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October 26, 2007

International Bureau
Office of Engineering and Technology
Federal Communication Commission

Subject: Amendment to include FCC 25.222 compliance data
ThinKom Solutions FCC OET Filing # 0347-EX-PL-2007
Confirmation # EL35261 (Ref # 5407)

Reference: Antenna System 1 – 20" Dia VICTS Antenna (Transmit)
16" Dia VICTS Antenna (Receive)

Antenna System 2 – 6"x24" CTS Flatplate Antenna (Transmit & Receive)

The following includes a comprehensive analysis of the subject antenna performance as measured relative to FCC 25.222, Blanket Licensing provisions for Earth Stations on Vessels (ESVs) receiving in the 10.95-11.2 GHz, 11.45-11.7 GHz and 11.7-12.2 GHz frequency band and transmitting in the 14.0-14.5 GHz frequency band, operating with Geostationary Satellites in the Fixed-Satellite Service. It should be noted that the FCC has issued a Notice of Proposed Rule Making (FCC 07-86) to allocate spectrum and adopt service rules and procedures to govern the use of Vehicle-Mounted Earth Stations (VMES) in certain frequency bands allocated to the Fixed-Satellite Service. ThinKom's STA license application would be applicable to any such new rule makings of the VMES system.

a) All applications for licenses for ESVs shall provide sufficient data to demonstrate that the ESV operations meet the following criteria, which are ongoing requirements that govern all ESV licensees and operations in these bands:

    1) The off-axis EIRP spectral density for co-polarized signals, emitted from the ESV in the plane of the geostationary satellite orbit as it appears at the particular earth station location shall not exceed the following values:
    $15-25\log(\Theta)-10\log(N)$ dBW/4kHz for $1.25° \leq \Theta \leq 7.0°$
    $-6-10\log(N)$ dBW/4kHz for $7.0° < \Theta \leq 9.2°$
    $18-25\log(\Theta)-10\log(N)$ dBW/4kHz for $9.2° < \Theta \leq 48°$

-24-10log(N) dBW/4kHz for 48°<Θ≤180°
where Θ is the angle in degrees from the axis of the main lobe. For an ESV network using frequency division multiple access (FDMA) or time division multiple access (TDMA) technique, N is equal to one. For an ESV network using code division multiple access (CDMA) technique, N is the maximum number of co-frequency simultaneously transmitting earth stations in the same satellite receiving beam.
ThinKom Response: See (b)(1)(1)

2) In all other directions, the off-axis EIRP spectral density for co-polarized signals emitted from the ESV shall not exceed the following values:
18-25log(Θ)-10log(N) dBW/4kHz for 1.25°≤Θ≤48°
-24-10log(N) dBW/4kHz for 48°<Θ≤180°
where Θ and N are defined as set forth in paragraph (a)(1) of this section
ThinKom Response: See (b)(1)(2)

3) For Θ>7°, the values given in paragraphs (a)(1) of this section may be exceeded by no more than 10% of the sidelobes, provided no individual sidelobe exceeds the criteria given by more than 3 dB
ThinKom Response: See (b)(1)(3)

4) In all directions, the off-axis EIRP spectral density for cross-polarized signals emitted from the ESV shall not exceed the following values:
5-25log(Θ)-10log(N) dBW/4kHz for 1.8°≤Θ≤7°
-16-10log(N) dBW/4kHz for 7°<Θ≤9.2°
where Θ and N are defined as set forth in paragraph (a)(1) of this section
ThinKom Response: See (b)(1)(4)

5) For non-circular ESV antennas, the major axis of the antenna will be aligned with the tangent to the geostationary satellite orbital arc at the target satellite point, to the extent required to meet specified off-axis EIRP criteria.
ThinKom Response: ThinKom's antennas meet the off-axis requirements without tilting the antenna.

6) A pointing error of less than 0.2°, between the orbital location of the target satellite and the axis of the main lobe of the ESV antenna.
ThinKom Response:

Our dual VICTS COTM system (Antenna System Type 1) consists of two antennas mounted to a common baseplate. The 16" diameter receive antenna is used to acquire and track the satellite. The receive beam is continuously con-scanned to keep the signal peaked and to continuously take out the drift of three base-mounted gyros. The carrier signal strength

is tracked using a narrowband filter and an envelope power detector. The 20" transmit antenna is slaved to the receive antenna pointing angles – it points directly at the satellite and does not con-scan. The antennas are belt driven by a motor/encoder/Hall-effect home sensor system which provides better than a 0.01° pointing accuracy for each antenna relative to their common base plate. Using this readout system, the antennas are carefully calibrated in our Near-field range to arrive at the precise relationship between the antenna platter angles and the RF beam location. We use high precision inclinometers on our baseplate to ensure we are level to within 0.01° and a laser alignment tool to control the base rotation angle to within 0.02° between the receive antenna calibration and the transmit antenna calibration. A 2048x2048 FFT is used to process the Near-field data followed by a MATLAB centroid routine to find the peak beam location in KxKy space. Our benchmarks show that this Near-field data processing approach results in better than 0.02° repeatability and better than 0.02° relative error between different scan angles. These 5 sources of error when RSS'd with our observed 0.11° residual pointing error for our receive antenna (con-scan while traveling over smooth roads) results in a 1 sigma pointing error of 0.12° for the transmit antenna. As a secondary mitigation measure, ThinKom will ensure that additional margin with respect to the EIRP PSD is maintained by using a spread spectrum waveform. When our software indicates that either antenna is more than 0.5° from its intended orientation or that the receive signal has dropped, we will issue a Tx mute within 50 msec.

