Technical Exhibit in Support of

General Dynamics SATCOM Technologies' Vehicle-Mounted Earth Station License Application

Prepared for the

Federal Communications Commission

February 9, 2011

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1. Introduction

General Dynamics SATCOM Technologies ("General Dynamics"), pursuant to 47 CFR § 25.226 of the Rules and Regulations ("Regulations") of the Federal Communications Commission (the "Commission"), respectfully requests the issuance of a new license to operate a network of Vehicle-Mounted Earth Stations ("VMES") throughout the United States. The proposed VMES terminals will operate receiving in the 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) Ku-Band frequencies and transmit in the 14.0-14.5 GHz (Earth-to-space) Ku-Band frequencies with Geostationary Satellites in the Fixed-Satellite Service. The proposed VMES terminals will communicate with already licensed hub stations located in the United States.[1]

The proposed VMES terminals consist of a variety of different antenna apertures intended to satisfy a range of potential broadband VMES communications requirements. They include:

- General Dynamics Model 17 Terminal (M17)	50 systems
- General Dynamics Model 20 Terminal (M20)	50 systems
- General Dynamics Model 24 Terminal (M24)	50 systems
- General Dynamics Model 30 Terminal (M30)	50 systems

The VMES manufacturer is General Dynamics. Each of the VMES terminals utilizes a pointing and tracking system-stabilized antenna to communicate with FSS Ku-Band satellites. Due to their respective sizes, the VMES antennas themselves do not strictly comply with § 25.209 of the Commission's Rules. However through the use of very precise antenna pointing and tracking, combined with careful EIRP power spectral-density control, General Dynamics will fully comply with the requirements specified in § 25.226 paragraph (a)(1).[2] In the instant exhibit, General Dynamics demonstrates full compliance with the VMES Regulations set forth below.

2. § 25.226 EIRP Spectral-Densities

From § 25.226 (a), *"…VMES licensees shall comply with the requirements in either paragraph (a)(1), (a)(2) or (a)(3) of this section and all of the requirements set forth in paragraphs (a)(4)-(a)(9) and paragraphs (c), (d), and (e) of this section. Paragraph (b)*

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[1] File No 0111-EX-RR-2009.

[2] Thus, pursuant to Question 35 ("Basic Qualifications") in the 312 Main Form, General Dynamics requests waiver of the antenna performance standards set forth in § 25.209 of the Commission's Rules only to the extent such a waiver is required. General Dynamics respectfully submits that such a waiver, if required, serves the public interest by contributing to the achievement of communications that are critical to essential domestic emergency response applications as well as tactical communications requirements for the U.S. military operating in the U.S. and around the world.

of this section identifies items that shall be included in the application for VMES operations to demonstrate that these ongoing requirements will be met."

The proposed VMES system complies with paragraph (a)(1) in that the EIRP spectral-density limits are complied with in all directions -- both in the GSO plane and in all directions other than along the GSO plane. Additionally, the proposed VMES antennas are circular, so paragraph (a)(1)(i)(D) does not apply—the off-axis EIRP spectral-density criteria are satisfied in all antenna orientations.

From § 25.226 (a)(1), *"The following requirements shall apply to a VMES that uses transmitters with off-axis EIRP spectral-densities lower than or equal to the levels in paragraph (a)(1)(i) of this subsection. A VMES or VMES system, operating under this subsection shall provide a detailed demonstration as described in paragraph (b) (1) of this section. The VMES transmitter also shall comply with the antenna pointing and cessation of emission requirements in paragraphs (a)(1)(ii) and (a)(1)(iii) of this subsection.*

> *(i) A VMES system shall not exceed the off-axis EIRP spectral-density limits and conditions defined in paragraphs (a)(1)(A)-(D) of this subsection.*
>
> *(A) The off-axis EIRP spectral-density emitted from the VMES, in the plane of the geostationary satellite orbit (GSO) as it appears at the particular earth station location, shall not exceed the following values:*

$15 - 10\log(N) - 25\log\theta$	dBW/4 kHz	for	$1.5° \leq \theta \leq 7°$
$-6 - 10\log(N)$	dBW/4 kHz	for	$7° < \theta \leq 9.2°$
$18 - 10\log(N) - 25\log\theta$	dBW/4 kHz	for	$9.2° < \theta \leq 48°$
$-24 - 10\log(N)$	dBW/4 kHz	for	$48° < \theta \leq 85°$
$-14 - 10\log(N)$	dBW/4 kHz	for	$85° < \theta \leq 180°$

> *where theta (θ) is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, the plane of the GSO is determined by the focal point of the antenna and the line tangent to the arc of the GSO at the orbital location of the target satellite. For VMES networks using frequency division multiple access (FDMA) or time division multiple access (TDMA) techniques, N is equal to one. For VMES networks using multiple co-frequency transmitters that have the same EIRP, N is the maximum expected number of co-frequency simultaneously transmitting VMES earth stations in the same satellite receiving beam. For the purpose of this subsection, the peak EIRP of an individual sidelobe shall not exceed the envelope defined above for θ between 1.5° and 7.0°. For θ greater than 7.0°, the envelope shall be exceeded by no more than 10% of the sidelobes, provided no individual sidelobe exceeds the envelope given above by more than 3 dB.*

(B) In all directions other than along the GSO, the off-axis EIRP spectral-density for co-polarized signals emitted from the VMES shall not exceed the following values:

18 - 10log(N) - 25logθ	*dBW/4 kHz*	*for*	*3.0° ≤ θ ≤ 48°*
-24 - 10log(N)	*dBW/4 kHz*	*for*	*48° < θ ≤ 85°*
-14 - 10log(N)	*dBW/4kHz*	*for*	*85° < θ ≤ 180°*

where θ and N are defined in (a)(1)(i)(A). This off-axis EIRP spectral-density applies in any plane that includes the line connecting the focal point of the antenna to the orbital location of the target satellite with the exception of the plane of the GSO as defined in paragraph (a)(1)(i)(A) of this section. For the purpose of this subsection, the envelope shall be exceeded by no more than 10% of the sidelobes provided no individual sidelobe exceeds the gain envelope given above by more than 6 dB. The region of the main reflector spillover energy is to be interpreted as a single lobe and shall not exceed the envelope by more than 6 dB.

(C) In all directions, the off-axis EIRP spectral-density for cross-polarized signals emitted from the VMES shall not exceed the following values:

5 - 10log(N) - 25logθ	*dBW/4 kHz*	*for*	*1.8° ≤ θ ≤ 7.0°*
-16 - 10log(N)	*dBW/4 kHz*	*for*	*7.0° < θ ≤ 9.2°*

where θ and N are defined as set forth in paragraph (a)(1)(i)(A) of this section. This EIRP spectral-density applies in any plane that includes the line connecting the focal point of the antenna to the target satellite.
(D) For non-circular VMES antennas, the major axis of the antenna shall be aligned with the tangent to the arc of the GSO at the orbital location of the target satellite, to the extent required to meet the specified off-axis EIRP spectral-density criteria.”

The proposed VMES terminals consist of four different antenna apertures intended to satisfy a range of potential broadband VMES communications requirements. The four antenna apertures include:

a. General Dynamics Model 17 Terminal (M17) – approximately 17 inches in diameter

b. General Dynamics Model 20 Terminal (M20) – approximately 20 inches in diameter

c. General Dynamics Model 24 Terminal (M24) – approximately 24 inches in diameter

d. General Dynamics Model 30 Terminal (M30) – approximately 30 inches in diameter

§ 25.226 (b)(1) provides, in relevant part, that "[a] *VMES applicant proposing to implement a transmitter under paragraph (a)(1) of this section shall demonstrate that the transmitter meets the off-axis EIRP spectral-density limits contained in paragraph (a)(1)(i) of this section. To provide this demonstration, the application shall include the tables described in paragraph (b)(1)(i) of this section … . The VMES applicant also shall provide the value N described in paragraph (a)(1)(i)(A) of this section."*

> *(i) Any VMES applicant filing an application pursuant to paragraph (a)(1) of this section shall file three tables showing the off-axis EIRP level of the proposed earth station antenna in the direction of the plane of the GSO; the co-polarized EIRP in the elevation plane, that is, the plane perpendicular to the plane of the GSO; and cross-polarized EIRP. Each table shall provide the EIRP level at increments of 0.1° for angles between 0° and 10° off-axis, and at increments of 5° for angles between 10° and 180° off-axis.*
>
> > *(A) For purposes of the off-axis EIRP table in the plane of the GSO, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, and the plane of the GSO is determined by the focal point of the antenna and the line tangent to the arc of the GSO at the orbital position of the target satellite.*
> >
> > *(B) For purposes of the off-axis co-polarized EIRP table in the elevation plane, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, and the elevation plane is defined as the plane perpendicular to the plane of the GSO defined in paragraph (b) (1) (i) (A) of this section.*
> >
> > *(C) For purposes of the cross-polarized EIRP table, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite and the plane of the GSO as defined in paragraph (b)(1)(i)(A) of this section will be used".*

Radiation patterns, in accordance with the requirements of § 25.226 paragraph (b)(1) are provided here for each of the proposed antenna apertures.

