Land Mobile Satellite Service (LMSS) and Maritime Mobile Satellite Service (MMSS) use GSO FSS satellite transponders. Others have evaluated its compliance with the requirements for protection of FSS networks to ensure that its VMES system will not cause unacceptable interference to authorized LMSS and MMSS systems even if such systems employed co-frequency transponders on adjacent FSS satellites.

Specifically, the forward link of the LMSS and MMSS systems employ a spread spectrum signal that is designed to prevent harmful interference to signals received by adjacent FSS satellites. Reciprocally, the mobile terminals of LMSS and MMSS systems must be able to tolerate interference from high power, wideband co-frequency signals of adjacent GSO FSS satellites. The forward link signal of the VMES system is indistinguishable (when Spread Spectrum is employed) from a wideband, high power digital signal on an FSS satellite. Thus, the VMES’s forward link signal will not cause unacceptable interference to the receive terminals of LMSS and MMSS systems in the U.S. even if such systems employed co-frequency transponders on adjacent FSS satellites.

9.5 Government Services

TracStar is aware that the 14.0 to 14.05 GHz segment of spectrum has been allocated to the U.S. Government for space research, and the 14.47 to 14.5 GHz segment has been allocated for radio astronomy. Recommendation ITU-R M.1643 specifies how VMES should protect both of these services.

To protect radio astronomy, when operating on transponders with an uplink frequency above 14.44 GHz within the line-of-sight of a radio astronomy station operating in the 14.47 to 14.5 GHz band, the VMESs will cease transmissions in this band during periods of scheduled radio astronomy observations. When operating on transponders with an uplink frequency at or below 14.44 GHz, the VMES will ensure that emissions in the 14.0 to 14.47 GHz band meet the PFD limits set forth in the Recommendation. These limits are:

$-190 + 0.5 \cdot \Theta$ dB(W/(m2 ·150 kHz)) for $\Theta < 10^{\circ}$
-185 dB(W/(m2 ·150 kHz)) for $10 < \Theta < 90^{\circ}$

The out-of-band emissions from a VMES modulator are at least 60 dB down at frequencies more than 20 MHz removed from the band edge. With the antenna elevation adjusted down to 15.4º above horizontal (worst case for CONUS on AMC-6), the VMES System, operating at or below 14.44 GHz, complies with the recommendation.

9.6 Radionavigation

In taking the steps specified in the Recommendation to avoid interference to radioastronomy and the space research service, the VMES will avoid interference to any existing maritime radionavigation services in the U.S. In any event, there are no records in the ITU Master Register indicating use of the radionavigation allocation in the 14.0 to 14.3 GHz band by any administration. Further, the CPM Report to WRC-03 found that "consideration of compatibility matters has not revealed a problem in the use of this band by AMSS with respect to RNS."[13]

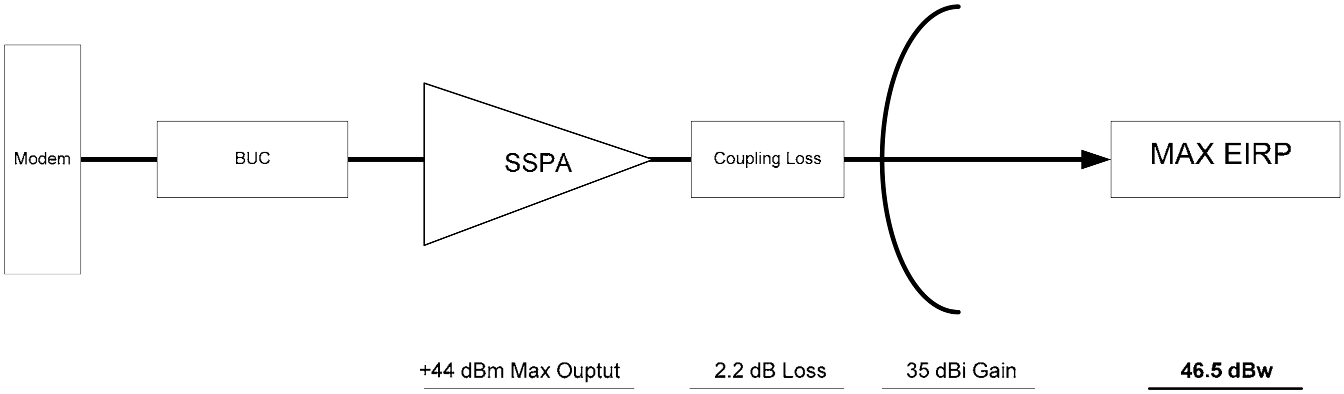
10. ANTENNA PLOTS

See separate TracStar Systems document - IMVS450M Patterns

11. EARTH STATION MAXIMUM EIRP

The maximum operational output power of the SSPA will be +44 dBm. The maximum antenna gain (including coupling losses) is 32.8 dBi. The maximum operational EIRP of the station will be 46.5 dBW.

MAXIMUM OPERATIONAL EIRP



12. CONCLUSION

TracStar demonstrates in this Technical Description that it will not cause interference to other licensees. TracStar has carefully analyzed all aspects of the proposed VMES system and, as fully demonstrated herein, can operate in a LMSS service in the 11.7 to 12.2 and 14.0 to 14.5 GHz bands without causing harmful interference to other authorized users.

Please feel free to contact the following for additional information, comments, or clarifications:

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