Our CTS Flatplate COTM system (Antenna System Type 2) consists of a single antenna mounted on an elevation over azimuth gimbal. Although the azimuth beam is narrower than that of Antenna System Type 1, there is inherently more error associated with pointing of the transmit beam because it shares a common aperture with the receive and therefore the transmit beam is con-scanned whenever the receive beam is con-scanned. This is true for any antenna sharing a common transmit and receive aperture. There are ways to mitigate this transmit beam pointing error by utilizing con-scan for initial acquisition (on Receive only) and then relying on an expensive Inertial Navigation Systems (INS) or incorporating electronic lobing modules to scan the azimuth receive beam without physically dithering the aperture. These methods are practical and acceptable for military or airborne systems and easily meet the pointing error requirement of less than 0.2°. However, in order to enable and field practical, cost-effective ESV products to emergency, first-responder, Homeland Security and enterprise users, ThinKom will utilize

the con-scan approach during the initial demonstrations and provide sufficient margin below the EIRP PSD mask to allow for pointing error. The demonstration system will include the error associated with the aperture continuously being con-scanned to keep the signal peaked and to continuously take out the drift of the two aperture-mounted gyros. Since these gyros are directly mounted on the Line-of-Sight (LOS), their drift can be more effectively corrected by conventional use of the receive signal strength and a small angle (+/- 0.2°) con-scan. The carrier signal strength will be tracked using a narrowband filter and an envelope power detector. The antenna drive system, composed of precision gears, motors, encoders and Hall-effect home sensors, provides better than a 0.02° pointing accuracy relative to the base plate. The receive and transmit beams are inherently aligned in a flat plate antenna to better than 0.10°. These 2 sources of error when RSS'd with our expected 0.05° residual pointing error for our receive antenna (small angle con-scan while traveling over smooth roads) results in a 1 sigma pointing error of 0.11°. When our software indicates that either antenna is more than 0.5° from its intended orientation or that the receive signal has dropped, we will issue a Tx mute within 50 msec. Once again, ThinKom will use a spread spectrum modem for transmit and rigorously manage activities with the satellite operator to ensure there is no adjacent satellite interference (i.e. we will insure that the prescribed off-axis EIRP requirements are met at all times, regardless of any transient beam-pointing excursions). We will carefully monitor our pointing performance (potentially with an independent Inertial Navigation System) since one of the primary goals of the experimental license is to help develop robust tracking algorithms and system architectures to resolve any issues before an application for a commercial license is put into place.

7) All emissions from the ESV 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 ESV antenna exceeds 0.5°, and transmission will not resume until such angle is less than 0.2°
ThinKom Response:

When our software indicates that VICTS COTM System (Antenna System Type 1) is more than 0.5° from its intended orientation or that the receive signal has dropped, it will issue a Tx mute within 50 msec. It will not resume transmit operation until the pointing error has fallen below the 0.2° requirement. Since our transmit antenna is slaved to our receive antenna but does not con-scan, we will avoid the inherent transmit mis-pointing found in most single aperture systems when conical RSSI is

used. The CTS Flatplate COTM System (Antenna System Type 2) will follow a similar protocol based on the discussion in (2)(6).

8) There shall be a point of contact in the United States, with phone number and address included with the application, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the ESVs, either directly or through the facilities of a U.S. Hub or a Hub located in another country with which the U.S. has a bilateral agreement that enables such cessation of emissions.

ThinKom Response:

ThinKom has assigned two contacts, available 24/7 with the authority and ability to cease all emissions from the ESVs:

Greg Otto (Primary)	Bill Henderson (Secondary)
639 14th Street	2805 190th Street
Manhattan Beach, CA 90266	Redondo Beach, CA 90278
Mobile: (310) 989-9117	Mobile: (310) 347-2314

9) ESVs that exceed the radiation guidelines of §1.1310 of this chapter, Radio frequency radiation exposure limits, must provide, with their environmental assessment, a plan for mitigation of radiation exposure to the extent required to meet those guidelines.

ThinKom Response:

The criteria listed in table 1 were used to evaluate the environmental impact of human exposure to radio frequency (RF) radiation.

§ 1.1311 47 CFR Ch. I (10–1–06 Edition)

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
30–300	61.4	0.163	1.0	6
300–1500	.....	.....	f/300	6
1500–100,000	.....	.....	5	6

Because the frequency range of interest, 14.0-14.5 GHz, falls within the 1500-100,000 MHz range, the Power density requirements is 5 mW/cm^2. The 20" Dia VICTS antenna (Type 1) has an active aperture area of >1000 cm^2, and therefore the power density will not exceed 4 mW/ cm^2 at any location near or even in contact with the surface of the antenna using a 4 Watt BUC. Similarly, the 6" x 24" CTS Flatplate antenna (Type 2) has an aperture area of 6" x 24"= 144 in^2 = 929 cm^2 and therefore, the power density will not exceed 4.3 mW/ cm^2 using a 4 Watt BUC. Both apertures safely meet the Maximum Permissible Exposure (MPE).

10) There shall be an exhibit included with the application describing the geographic area(s) in which the ESVs will operate.

ThinKom Response:

The geographical area that the ESVs will operate within is defined as the Continental United States. ThinKom will coordinate with all satellite operators to identify space segment for experimental demonstrations, ensure there is no adjacent satellite interference and ensure compliance to the EIRP spectral density mask. Please see FCC Form 442 filing, Exhibit A (Concept of Operation) for further details.

b) Applications for ESV operation in the 14.0-14.5 GHz to geostationary satellites in the fixed-satellite service must include, in addition to the particulars of operation identified on Form 312 and associated Schedule B, the following data for each earth station antenna type.