2.1 General Dynamics Model 17 Terminal (M17)

The General Dynamics Model 17 Terminal utilizes an antenna aperture which is circular and is approximately 17-inches in diameter. To ensure that the EIRP spectral-density limits prescribed in § 25.226 paragraph (a)(1) are satisfied, the Model 17 input power spectral-density is limited to -23.0 dbW/4 kHz. This results in the following EIRP spectral-density performance:

Off-axis EIRP level of the proposed earth station antenna in the direction of the plane of the GSO.

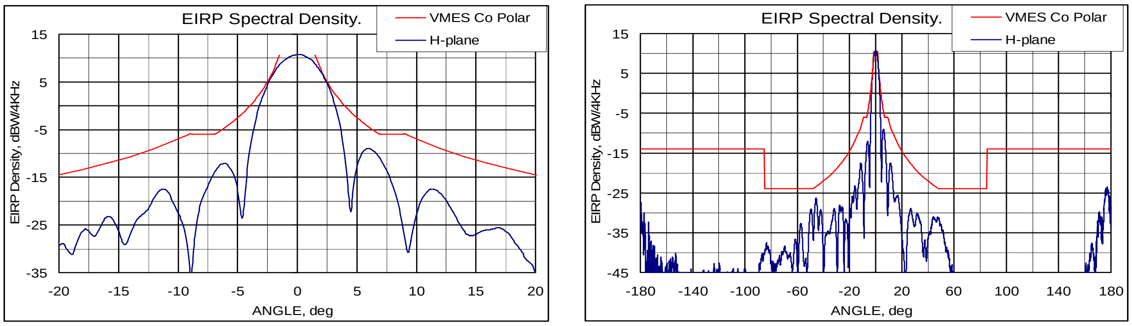


Figure 2.1.1 M17 Off-Axis EIRP in the plane of the GSO (Azimuth or H-plane)

Co-polarized EIRP in the elevation plane, that is, the plane perpendicular to the plane of the GSO.

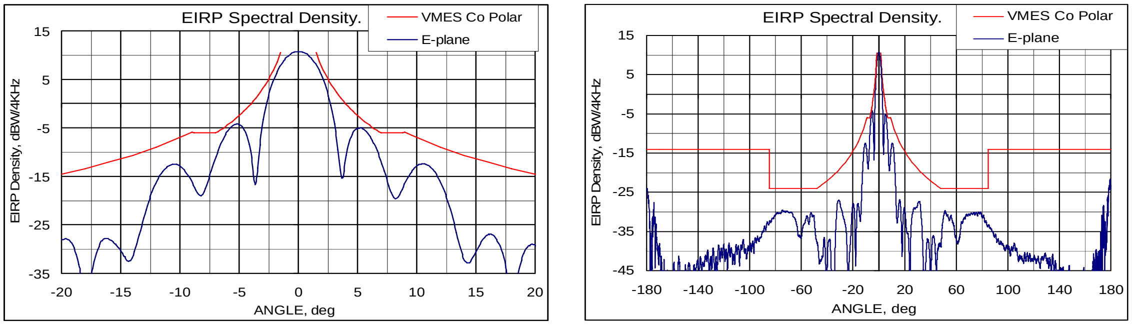


Figure 2.1.2 M17 Off-Axis EIRP in the plane perpendicular to GSO (elevation or E-plane)

Cross-polarized EIRP in the plane of the GSO.

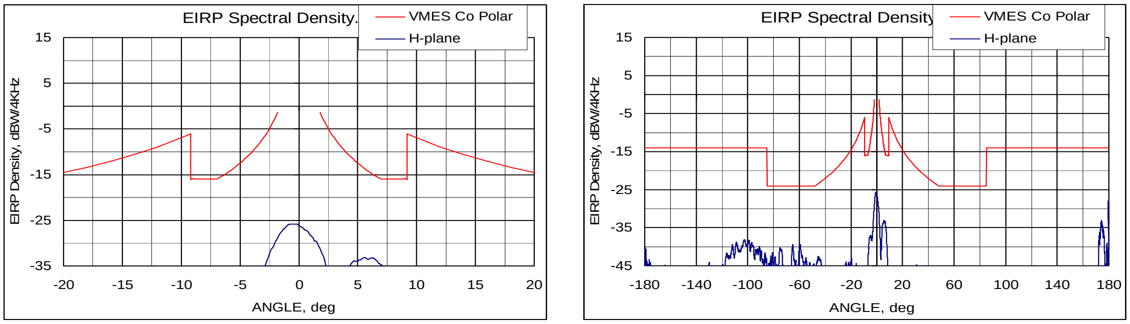


Figure 2.1.3 M17 Off-Axis Cross-Polarized EIRP in the plane of the GSO (Azimuth or H-plane)

2.2 General Dynamics Model 20 Terminal (M20)

The General Dynamics Model 20 Terminal utilizes an antenna aperture which is circular and is approximately 20-inches in diameter. To ensure that the EIRP spectral-density limits prescribed in § 25.226 paragraph (a)(1) are satisfied, the Model 20 input power spectral-density is limited to -23.0 dbW/4 kHz. This results in the following EIRP spectral-density performance:

Off-axis EIRP level of the proposed earth station antenna in the direction of the plane of the GSO.

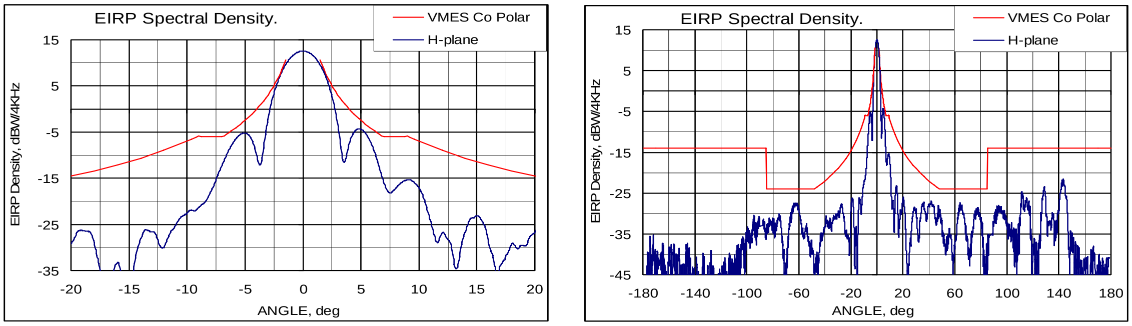


Figure 2.2.1 M20 Off-Axis EIRP in the plane of the GSO (Azimuth or H-plane)

Co-polarized EIRP in the elevation plane, that is, the plane perpendicular to the plane of the GSO.

