Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the matter of	)	
	)	
Amendment of Parts 2 and 25 of the	)	
Commission's Rules to Allocate Spectrum	)	
and Adopt Service Rules and Procedures to	)	IB Docket No. 07-101
Govern the Use of Vehicle-Mounted Earth	)	
Stations in Certain Frequency Bands	)	
Allocated to the Fixed-Satellite Service	)	
	)	

COMMENTS OF VIASAT, INC.

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Summary

ViaSat, Inc. ("ViaSat") strongly supports the Commission's proposal to license Vehicle-Mounted Earth Stations ("VMES") as an application of the fixed-satellite service ("FSS") in the conventional and extended Ku-band frequencies, and to modify the U.S. Table of Allocations and adopt service rules to facilitate this goal. In shaping a new regulatory regime for VMES, the Commission should: (i) provide certainty to manufacturers, service providers, and potential investors in mobile earth station systems like VMES; while (ii) accommodating a variety of technologies and system configurations – including systems incorporating small, low-profile antennas, spread spectrum modulation, and aggregate power control that would allow the development of commercial broadband applications of VMES that do not cause harmful interference to adjacent satellites.

While existing Earth Station on Vessel ("ESV") service rules provide a reasonable starting point for VMES service rules, several critical modifications are necessary in light of the differences between the applications. In particular, the Commission's VMES rules should: (i) dispense with stringent antenna pointing accuracy requirements with respect to systems that can comply with the off-axis EIRP density mask by using technology such as spread spectrum systems (even if antennas are not precisely "pointed"); (ii) adopt a reasonable antenna pointing accuracy requirement in other cases that is a function of antenna beamwidth and input power density, rather than a stringent fixed angular limit applied equally to all antennas; (iii) allow VMES network operators to comply with the off-axis power limit on an aggregate basis, and adjust the limit for individual VMES antennas, to accommodate systems capable of employing aggregate power control and thereby dynamically and efficiently allocating system resources; and (iv) allow greater increases in power density outside of the plane of geostationary satellites than are currently allowed in the ESV rules.

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COMMENTS OF VIASAT, INC.

ViaSat, Inc. ("ViaSat") submits the following comments in response to the Commission's *Notice of Proposed Rulemaking* ("*NPRM*") in connection with the above-referenced proceeding.[1] In the *NPRM*, the Commission seeks comment "on whether to license Vehicle-Mounted Earth Stations ('VMES') as an application of the fixed-satellite service ('FSS') in the conventional and extended Ku-band frequencies."[2] ViaSat strongly supports the Commission's proposal to license VMES in these bands, and to modify the U.S. Table of Allocations and adopt service rules to facilitate this goal.

In shaping a new regulatory regime for VMES, the Commission should strive to create an environment that is conducive to the development and implementation of VMES systems that can be used to provide advanced government and commercial applications. VMES systems have the potential to expand the availability of broadband Internet access to users in motor vehicles, including applications for public safety users and emergency responders. The

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1 *Amendment of Parts 2 and 25 of the Commission's Rules to Allocate Spectrum and Adopt Service Rules and Procedures to Govern the Use of Vehicle-Mounted Earth Stations in Certain Frequency Bands Allocated to the Fixed-Satellite Service*, Notice of Proposed Rulemaking, IB Docket No. 07-101, FCC 07-86 (May 9, 2007) ("*NPRM*").

2 *Id.* at ¶ 1.

Commission should facilitate the development of smaller, low-cost antennas that will make commercial VMES service viable. As Internet services become an increasingly important part of the lives of consumers, it is important that government regulation afford technologies that promote ubiquitous availability of broadband connectivity the opportunity to develop and flourish while still providing appropriate protection to incumbent users of radio spectrum. As such, the Commission should adopt rules that: (i) provide certainty to manufacturers, service providers, and potential investors in mobile earth station systems like VMES; while (ii) accommodating a variety of technologies and minimizing uncertainty with respect to new systems that do not fit squarely within legacy rules. While the existing service rules for ESV provide a reasonable starting point for such rules, several critical modifications are necessary in order to best accommodate systems employing small VMES terminals and spread spectrum technologies.

Background

ViaSat. Founded in 1986, ViaSat is a digital communications company specializing in satellite and other wireless networking technologies. ViaSat's innovative product offerings include satellite networks for commercial and government markets, terminals for battlefield data collection and distribution, data encryption devices, wireless data collection and monitoring systems, communication test and training simulators, and other networking hardware and software. ViaSat is developing antenna and modulation technology to make high-speed data communications available to users while traveling in vehicles. ViaSat has substantial business operations in the traditional VSAT market segment, and thus has a strong interest in protecting incumbent uses of the Ku-band. Therefore, ViaSat can provide a balanced perspective on the issues in this proceeding.