ThinKom Response: ThinKom is not applying for a commercial license; rather an experimental license and therefore the Form 312 & Schedule B do not apply

1) A series of EIRP density charts or tables, calculated for a production earth station antenna, based on measurements taken on a calibrated antenna range a 14.25 GHz, with the off axis EIRP envelope set forth in paragraphs (a)(1) through (a)(4) of this section superimposed, as follows:
ThinKom Response:

All ultra low-profile antennas exhibit EIRP density patterns that depend on the ES location (lat/long) and the longitude of the satellite because the tilt of the local ES azimuth plane with respect to the geostationary plane depends on the ES/satellite geometry. Therefore, there are an infinite number of EIRP PSD plots that could be generated for different combinations of ES locations, satellite longitudes, satellite parameters (G/T) and modem parameters (Modulation, FEC, Spreading, etc.). ThinKom has analyzed the EIRP PSD performance for both antenna systems for a broad range of ES/satellite geometries showing excellent margins in all cases. For the flat plate antenna, specifying the geo-tilt (i.e. the angle between local and geo-stationary plane horizontal) is sufficient to determine the geo-plane patterns. For the VICTS antenna both the geo-tilt and the satellite elevation angle are required to determine the geo-plane patterns. For both systems, the worst performance is obtained when the ES is at a low latitude and the longitudinal ES/satellite offset is large. Representative cases are shown in the figures below. For the VICTS antenna system, the three cases shown all have the ES at 35 degrees north latitude and the satellite is at elevations angles of 45, 29,

and 49 degrees respectively. These parameters correspond to operation in Los Angeles with the following satellites: AMC4, AMC6, and Galaxy 27 (these are the primary satellites that ThinKom plans to test with). The performance obtained in the first two cases both represent typical performance that can be expected in the CONUS. The third case is near worst case within the CONUS. The plots were all obtained from measured near-field data. For the flat plate antenna, each of the plots shows graphs for three different geo-tilt angles: 0, 30, and 50 degrees. These cover essentially the full range of possible geo-tilt angles within the CONUS (except for some pathological cases such as the ES in southern Florida with the satellite over the Pacific). The plots were obtained using results obtained from a finite element simulation (using Ansoft HFSS software) of the design. A full-sized (6”x24”) prototype of the antenna has not yet been made, but the measured results of a ¼ sized (6”x6”) prototype are in good agreement with the simulations.

In order to generate the PSD plots, it was necessary to assume a certain value for the on-axis PSD. For the VICTS antenna, a value of 10 dBW / 4KHz was used. For operation with AMC4 and Galaxy 27 from Los Angeles, this leads to off-axis PSD performance that has reasonable margin with regard to meeting the requirements (see figures below). For the case of AMC6 from Los Angeles, the performance is marginally compliant. However, it should be noted that the nearest adjacent 11.7-12.2 GHz satellite that is to the East of AMC6 is 9 degrees away. Therefore, if it is necessary to test with 10 dBW/4KHz on AMC6, adjacent satellite interference can be prevented by deliberately mis-pointing the transmit antenna by 0.5 deg. to the East (implementing this is facilitated by the fact that separate antennas are used for transmit and receive).

For the flat plate antenna, an on-axis PSD of 12 dBW/ 4KHz was assumed calculating the PSD patterns. As can be seen in the figures below, this leads to having reasonable margin with respect to meeting the off-axis geo-plane PSD requirements for geo-tilt angles below 50 degrees. For geo-tilt angles below 30 degrees, the margin is considerable.

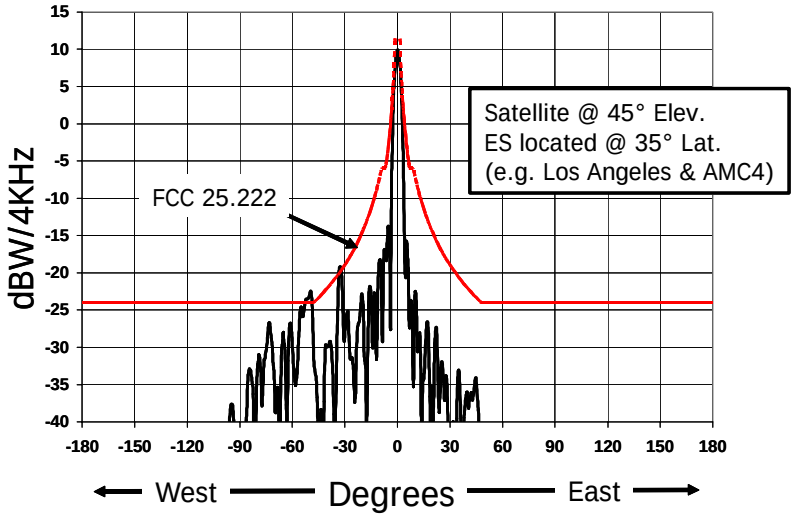
Link budgets were created in order to determine the minimum EIRP spectral density necessary to close the link. In these budgets, a satellite G/T of 3.5 dBi/K was used. AMC4 and AMC6 have a G/T greater than or equal to this value in all of the locations that ThinKom intends to test the systems (e.g. Los Angeles, Washington D.C., Chicago, San Francisco Bay Area). Detailed G/T information on Galaxy 27 has not yet been obtained, but it is expected to be similar to AMC4 and AMC6. Analysis

was done using two different sets of modem parameters. For the iDirect 8350 modem the following was used: required EbN0=4.7dB, FEC=0.431, BPSK modulation, and 4x spreading. For the Hughes HX150 modem these parameters were used: required EbN0=3.5 dB, FEC=0.333, QPSK modulation, and 4x spreading. Nearly the same value for the required on-axis EIRP PSD was obtained for the two modems: 6-7 dBW/4KHz. However, the modem parameters listed above imply a low spectral efficiency. In order to demonstrate the best possible spectral efficiency, ThinKom requests approval for transmitting up to 10 dBW / 4 KHz with the VICTS antenna system, and 12 dBW / 4KHz with the flat plate antenna system (13 dBW / 4KHz when the Geo-tilt angle is less than 35 degrees).