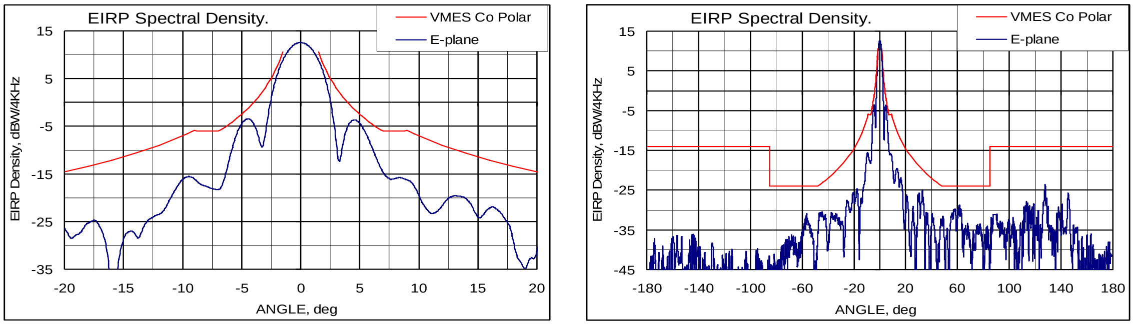


Figure 2.2.2 M20 Off-Axis EIRP in the plane perpendicular to GSO (elevation or E-plane)

Cross-polarized EIRP in the plane of the GSO.

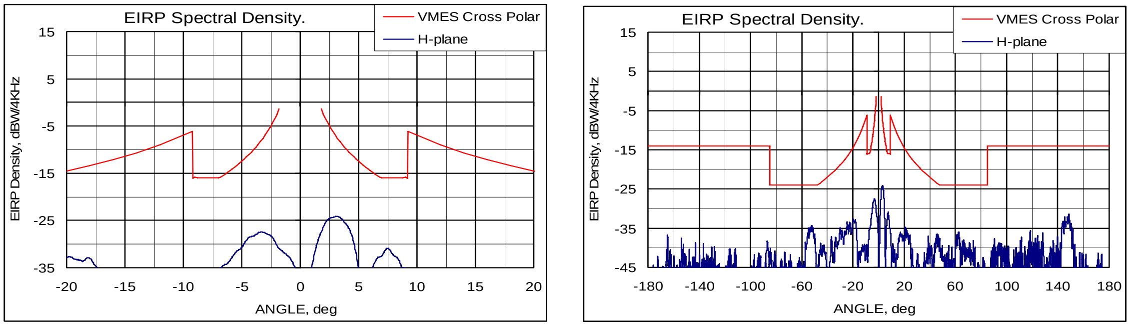


Figure 2.2.3 M20 Off-Axis Cross-Polarized EIRP in the plane of the GSO (Azimuth or H-plane)

2.3 General Dynamics Model 24 Terminal (M24)

The General Dynamics Model 24 Terminal utilizes an antenna aperture which is circular and is approximately 24-inches in diameter. To ensure that the EIRP spectral-density limits prescribed in § 25.226 paragraph (a)(1) are satisfied, the Model 24 input power spectral-density is limited to -23.0 dbW/4 kHz. This results in the following EIRP spectral-density performance:

Off-axis EIRP level of the proposed earth station antenna in the direction of the plane of the GSO.

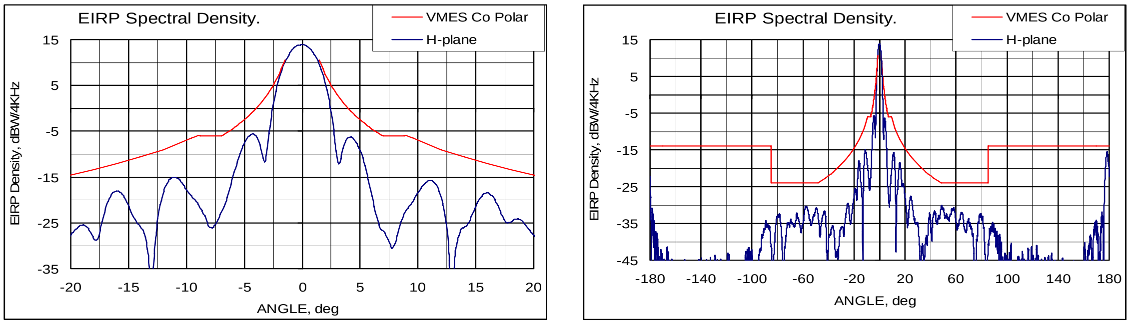


Figure 2.3.1 M24 Off-Axis EIRP in the plane of the GSO (Azimuth or H-plane)

Co-polarized EIRP in the elevation plane, that is, the plane perpendicular to the plane of the GSO.

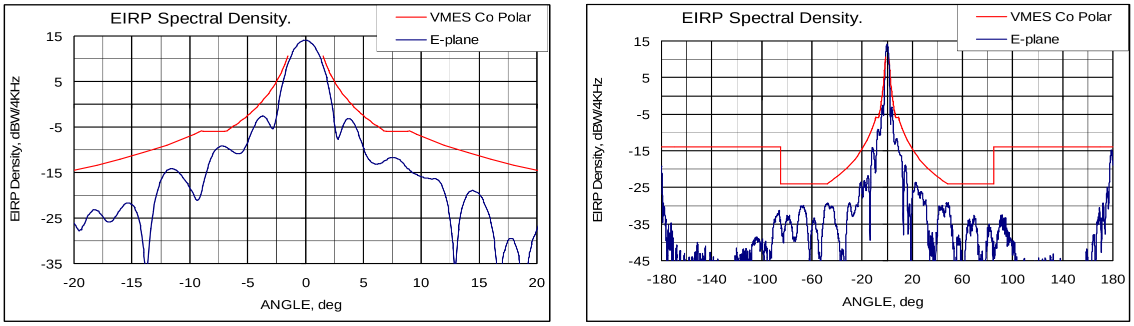


Figure 2.3.2 M24 Off-Axis EIRP in the plane perpendicular to GSO (elevation or E-plane)

Cross-polarized EIRP in the plane of the GSO.

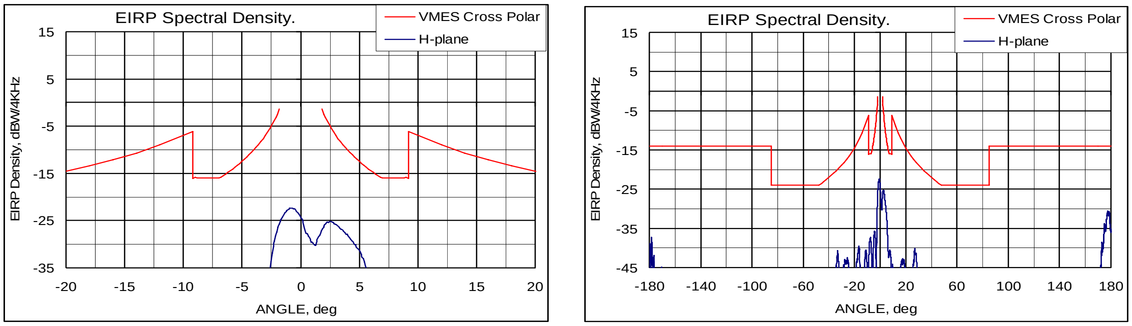


Figure 2.3.3 M24 Off-Axis Cross-Polarized EIRP in the plane of the GSO (Azimuth or H-plane)

2.4 General Dynamics Model 30 Terminal (M30)

The General Dynamics Model 30 Terminal utilizes an antenna aperture which is circular and is approximately 30-inches in diameter. To ensure that the EIRP spectral-density limits prescribed in § 25.226 paragraph (a)(1) are satisfied, the Model 30 input power spectral-density is limited to -23.0 dbW/4 kHz. This results in the following EIRP spectral-density performance:

Off-axis EIRP level of the proposed earth station antenna in the direction of the plane of the GSO.

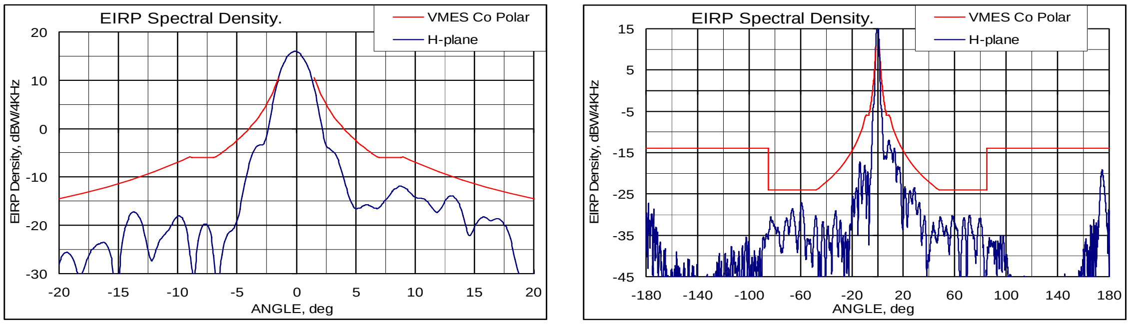


Figure 2.4.1 M30 Off-Axis EIRP in the plane of the GSO (Azimuth or H-plane)

Co-polarized EIRP in the elevation plane, that is, the plane perpendicular to the plane of the GSO.

