

VMES Technical Considerations

This document provides technical information regarding the intended operations of the TracStar 0.45 meter VMES system. Operations are such that they comply in particular as it relates to FCC Part 25.226. 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. The proposed TracStar 0.45 meter VMES terminals have been previously licensed by the FCC for VMES services and this application for license modification certifies that the 0.45 meter antennas will be operated in a similar fashion.

DESCRIPTION

Network Configuration

The network will consist of five identical remote antenna system/s and operate in conjunction with the existing 3.7 meter hub antenna on Call Sign E090163 providing a point-to-point duplex satellite data link while using a 0.45 meter 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 to 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 will provide on-site or remote monitoring 24 x 7 support for the NMS.

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.

TracStar 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 reflector and aperture (mirror and pillbox) is elliptical in shape with an effective parabolic equivalent diameter of 0.45m.

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.

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.

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 $\pm 0.1^\circ$ 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 $\pm 0.2^\circ$, but this is $\pm 0.0^\circ$ 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 $\pm 0.25^\circ$, but this is $\pm 0.0^\circ$ through the use of signal tracking assistance.
- D = Dynamic pointing errors between the desired pointing angle and the antenna pointing while in motion. ($\pm 0.19^\circ$, 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($(0.1)^2 + 0^2 + 0^2 + (0.19)^2$)

= **$\pm 0.2^\circ$**

Beyond **$\pm 0.2^\circ$** the transmitter is muted in less than **100 mSec** (47cfr25.222requirements).

Antenna/Vehicle are NOT in motion $E < 0.1^\circ$, 100% of the Time Transmitter is Enabled

Antenna/Vehicle are in motion $E < 0.2^\circ$ (paved or dirt roads) Transmitter is Enabled

Extreme Terrain $E < 0.2^\circ$, 85% of the time

Off-road mobile vehicle Transmitter is Enabled

Conditions Antenna/Vehicle are in motion $E > 0.2^\circ$

Transmitter is **MUTED**

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.

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 41.2 dBW. This power is spread over the noise bandwidth ($B_n = xx.x \text{ MHz}$) of the Forward link signal with EIRP density of $x.x \text{ dBW/4 kHz}$.

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 both FCC and ITU requirements. The applicant 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 this license modification request.

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.

Government Services

The applicant 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· Θ 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 20° above horizontal the VMES System, operating at or below 14.44 GHz, complies with the recommendation.

Radionavigation

The Applicant will follow FCC and ITU Recommendations 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.