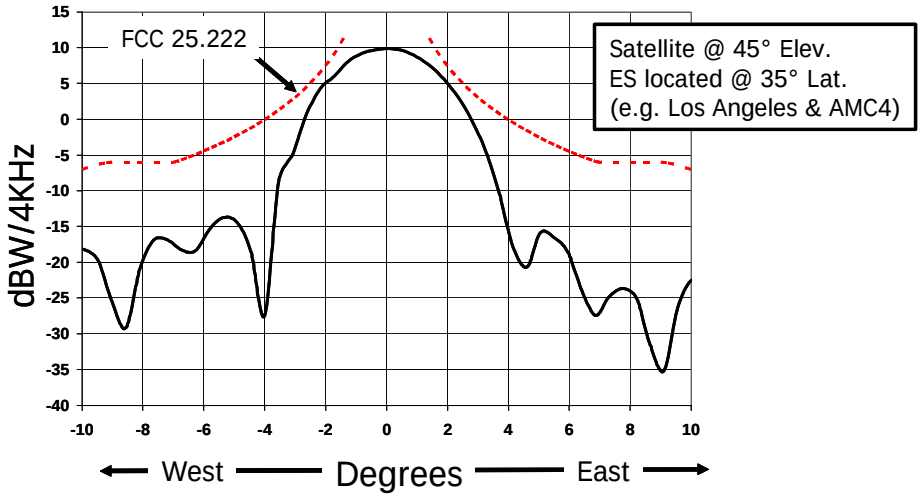
The plots below show compliance to all of the geo-plane PSD requirements. ThinKom continues to work with the satellite operators to rigorously evaluate PSD compliance in order to prevent adjacent satellite interference

1) Showing off-axis co-polarized EIRP spectral density in the azimuth plane, for off-axis angles from minus 10° to plus 10° and from minus 180° to plus 180°.

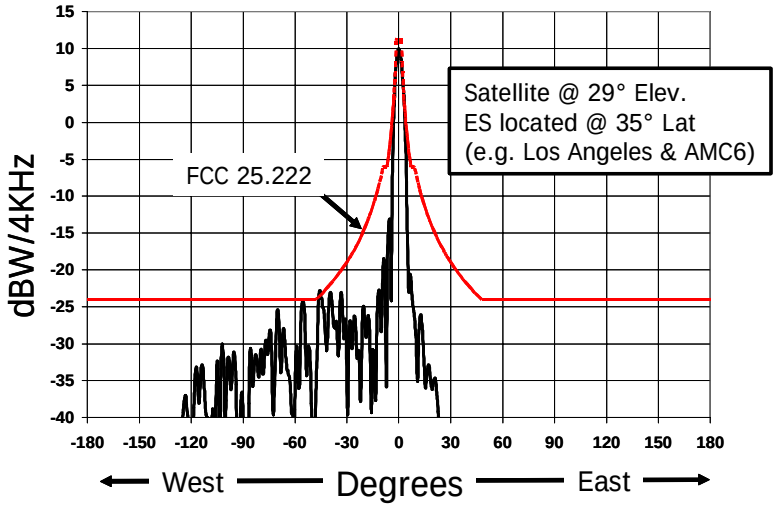
ThinKom Response: The following two PSD plots are for off-axis angles from minus 10° to plus 10° and from minus 180° to plus 180°.



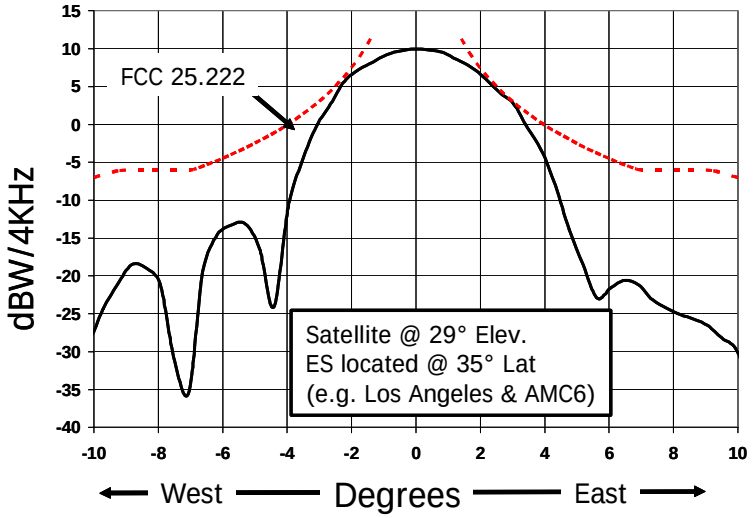
20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Azimuth Plane



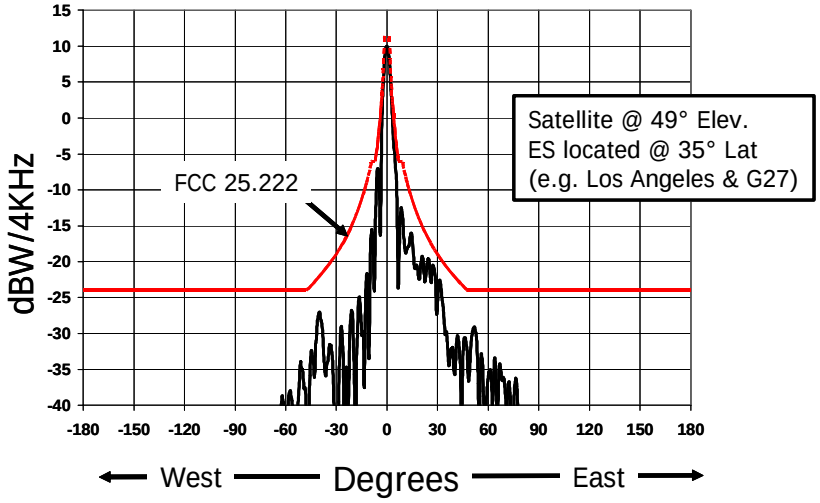
20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Azimuth Plane