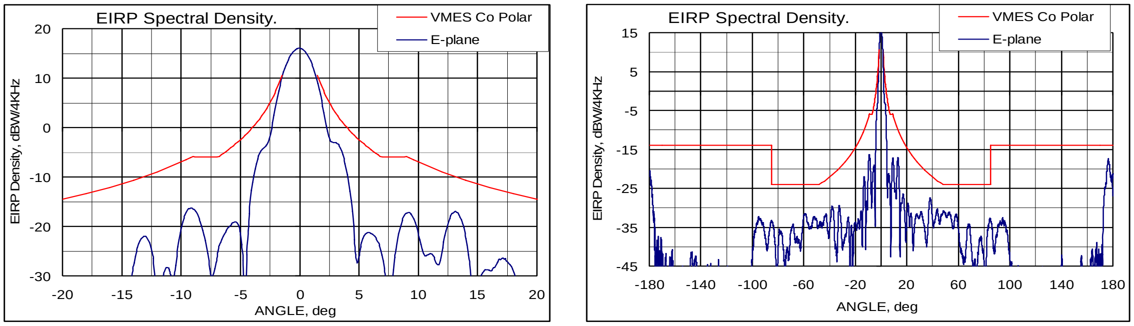


Figure 2.4.2 M30 Off-Axis EIRP in the plane perpendicular to GSO (elevation or E-plane)

Cross-polarized EIRP in the plane of the GSO.

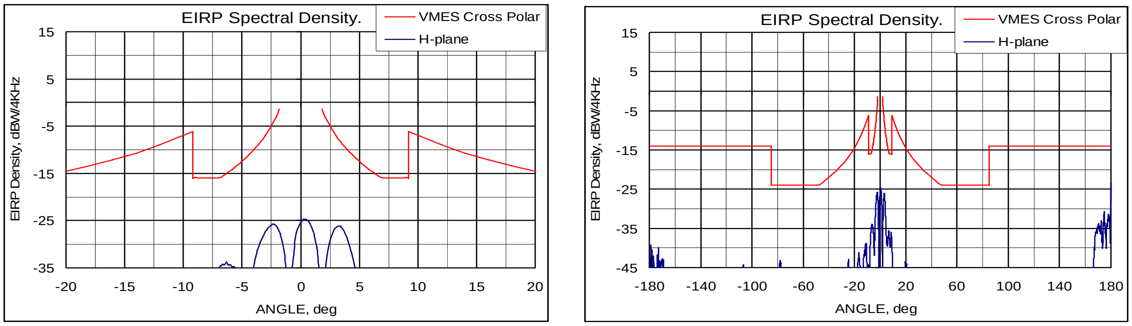


Figure 2.4.3 M30 Off-Axis Cross-Polarized EIRP in the plane of the GSO (Azimuth or H-plane)

3. Antenna Pointing and Control Functions

3.1 § 25.226 (a)(1)(ii) antenna pointing accuracy

From § 25.226 (a)(1)(ii) *"Each VMES transmitter shall meet one of the following antenna pointing requirements:*

> *(A) Each VMES transmitter shall maintain a pointing error of less than or equal to 0.2° between the orbital location of the target satellite and the axis of the main lobe of the VMES antenna … "*

General Dynamics has designed the proposed VMES terminals with an Antenna Pointing and Tracking system that makes use of a closed-loop servo system that performs the following functions:

1. Utilizes a GPS receiver and Inertial Reference Unit to accurately determine the exact location and attitude of the vehicle or mount on which the VMES terminal is operating.
2. Utilizes an Antenna Control Unit to calculate the satellite look angles of the VMES terminal based upon a combination of the ephemeris of the desired satellite and the VMES terminal location and attitude.
3. Utilizes antenna-mounted sensors to accurately measure the angles, antenna velocities, and antenna accelerations during operation.
4. Utilizes a downlink tracking receiver which accurately measures the downlink signal strength from the desired satellite to close the antenna tracking servo loop and ensure that the VMES antenna remains optimally pointed towards the satellite of interest during all phases of operation, including updating the satellite ephemeris based on actual observed pointing and tracking conditions.

General Dynamics has confirmed the design and actual antenna pointing and tracking performance of our VMES terminals through tests of the operational VMES terminals transmitting to a desired and adjacent satellite with instrumentation to carefully and accureately measure the downlink signals. Energy transmitted from each earth station antenna towards a desired geostationary satellite not only arrives at the Target geostationary satellite of interest, but also at other satellites which might be visible in both geostationary and non-geostationary orbits. While the simultaneous objective for every satellite communications earth terminal is to maximize the energy towards the desired satellite while minimizing energy towards any other satellites, some energy is always present. Larger uplink earth terminal antennas tend to have better (meaning narrower beamwidth) antenna radiation patterns, with higher gain, that result in more of the desired energy being transmitted in the desired direction rather than other directions. As earth terminal antennas approach smaller sizes, such as those used in VMES applications, some of the radiated energy is inevitably radiated to satellites immediately adjacent to the satellite of interest in the geostationary arc.

The effective transmission of energy towards different geostationary satellites from multiple earth terminals, and the resultant radiation towards adjacent satellites, is graphically illustrated in Figure 3.1. General Dynamics' VMES terminals are produced under the product name of "Satcom-On-The-Move", or "SOTM" so those terms also describe General Dynamics' VMES terminals.

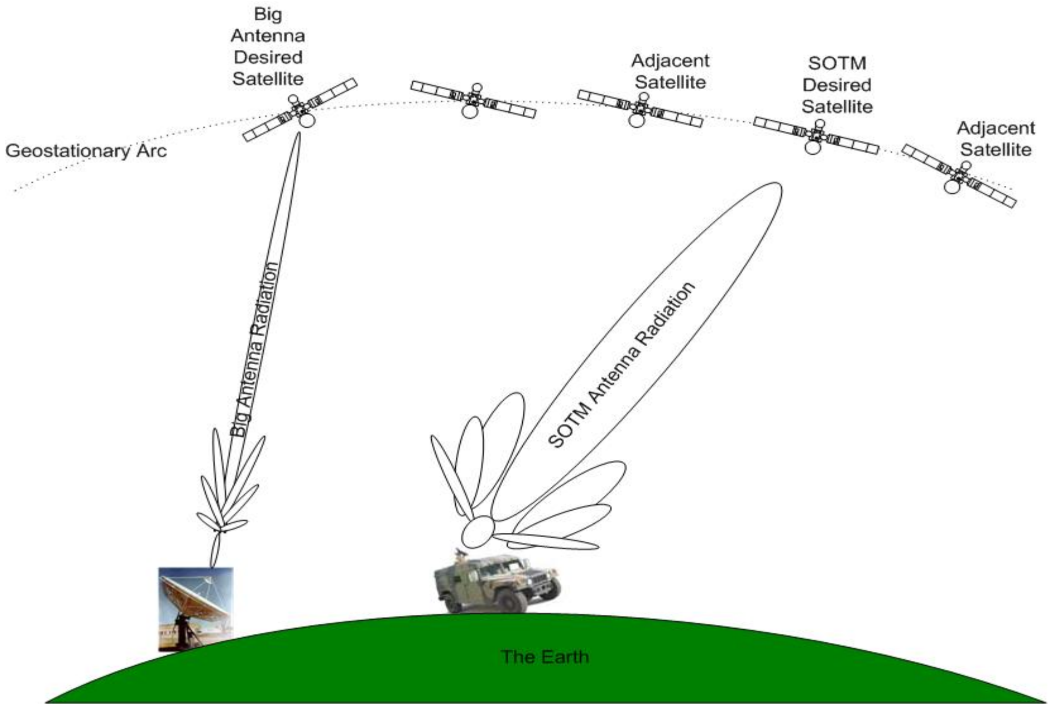


Figure 3.1 VMES / SOTM EIRP spectral-density conditions

Since some energy will be present at adjacent satellites, General Dynamics' VMES antenna pointing test procedure draws upon the ability to measure the energy being legally transmitted towards an adjacent satellite and, thus, re-transmitted via the downlink from that satellite. In the case of SOTM/VMES terminals, the antennas are small enough that the antenna gain towards the satellite of interest will only be a few dB higher than the effective antenna gain towards a geostationary satellite spaced only 2 degrees away on the geostationary arc. For an antenna as small as 18-inches in size, this difference in gain is only on the order of about 8 dB. Larger antennas result in a larger difference in the gain on antenna boresight compared to the effective gain at 2 degrees from boresight.

General Dynamics' VMES terminals include several different antenna sizes, as described above. In each case, the EIRP spectral-density requirements specified in § 25.226 paragraph (a)(1) are satisfied through careful control of the input power spectral-density, and resultant EIRP spectral-density, combined with high levels of antenna pointing and tracking accuracy.

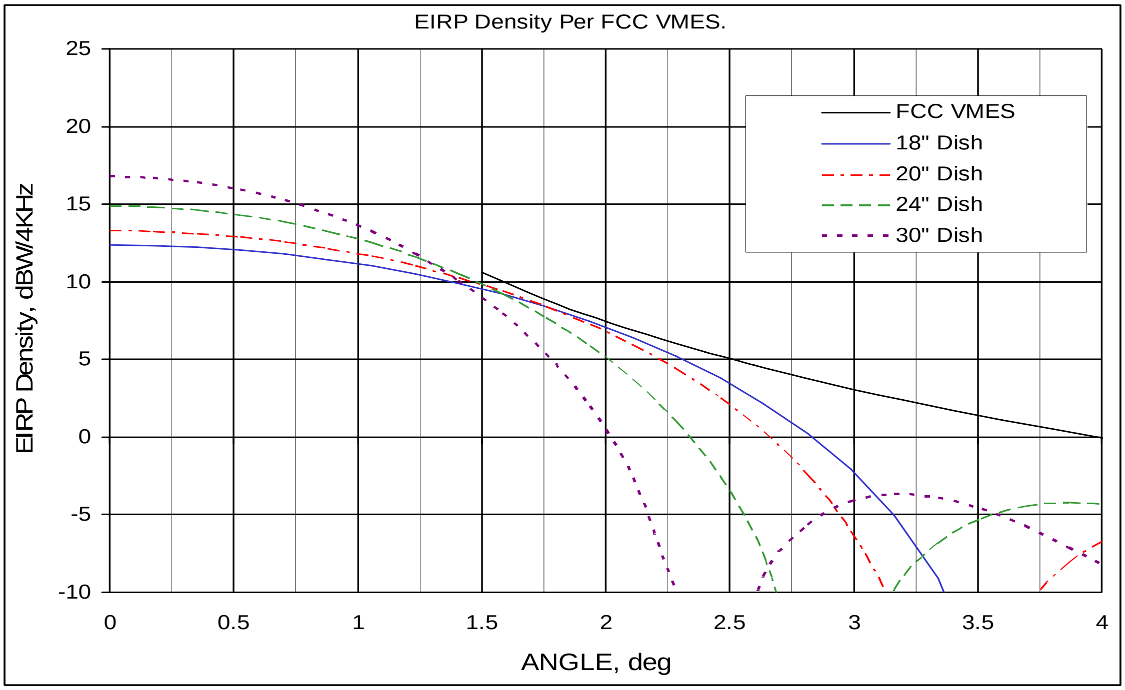


Figure 3.2 VMES /SOTM EIRP Spectral-Density Comparison

The antenna pointing test procedure developed by General Dynamics relies upon simultaneously measuring the downlink signals from both the desired satellite and an adjacent satellite. A block diagram of the test setup is provided in Figure 3.3.

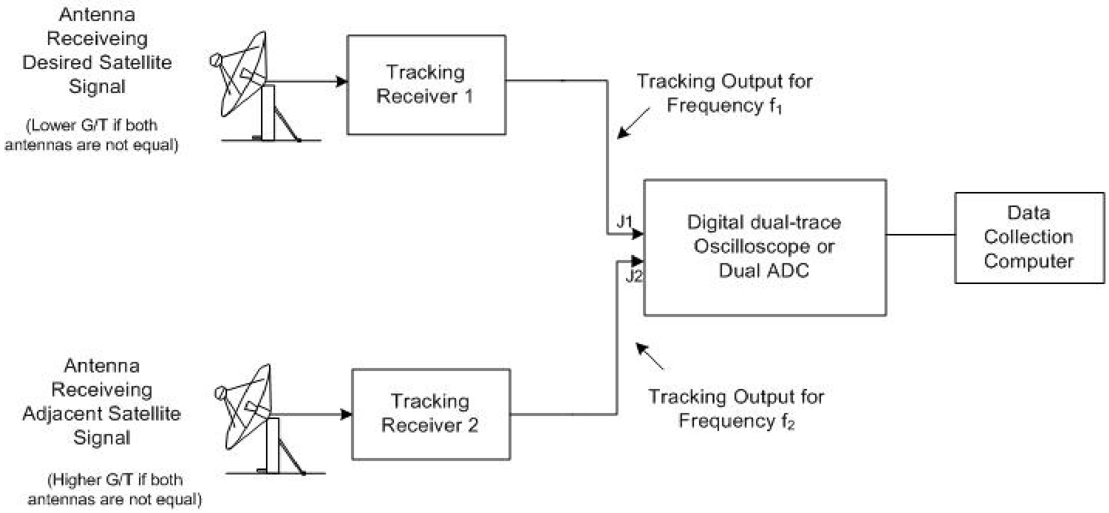


Figure 3.3 Antenna Pointing Measurement Block Diagram

In practice, General Dynamics has confirmed that by transmitting a CW signal from a VMES terminal towards a desired satellite permits the downlink signals from both the desired satellite an adjacent satellite to be measured using appropriately large downlink receiving earth stations pointed towards the two satellites.

The antenna pointing accuracy test procedure used in measurement is as follows:

1. The VMES terminal under test radiates a CW tone on a desired test frequency towards the target satellite. The amplitude of the transmitted CW tone should be carefully adjusted to the exact level at which the calculated EIRP spectral density towards the adjacent satellite is precisely at the FCC-mandated adjacent satellite EIRP spectral density limit.

2. Once the VMES terminal is confirmed to be transmitting the desired uplink EIRP CW signal level, the downlink measurement apparatus can be calibrated. This calibration is achieved through a multi-step process:

    a. Peak the downlink receive earth terminals on both the target satellite and the adjacent satellite.

    b. Set the center frequency of Tracking Receiver 1 and Tracking Receiver 2 to the desired downlink Center Frequency, which will result in the downlink signals being measured on the Tracking Receiver tracking output signal line.

    c. Ensure that the measurement dual-trace oscilloscope or dual-channel ADC is measuring Tracking Signal levels in an acceptable range.

    d. Confirm that the entire system is operating in the linear range of all subsystems and components.

3. An angle calibration process is then performed. If space segment is available on two adjacent satellites, and intentional radiations in excess of the nominal permitted adjacent satellite signal levels are permitted, the measurements can be taken on the desired and adjacent satellites using an initial “angle calibration” test run. With this approach, the measurement equipment is set up and calibrated and then the VMES antenna under test is intentionally stepped from the desired satellite to the adjacent satellite. Resultant C or (C+N) levels are then measured and recorded at each step along the movement of the VMES antenna under test which can serve as an absolute calibration of the true angular offset. This approach can provide optimal measurement results because higher (C+N) signal levels can be utilized on the adjacent satellite. It also eliminates any need to rely upon previously-measured or theoretical antenna pattern data because the measurement data collected in the calibration run reflects any antenna pattern or terminal factors which might affect the signal levels on both the desired and adjacent satellites. It was this approach

that was used by General Dynamics to calibrate the angle measurements in our VMES antenna pointing and tracking tests.