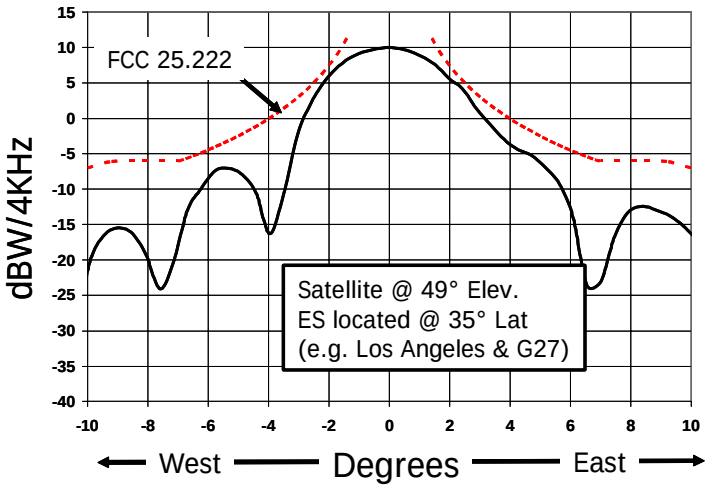
20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Azimuth Plane



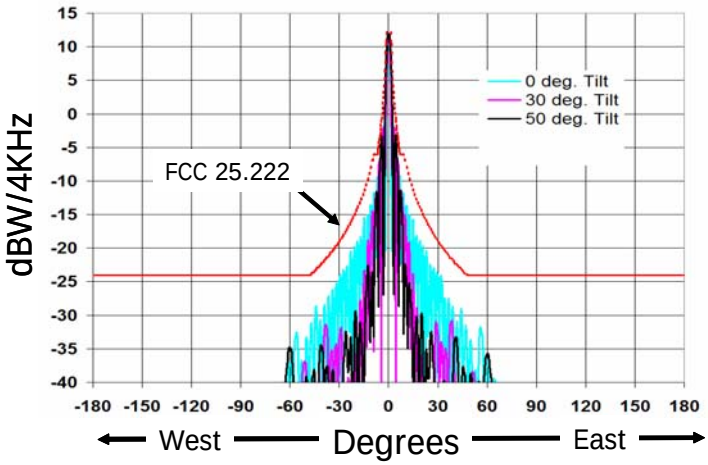
20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Azimuth Plane



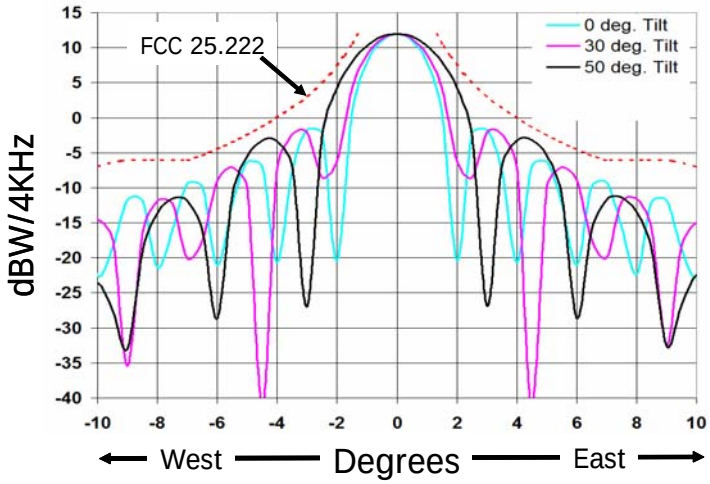
20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Azimuth Plane



20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Azimuth Plane

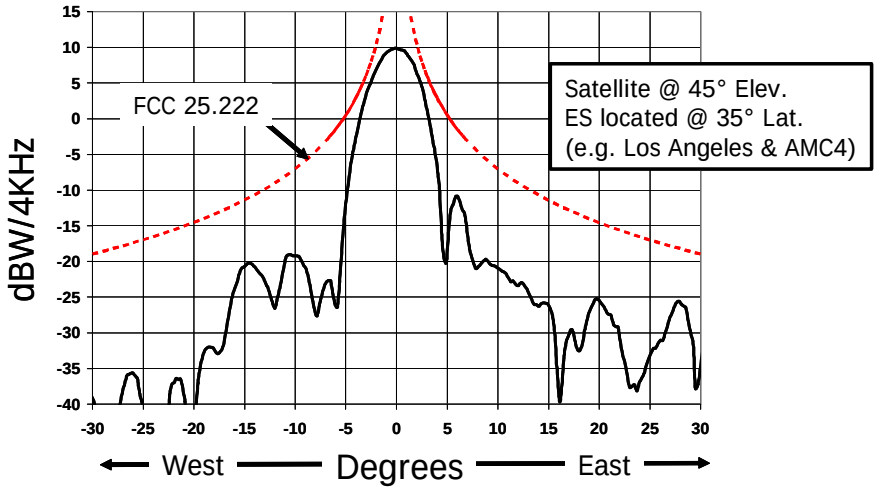


6" x 24" CTS Flatplate (Antenna Type 2): Co-Polarized EIRP Spectral Density, Azimuth Plane

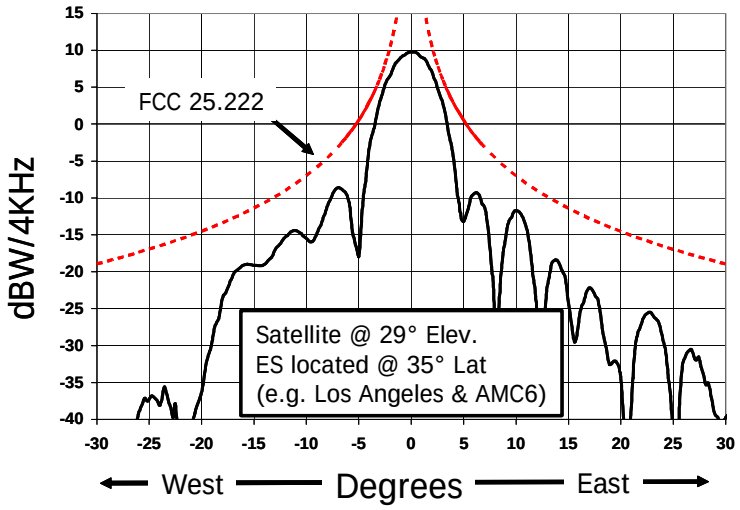


6" x 24" CTS Flatplate (Antenna Type 2): Co-Polarized EIRP Spectral Density, Azimuth Plane