4. Following collection of the angle calibration test data, the test apparatus is then used to measure the VMES antenna pointing and tracking errors during actual operation. The VMES terminal is operated on a test course in the anticipated environmental conditions. While transmitting a constant CW signal towards the desired satellite, downlink signals are measured on both the desired and adjacent satellites using the two downlink antennas. Comparing the absolute downlink signal levels observed during the operational test run with the downlink signal delta measurements obtained in the "angle calibration" tests permits direct observation of the resultant VMES antenna pointing and tracking errors.

Using this test procedure, General Dynamics has verified the VMES antenna pointing and tracking accuracy actually demonstrated in the field. The signal levels measured on both the desired and adjacent satellites are very low, being fairly close to the noise floor. Good measurement results depend upon an ability to measure the delta in the downlink signals from the desired and adjacent satellites with sufficient resolution and accuracy. Factors such as weather attenuation on the uplink from the VMES terminal to both the desired and adjacent satellites, and weather on the downlink from the desired and adjacent satellites to the downlink monitoring earth stations, if not carefully monitored, can easily degrade measurement accuracy. To ensure reliable measurement results, the atmospheric attenuation on all signal paths as well as the gain through each system element in the measurement loop must be stable. General Dynamics has verified that all these conditions were satisfied in our detailed VMES test activities.

General Dynamics has conducted a series of tests of the different versions of our VMES terminals. Each uses the same Antenna Control Unit and antenna drive system. Under these conditions, the antenna pointing and tracking accuracy of each of the different types of VMES terminals in the product family have been confirmed to be identical. One element that can be different in various versions of General Dynamics' VMES terminals is the Inertial Measurement Unit, or IMU, which is also sometimes called an Inertial Navigation Unit, or INU. General Dynamics has qualified INUs built both by Honeywell and by GE Aerospace. Both of these units utilize GPS receivers for initial position determination, but they also contain laser ring gyroscopes to determine the VMES terminal roll, pitch, and yaw, as well as rate of change in roll, pitch, and yaw. While the Honeywell unit provides slightly greater precision in its measurements, the unit built by GE Aerospace is slightly less expensive and is demonstrated to still provide suitable performance. Indeed, both of these INUs satisfy the Commission's requirements when implemented in conjunction with General Dynamics' VMES terminals. Given the proven performance of units, General Dynamics requests the Commission's authorization to use either unit in fielding the proposed VMES terminals.

On August 4, 2010, General Dynamics performed testing of a representative Model 20 VMES terminal employing an INU produced by GE Aerospace. General Dynamics had previously performed tests on several other versions of our VMES terminals and asserts that the tests conducted on August 4. 2010 represent the true antenna pointing and tracking performance that can be anticipated for each of the different General Dynamics VMES terminals.

The VMES antenna pointing and tracking tests performed on August 4, 2010, were conducted with the following conditions:

Target Satellite: AMC-4

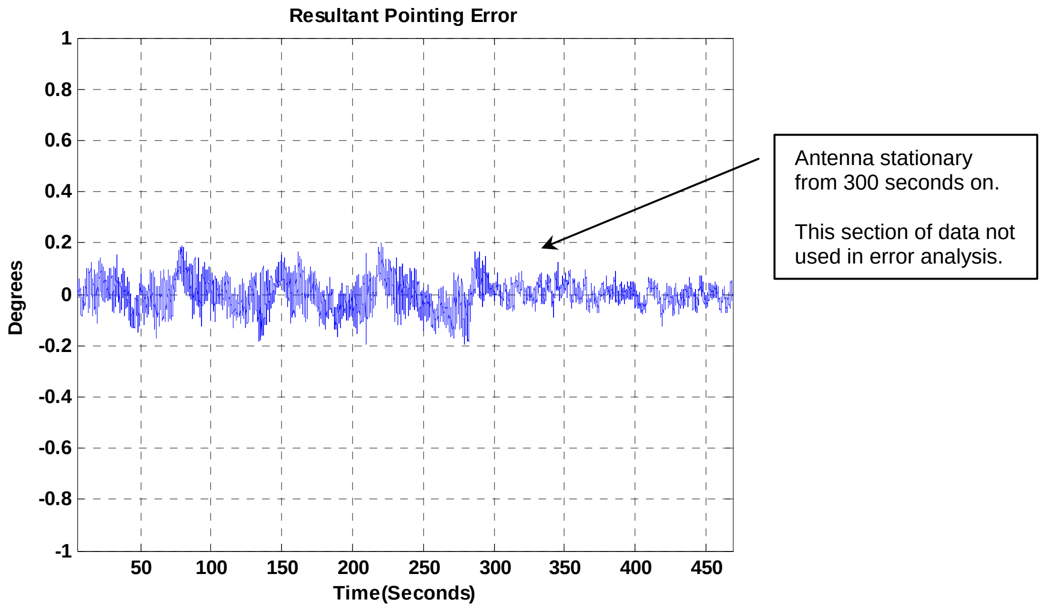
Adjacent satellite: AMC-1

Uplink frequency: 14.243 GHz

Test location: vicinity of Kilgore, Texas

Weather conditions during the test: clear skies

The results of the antenna pointing and tracking test confirmed that the Model 20 VMES antenna did, in fact, demonstrate a pointing error of less than 0.2 degrees along the geostationary arc during the complete test period. Tracking error measurements are represented graphically in Figure 3.4



Antenna stationary from 300 seconds on.

This section of data not used in error analysis.

Figure 3.4 Measured Pointing Error

As both a confirmation that the test equipment used in the measurement system was functioning properly and to confirm that potential error contributions did not adversely impact the measurement results, General Dynamics examined the angular “errors” measured while the antenna was completely stationary. As shown in the test data in Figure 3.4 above, the data from the period 300 seconds into the test until the end of the test represent measurements made while the VMES antenna and vehicle were completely stable and remained fix-pointed at the satellite of interest. The measured error during that period represents the “noise” in the measurement system as deviating from ideal measurement results. It can clearly be attributed to both atmospheric noise as well as electrical noise in the complete satellite signal link from the VMES CW uplink to the two downlink measurement tracking receivers.

3.2 § 25.226 (a)(1)(iii) cessation of emission requirements

From § 25.226 (a)(1)(iii), *“Each VMES transmitter shall meet one of the following cessation of emission requirements:*

> *(A) For VMESs operating under paragraph (a)(1)(ii)(A) of this section, all emissions from the VMES shall automatically cease within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the VMES antenna exceeds 0.5°, and transmission shall not resume until such angle is less than or equal to 0.2° ... ”*

General Dynamics has designed the proposed VMES terminals with an Antenna Pointing and Tracking system that makes use of a closed-loop servo system as described in Section 3.1 above. As part of its antenna pointing function, the Antenna Pointing and Tracking system mutes the uplink transmitter to satisfy the cessation of emission requirement as necessary. This functionality is provided in the following way:

a. The proposed VMES terminals utilize a GPS receiver to determine the location of the VMES terminal itself. The GPS-derived location information is updated on the order of every few seconds and is not critical to accurate antenna pointing. (In fact, the most critical function of this GPS-derived location information is for initial acquisition of the satellite signal.) Once the VMES terminal is in normal operation, the satellite antenna look angle information is constantly updated through the closed-loop servo system and any long-term drift is corrected out.

b. The Inertial Reference Unit used by the VMES terminals provides constantly-updated information on the verticality, velocity, and acceleration of the VMES terminal platform. The VMES Inertial Reference Unit must provide accurate measurements of the VMES terminal’s attitude at a exceedingly short time intervals to permit calculation of the intended antenna look angles so that this angle can be compared with the measured antenna look angles. In practice, the VMES Inertial Reference Unit used by General Dynamics provides attitude information to an accuracy on the order of 0.01 degrees at an interval between measurements of not more than approximately 20 milliseconds. Additionally, the velocity and acceleration information reported by the Inertial Reference Unit is utilized by the closed-loop servo system to refine the antenna position drive commands based upon movement of the VMES antenna platform.

c. Sensors mounted on the VMES antenna and pedestal itself accurately measure antenna pointing angles relative to the VMES mounting platform, antenna velocities, and antenna accelerations. The position sensors measure antenna pointing angles in azimuth, elevation, and polarization, to an accuracy of less than approximately 0.01 degrees and this information is incorporated in the Antenna Control Unit antenna angle calculations at an interval between calculations of not more than approximately 20 milliseconds.

Utilizing these inputs, the VMES Antenna Control Unit ensures that transmissions are interrupted if the VMES antenna pointing error exceeds 0.5 degrees and does not restore transmissions until VMES antenna pointing error is again less than or equal to 0.2 degrees. The RF transceiver mounted on the rear of the VMES antenna is directly commanded by the VMES Antenna Control Unit to mute the transmitter. This is accomplished by muting the actual uplink Solid State Power Amplifier ("SSPA") and can be achieved in less than 10 milliseconds.

Effective implementation of this emission cessation function relies upon two critical factors. First, the transmitter mute function itself must be capable of responding to system commands in a period much less than 100 milliseconds. Field tests confirm that the transmit power amplifier mute function as implemented by General Dynamics can be performed in a sufficiently short time period that the muting is assured to be performed in much less than 100 milliseconds. Secondly, the reference by which it is determined that antenna pointing is in error must be sufficiently accurate to ensure that pointing errors on the order of 0.1 degrees can be observed. Field testing of General Dynamics' VMES terminals described in Section 3.1 above, completely independent of the antenna pointing angles reported by the VMES itself, confirm that the calculations of antenna pointing angles match observed antenna pointing angles to an accuracy much better than 0.1 degrees.

Thus, General Dynamics confirms that the proposed VMES terminals contain functionality which will mute the uplink transmitter and ensure that emissions cease if antenna pointing errors exceed 0.5 degrees and that emissions will not resume until antenna pointing errors are confirmed to be less than or equal to 0.2 degrees.

3.3 § 25.226 (a)(4) contention protocol must be reasonable

From § 25.226 (a)(4) *"An applicant filing to operate a VMES terminal or system and planning to use a contention protocol shall certify that its contention protocol use will be reasonable"*

The VMES terminals proposed by General Dynamics in the instant license application utilize versions of the ViaSat Linkway VSAT system modems. These modems are produced by ViaSat and have provided successful VSAT services on FSS Ku-Band systems for several years. Their signal structure is based on fairly typical VSAT modulation with time slots assigned in the network by a designated network control station. Communication for the purposes of time slot coordination are conducted in a single contention-based burst within the TDMA frame, called the signaling burst (SB). The SB contention protocol is slotted ALOHA -- the most widely known and studied random access protocol -- which used by the majority of VSAT TDMA network modems.

The Linkway TDMA frame time is 27 ms. In each TDMA frame the SB sub-frame, for a 10 MSPS carrier for example, is 0.31 ms. Using the slotted ALOHA contention protocol, each VMES terminal attempting to communicate on the SB would synchronize with the control station burst timing prior requesting access. Following the request for access to the network control terminal, network traffic is then assigned within the TDMA burst structure in a traffic slot so only the request need be transmitted in the SB, reducing the total amount of traffic and thus contention for SB sub-frame resources. Within the SB sub-frame, collisions are only expected when multiple VMES station modems request a time slot simultaneously; and most slots will have already been assigned outside of the SB sub-frame. Thus, the probability of signal collisions within the SB sub-frame is very low and easily supports the theoretical capacity of 0.38 of the available SB communications capacity.

Using this slotted ALOHA technique, as an implementation of the most widely used VSAT contention protocol, General Dynamics certifies that the contention protocol used is reasonable.

3.4 § 25.226 (a)(5) point of contact in the United States

From § 25.226 (a) (5) *"There shall be a point of contact in the United States, with phone number and address, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the VMESs."*

When in operation, the proposed VMES terminals will be in continuous contact with the ViaSat Network Operations Center. This facility can be contacted 24 hours a day, seven days a week, and has full authority to remotely command transmissions to cease from any and all VMES terminals in the network.

The network control contact information is:

ViaSat Network Operations Center Duty Officer
Telephone: 888 272-7232
Email: noc-carlsbad@viasat.com
Address: 6155 El Camino Real
Carlsbad, CA 92009

3.5 § 25.226 (a)(6) VMES location logging

From § 25.226 (a)(6) *"For each VMES transmitter, a record of the vehicle location (i.e., latitude/longitude), transmit frequency, channel bandwidth and satellite used shall be time annotated and maintained for a period of not less than one (1) year. Records shall be recorded at time intervals no greater than every five (5) minutes while the VMES is transmitting. The VMES operator shall make this data available upon request to a coordinator, fixed system operator, fixed-satellite system operator, NTIA, or the Commission within 24 hours of the request."*

When in operation, the proposed VMES terminals will continuously determine their location through the use of GPS receivers installed in each VMES. The location information will be reported to the proposed VMES network control facility and recorded at time intervals not to exceed five (5) minutes whenever the VMES is transmitting. Additionally, each VMES will report to the Network Control Facility the time any transmissions begin. The Network Control Facility will additionally record the time any VMES transmissions cease, or, in default if communications are lost, the time of the last VMES transmission heard from each VMES terminal. The network control facility will record the VMES identification information in addition to the following information:

- Time stamp for each data entry
- VMES location in terms of latitude and longitude

For each set of data, and until it is changed for any VMES, the following information will also be recorded by the Network Control Facility:

- Transmit (uplink) frequency
- Transmit channel bandwidth and modulation characteristics
- VMES EIRP limit referenced to the Network Control Facility
- Satellite used

The data records collected by the Network Control Facility in connection with the proposed VMES operations will be maintained for a period of not less than 12 months, and typically 18 months,. The VMES data will be made available upon request to a coordinator, fixed system operator, fixed-satellite system operation, NTIA, or the Federal Communications Commission within 24 hours of a request via telephone, email, or postal mail made to the Network Control Facility listed in the previous section.

3.6 § 25.226 (a)(7) lack of protection from terrestrial stations

General Dynamics fully understands and agrees that the VMES operation proposed under this application will not claim and will not receive protection from any authorized terrestrial stations to which frequencies are either already assigned (or may be assigned in the future) in the frequency bands of 10.95-11.2 GHz and 11.45-11.7 GHz. Testing conducted under an Experimental Authorization by General Dynamics has confirmed that this lack of protection has not proven to be a factor in the proposed types of VMES operations.

3.7 § 25.226 (a)(8) limited protection in downlink bands

General Dynamics fully understands and agrees that the VMES operation proposed under this application will receive only that protection from interference caused by space stations other than the target space station only to the degree to which harmful interference would not be expected to be caused to an earth station employing an antenna conforming to the referenced patterns defined in paragraphs (a) and (b) of section 25.209 and stationary at the location at which any interference occurred. Testing conducted under an Experimental Authorization by General Dynamics has confirmed that this level of protection is more than sufficient to fully support the proposed types of VMES operations.

3.8 § 25.226 (a)(9) VMES to automatically cease transmitting

From § 25.226 (a)(9), *"Each VMES terminal shall automatically cease transmitting within 100 milliseconds upon loss of reception of the satellite downlink signal."*

The proposed VMES terminals utilize two separate receivers which are each capable of detecting the satellite downlink signals and will both support automatic uplink transmitter muting. The first receiver is a tracking receiver implemented in the VMES Antenna Control Unit to update the Antenna Pointing and Tracking solution. The tracking receiver normally tracks on the downlink beacon signal from the intended satellite, but it is also capable of tracking on any downlink signal from the satellite. If the tracking receiver loses the downlink signal it is tracking, whether the satellite beacon or any other downlink signal, it commands the VMES to mute the transmit signal. The transmitter mute function is implemented by a direct hardware connection within the VMES RF transceiver and is commanded by the VMES Antenna Control Unit. The chain of events and associated time requirements are:

1) Tracking Receiver detects loss of downlink signal within less than 50 milliseconds of the actual signal event.
2) The VMES Antenna Control Unit receives an indication from the Tracking Receiver of the loss of the downlink signal within 5 milliseconds of the loss of signal detection. (The tracking receiver provides continuous signal strength updates to the Antenna Control Unit at a frequency of approximately 20 Hz.)
3) The VMES Antenna Control Unit commands the VMES uplink Solid State Power Amplifier ("SSPA") to mute the uplink signal via a direct hardware connection. This is done with digital logic circuitry in the Antenna Control Unit and requires only microseconds to complete.
4) The VMES uplink SSPA receives the transmitter mute command from the VMES Antenna Control Unit and disables the SSPA power amplification function. This process requires on the order of 1 millisecond due to the functionality of the SSPA transmit logic and switching circuitry.