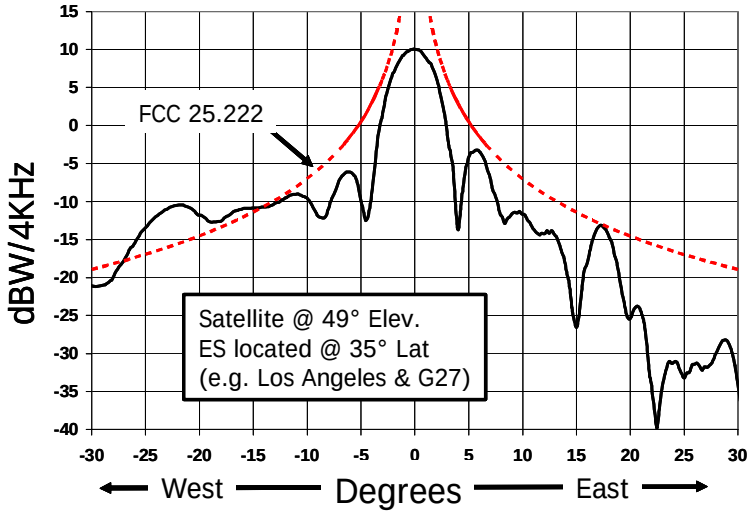
2) Showing off-axis co-polarized EIRP spectral density in the elevation plane, at off-axis angles from 0° to plus 30°. **ThinKom Response**: The following PSD plots are for off-axis co-polarized EIRP spectral density in the elevation plane, at off-axis angles from minus 30° to plus 30°.



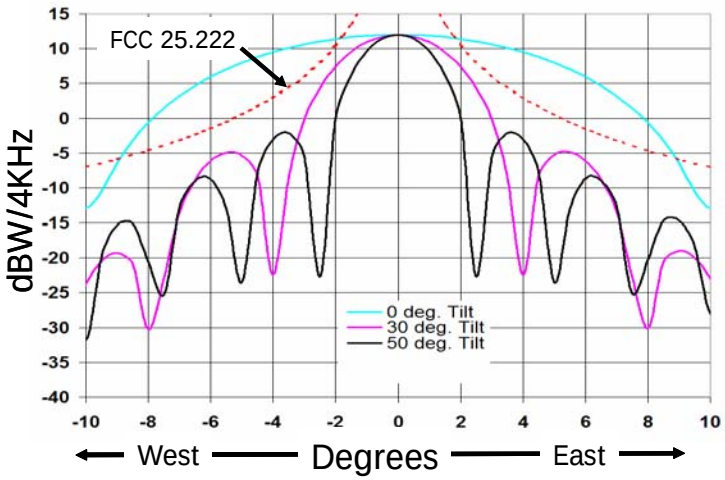
20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Elevation Plane



20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Elevation Plane

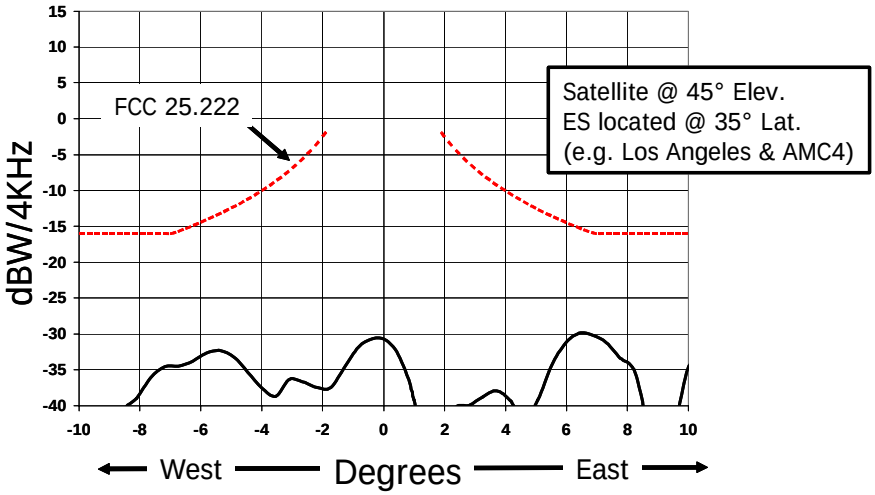


20" Dia VICTS (Antenna Type 1): Co-Polarized EIRP Spectral Density, Elevation Plane

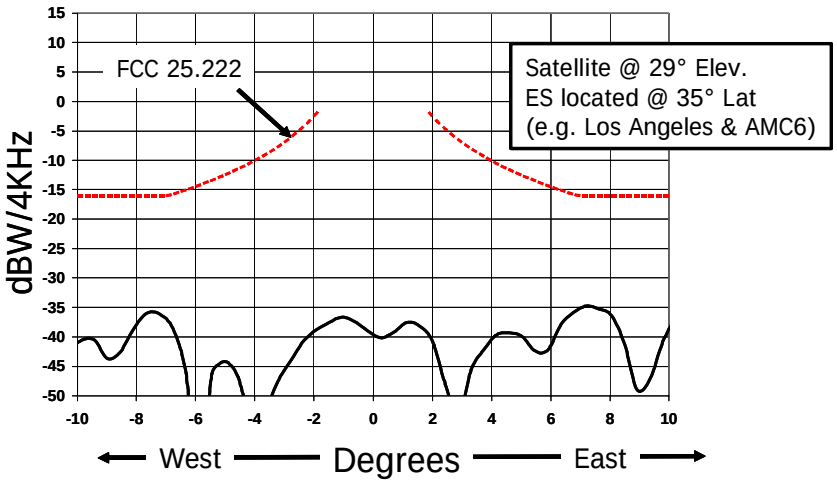


6" x 24" CTS Flatplate (Antenna Type 2): Co-Polarized EIRP Spectral Density, Elevation Plane