5) Thus cessation of VMES transmissions due to loss of downlink signal as determined by the tracking receiver requires a total of approximately 57 milliseconds, maximum.

In addition to the tracking receiver mute function, the proposed VMES terminals also continuously monitor the traffic downlink signal, which is also called the “out-route” signal in VSAT operating terms. The modem system utilized by the proposed VMES terminals utilizes a version of the standard ViaSat Linkway VSAT network modem hardware supporting a Time-Division Multiplex (TDM) out-route signal and a Time-Division Multiple Access (TDMA) uplink or in-route modulation scheme. The ViaSat Linkway modem continuously receives both traffic and control information via demodulation of the out-route signal. As a standard feature of these modems, the modems themselves will command the transmitter to mute transmissions if the out-route carrier cannot be effectively demodulated, indicating either loss of the out-route transmissions themselves or excessive attenuation on the downlink from the out-route transmission. Muting is accomplished by canceling the next uplink TDMA burst, which is all accomplished within the modem itself and does not rely upon external inputs from the tracking receiver or external commands issued to the SSPA. Effective uplink muting is accomplished using this method in a time period of typically less than 10 milliseconds.

4. VMES Coordination and Exclusion Zones

4.1 § 25.226 (c) VMES protection for NASA TDRSS facilities

From § 25.226 (c), *“(1) Operations of VMESs in the 14.0-14.2 GHz (Earth-to-space) frequency band within 125 kms of the NASA TDRSS facilities on Guam (latitude 13° 36' 55" N, longitude 144° 51' 22" E) or White Sands, New Mexico (latitude 32° 20' 59" N, longitude 106° 36' 31" W and latitude 32° 32' 40" N, longitude 106° 36' 48" W) are subject to coordination with the National Aeronautics and Space Administration (NASA) through the National Telecommunications and Information Administration (NTIA) Interdepartment Radio Advisory Committee (IRAC). Licensees shall notify the International Bureau once they have completed coordination. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations.*

(2) When NTIA seeks to provide similar protection to future TDRSS sites that have been coordinated through the IRAC Frequency Assignment Subcommittee process, NTIA will notify the Commission’s International Bureau that the site is nearing operational status. Upon public notice from the International Bureau, all Ku-band VMES licensees shall cease operations in the 14.0-14.2 GHz band within 125 kms of the new TDRSS site until the licensees complete coordination with NTIA/IRAC for the new TDRSS facility. Licensees shall notify the International Bureau once they have completed coordination for the new TDRSS site. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the

operations. The VMES licensee then will be permitted to commence operations in the 14.0-14.2 GHz band within 125 kms of the new TDRSS site, subject to any operational constraints developed in the coordination process."

The proposed VMES terminals utilize a GPS receiver to determine the location of the VMES terminal itself, as described in paragraph 3.2.a above. The GPS-derived location information is updated on the order of every few seconds and is not critical to accurate antenna pointing. This same GPS-derived location information is used to ensure that the VMES terminals satisfy the geographic operational coordination and exclusion zone requirements.

The VMES terminals utilize a Monitor & Control processor in conjunction with the VMES Antenna Control Unit for operator interface with the terminals. The VMES Monitor & Control processor provides the facility for the VMES operator to control normal VMES functions such as designation of the intended satellite, entering satellite ephemeris data, transmitter activation and muting, uplink power measurement and control, etc. To ensure proper geographic coordination and exclusion operation, the VMES Monitor & Control system continuously compares the determined VMES location information with the regions within 125 kms of the NASA TDRSS facilities on Guam and in White Sands, New Mexico. When the Commission specifies that protection will be provided to future TDRSS sites, the location of those sites will also be programmed into the VMES Monitor & Control system for similar comparison to ensure protection.

The VMES Monitor & Control system will normally mute the transmitter if the terminal is determined to be within any of the TDRSS coordination zones. A special password-protected feature, only available to VMES system administrators and not available to normal VMES terminal operators, is provided to override the geographic coordination zone transmitter mute function for those cases where the required coordination has successfully been accomplished. Proper operation of this transmitter mute functionality can be ensured through both local reporting to the VMES operator via the Monitor & Control system as well as via the remote location logging which is reported to the VMES network control facility and continuously logged there.

4.2 § 25.226 (d) VMES protection for Radio Astronomy Service facilities

From § 25.226 (d), *"(1) Operations of VMESs in the 14.47-14.5 GHz (Earth-to-space) frequency band in the vicinity of radio astronomy service (RAS) observatories observing in the 14.47-14.5 GHz band are subject to coordination with the National Science Foundation (NSF). The appropriate NSF contact point to initiate coordination is Electromagnetic Spectrum Manager, NSF, 4201 Wilson Blvd., Suite 1045, Arlington VA 22203, fax 703-292-9034, email esm@nsf.gov. Licensees shall notify the International Bureau once they have completed coordination. Upon receipt of the coordination agreement from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations.*

(2) Table 1 provides a list of each applicable RAS site, its location, and the applicable coordination zone.

Table 1 Applicable Radio Astronomy Service (RAS) Facilities and Associated Coordination Distances.

Observatory	***Latitude (North)***	***Longitude (West)***	***Radius (km) of Coordination Zone***
Arecibo Observatory, Arecibo PR	*18° 20′ 37″*	*66° 45′ 11″*	*Island of Puerto Rico*
Green Bank WV	*38° 25′ 59″*	*79° 50′ 23″*	*160*
Very Large Array, near Socorro NM	*34° 04′ 44″*	*107° 37′ 06″*	*160*
Pisgah Astronomical Research Institute, Rosman NC	*35° 11′ 59″*	*82° 52′ 19″*	*160*
U of Michigan Radio Astronomy Observatory, Stinchfield Woods MI	*42° 23′ 56″*	*83° 56′ 11″*	*160*
Very Long Baseline Array (VLBA) stations:			
Owens Valley CA	*37° 13′ 54″*	*118° 16′ 37″*	*160**
Mauna Kea HI	*19° 48′ 05″*	*155° 27′ 20″*	*50*
Brewster WA	*48° 07′ 52″*	*119° 41′ 00″*	
Kitt Peak AZ	*31° 57′ 23″*	*111° 36′ 45″*	
Pie Town NM	*34° 18′ 04″*	*108° 07′ 09″*	
Los Alamos NM	*35° 46′ 30″*	*106° 14′ 44″*	
Fort Davis TX	*30° 38′ 06″*	*103° 56′ 41″*	
North Liberty IA	*41° 46′ 17″*	*91° 34′ 27″*	
Hancock NH	*42° 56′ 01″*	*71° 59′ 12″*	
St. Croix VI	*17° 45′ 24″*	*64° 35′ 01″*	

** Owens Valley CA operates both a VLBA station and single-dish telescopes.”*

The proposed VMES terminals will utilize the same functionality described in paragraph 4.1 above to protect the applicable Radio Astronomy Service facilities listed in § 25.226 Table 1. The VMES Monitor & Control system will compare the GPS-derived location information with each of the zones calculated from Table 1 and utilize the same transmitter mute functionality. Additionally, when the Commission specifies that protection will be provided to future RAS sites, the location of those sites will additionally be programmed into the VMES Monitor & Control system for similar comparison.

The VMES Monitor & Control system is designed to mute the transmitter if the terminal is determined to be within any of the RAS coordination zones. A special password-protected feature, only available to VMES system administrators and not available to normal VMES terminal operators, is provided to override the geographic coordination zone transmitter mute function for those cases where the required coordination has successfully been accomplished. Proper operation of this transmitter mute functionality can be ensured through both local reporting to the VMES operator via the Monitor & Control system as well as via the remote location logging which is reported to the VMES network control facility and continuously logged there.

4.3 § 25.226 (e) Global Positioning Satellite position location technology

From § 25.226 (e), *"VMES licensees shall use Global Positioning Satellite-related or other similar position location technology to ensure compliance with paragraphs (c) and (d) of this section."*

The proposed VMES terminals utilize a GPS receiver to determine the location of the VMES terminal and, thus, ensure compliance with paragraphs § 25.226 (c) and § 25.226 (d).