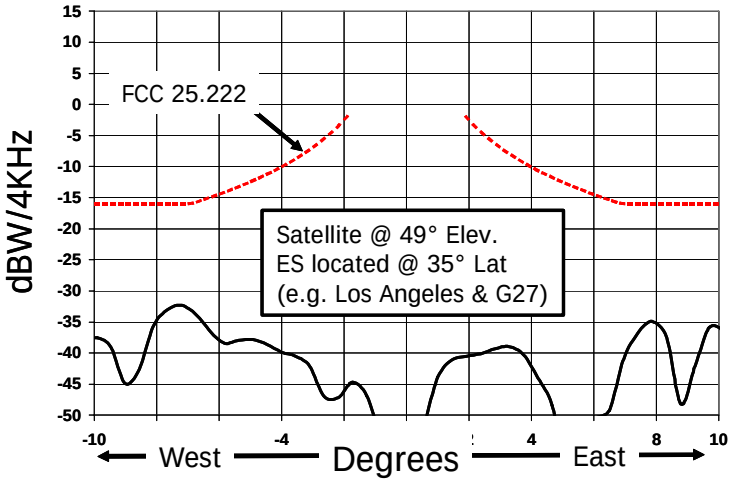
3) Showing off-axis cross-polarized EIRP spectral density in the azimuth plane, at off-axis angles from minus 10° to plus 10°. **ThinKom Response**: The following PSD plots are for off-axis cross-polarized EIRP spectral density in the azimuth plane, at off-axis angles from minus 10° to plus 10°.



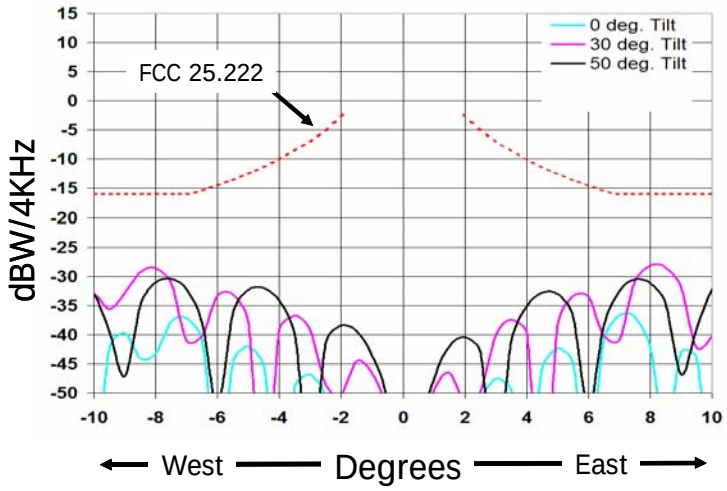
20" Dia VICTS (Antenna Type 1): Cross-Polarized EIRP Spectral Density, Azimuth Plane



20" Dia VICTS (Antenna Type 1): Cross-Polarized EIRP Spectral Density, Azimuth Plane

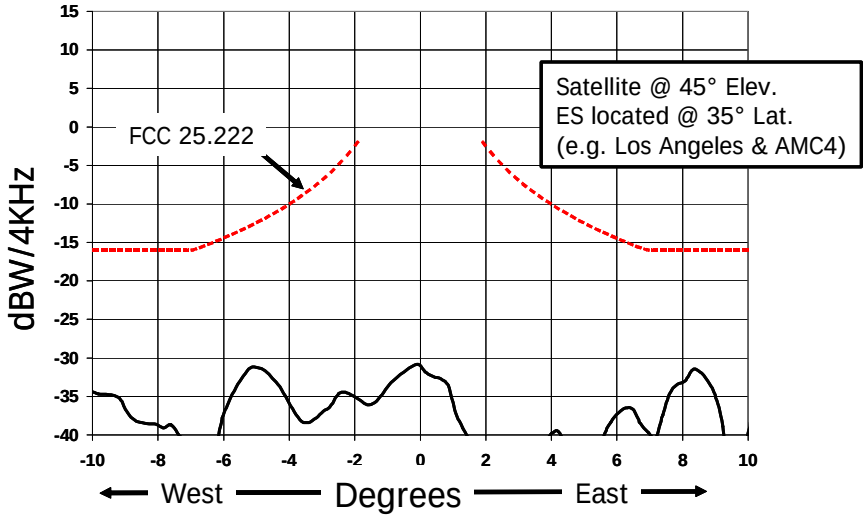


20" Dia VICTS (Antenna Type 1): Cross-Polarized EIRP Spectral Density, Azimuth Plane

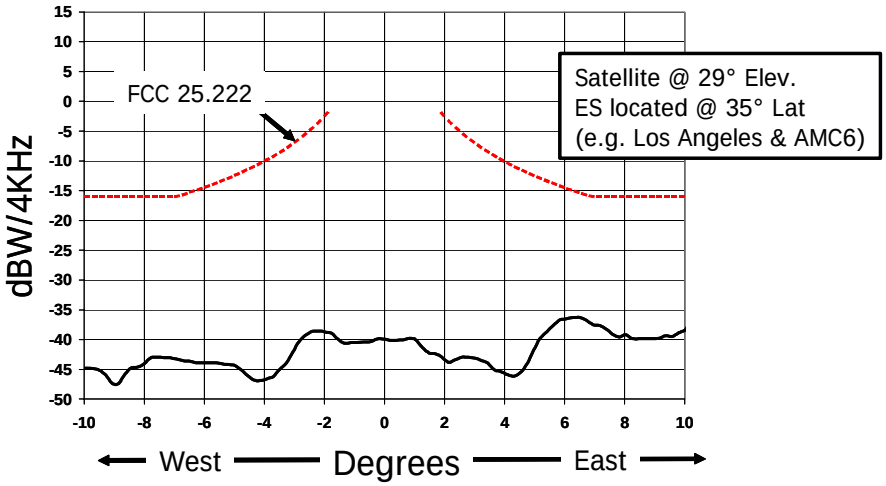


6" x 24" CTS Flatplate (Antenna Type 2): Cross-Polarized EIRP Spectral Density, Azimuth Plane

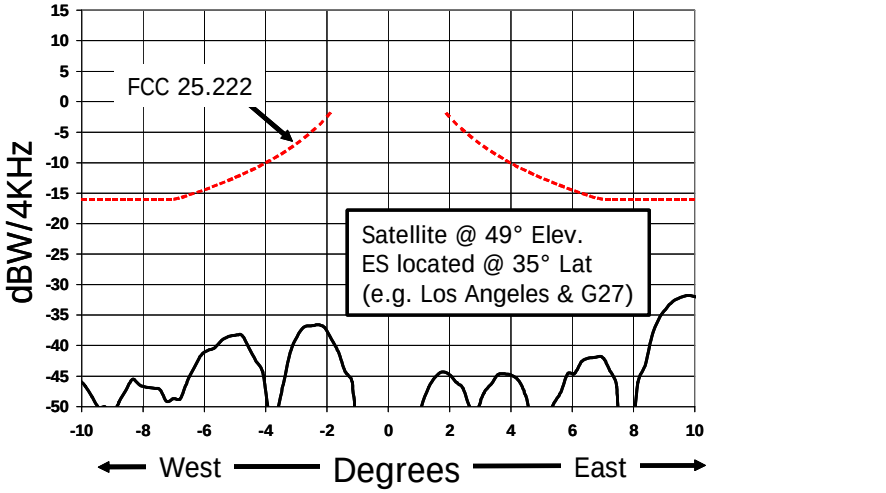
4) Showing off-axis cross-polarized EIRP spectral density in the elevation plane, at off-axis angles from minus 10° to plus 10°; or.
ThinKom Response: The following PSD plots are for off-axis cross-polarized EIRP spectral density in the elevation plane, at off-axis angles from minus 10° to plus 10°.



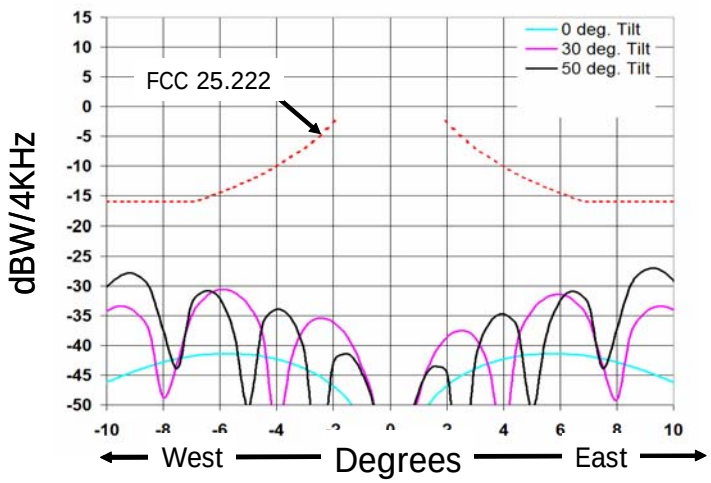
20" Dia VICTS (Antenna Type 1): Cross-Polarized EIRP Spectral Density, Elevation Plane



20" Dia VICTS (Antenna Type 1): Cross-Polarized EIRP Spectral Density, Elevation Plane



20" Dia VICTS (Antenna Type 1): Cross-Polarized EIRP Spectral Density, Elevation Plane



6" x 24" CTS Flatplate (Antenna Type 2): Cross-Polarized EIRP Spectral Density, Elevation Plane

2) A series of gain charts or tables for a production earth station … **ThinKom Response**: Not applicable, responded to (b)(1)

3) A certification that the ESV antenna conforms to the gain pattern … **ThinKom Response**: Not applicable, responded to (b)(1)

c) ESVs receiving in the 10.95-11.2 GHz, 11.45-11.7 GHz and 11.7-12.2 GHz frequency bands and transmitting in the 14.0-14.5 GHz frequency band shall operate with the following provisions

1) For each ESV transmitter a record of the ship locations (lat/long), transmit frequency, channel bandwidth and satellite used shall be time annotated and maintained for a period of not less than 1 year. Records will be recorded at time intervals no greater than every 20 minutes while the ESV is transmitting. The ESV operator will 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. **ThinKom Response**: ThinKom will generate and administer procedural requirements to ensure compliance. Log books will be maintained for a period of not less than 1 year and will be provided to the proper organizations upon request.

2) ESV operators communicating with vessels of foreign registry must maintain detailed information on each vessel's country of registry and a point of contact for the relevant administration responsible for licensing ESVs.

ThinKom Response: Not applicable

d) ESV operators shall control all ESVs by a Hub earth station located in the United States, except that an ESV on U.S. registered vessels may operate under control of a Hub earth station location outside the United States provided the ESV operator maintains a point of contact within the United States that will have the capability and authority to cause an ESV on a U.S. registered vessel to cease transmitting if necessary.

ThinKom Response: ESV operators shall control all ESVs by a Hub earth station located in the United States

e) Operating of ESVs in the 14.47-14.5 GHz frequency band within a) 45 km of the radio observatory on St. Croix, Virgin Islands b) 125 km of the radio observatory on Mauna Kea, Hawaii and c) 90 Km of the Arecibo Observatory on Puerto Rico are subject to coordination…

ThinKom Response: Not applicable. Demonstrations will avoid all coordinated areas

f) In the 10.95-11.2 GHz and 11.45-11.7 GHz frequency bands ESVs shall not claim protection from interference from any authorized terrestrial stations to which frequencies are either already assigned, or may be assigned in the future.

ThinKom Response: ThinKom agrees (no interference expected)

Sincerely,

Greg Otto
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