ArcLight® Technology. ViaSat's proprietary ArcLight® technology makes possible a wide range of mobile applications, including VMES, using FSS frequency bands and existing FSS infrastructure. Specifically, ArcLight® technology enables: (i) more efficient use of bandwidth, especially for random traffic patterns, without loss of data throughput capacity due to reservation schemes or contention-based protocols; (ii) lower power requirements through the use of spread spectrum transmissions; and (iii) advanced signal encoding using a combination of Code Reuse Multiple Access (CRMA) and Asymmetric Paired Carrier Multiple Access (A-PCMA) technologies. A-PCMA enables inbound and outbound data transmissions to be combined within the same bandwidth. CRMA, similar to CDMA coding in cellular phone systems, provides very efficient use of channel capacity, resulting in lower bandwidth consumption for the entire network. In addition, the CRMA spread spectrum waveform permits applications using antennas that are smaller than standard VSATs due to the extremely low-density transmissions that significantly reduce the potential for adjacent satellite interference.

Discussion

I. THE COMMISSION SHOULD TREAT VMES AS AN APPLICATION OF FSS IN THE KU- AND EXTENDED KU-BANDS

ViaSat strongly supports the Commission's proposal to add a non-Federal footnote to the U.S. Table of Allocations for the 11.7-12.2 GHz and 14.0-14.5 GHz bands providing that "Vehicle-Mounted Earth Stations (VMES) as regulated under 47 CFR part 25 are an application of the fixed-satellite service and may be authorized to communicate with space stations of the fixed-satellite service on a primary basis."[3] ViaSat agrees that the Commission should treat VMES as an application of FSS, and therefore should afford VMES primary status

to the extent that VMES terminals are no more interfering than and no more susceptible to interference than a typical VSAT. ViaSat also supports the Commission's proposal to adopt a footnote that would permit VMES operations in the 10.95-11.2 GHz and 11.45-11.7 GHz "extended" Ku-bands on a secondary, non-interference basis with respect to the fixed service.[4]

As the Commission recognized in the ESV proceeding, affording primary status to VMES in the Ku-band frequencies would ensure the ability of VMES terminals to access multiple satellites following FSS inter-system coordination, and also would facilitate inter-system coordination among FSS operations, because multiple applications of FSS satellite capacity would have primary status.[5] Moreover, such treatment would promote the efficient use of spectrum and help to meet the growing demand for two-way broadband capabilities for vehicle users in motion by offering a less restrictive operating environment with greater (*i.e.*, primary) regulatory rights. Authorizing VMES terminals to operate on a primary basis is consistent with the growing trend toward mobile applications of the FSS allocation and would provide certainty to support needed investment.

Despite the potential ubiquity of VMES terminals, treating VMES as an application of FSS need not increase the potential for harmful interference into traditional FSS operations. Specifically, granting VMES primary status would not necessarily create increased noise-power from VMES into FSS operations.[6] VMES terminals that meet the appropriate off-axis EIRP density ("OAED") limits will be no more interfering than fixed earth terminals. As

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3 *Id.* at ¶ 40.

4 *NPRM* ¶ 28.

5 *See Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands*, Report and Order, 20 FCC Rcd 674 at ¶¶ 78, 79 (2005) ("*ESV Order*").

6 *Cf. NPRM* ¶ 18.

discussed below, antennas employing spread spectrum technologies can control interference even where deployed in a ubiquitous fashion. Increasing the efficiency with which Ku- and extended Ku-band spectrum is used by authorizing VMES operations offers significant public interest benefits without harming existing FSS uses.

Further, adopting the proposed footnotes would ensure that VMES is treated in a manner consistent with other Ku-band systems, including Earth Station on Vessel ("ESV") systems.[7] The consistent treatment of similarly-situated systems, such as VMES, ESV, and AMSS systems, provides a stable set of technical parameters that would allow manufacturers and service providers to develop mobile systems that are capable of functioning across these operational environments. Such interoperability would facilitate the aggregation of demand across mobile services in the Ku-band, allowing manufacturers and service providers to provide service at lower cost to the end user. Thus, consistent treatment would encourage the most efficient use of existing Ku-band satellite resources and mobile terminal technology, and promote the economic viability of VMES, ESV, and AMSS systems.

Even after VMES is afforded primary status in the Ku-band frequencies, VMES operators would coordinate operations with space research facilities, as is required for ESV and "traditional" FSS applications.[8] ViaSat agrees that VMES operations should coordinate with the Tracking and Data Relay Satellite System ("TDRSS") in the 14.0-14.2 GHz band and the Radio

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[7] Similarly, ViaSat and other commenters in the Commission's pending proceeding to adopt service rules for Aeronautical Mobile Satellite Service ("AMSS") supported similar footnotes for AMSS systems. *See Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service*, IB Docket No. 05-20. If the Commission affords VMES primary status, it should also treat AMSS as primary. Adopting secondary status for AMSS as originally proposed in the AMSS Notice of Proposed Rulemaking would unnecessarily disadvantage AMSS systems.

[8] *See NPRM* ¶¶ 31, 37.

Astronomy Service ("RAS") in the 14.47-14.5 GHz band. In ViaSat's experience, applicants and licensees of mobile applications in the FSS bands can successfully negotiate coordination directly with NASA and the NSF without involvement by the Commission. Therefore, the Commission should maintain the same coordination procedures that it adopted for ESV and that are required for other mobile operations in the Ku-band uplink frequencies.

II. THE COMMISSION SHOULD ADOPT VMES SERVICE RULES THAT FACILITATE INNOVATIVE AND TECHNOLOGICALLY-DIVERSE SERVICE OFFERINGS

ViaSat generally supports the *NPRM* proposal to use the ESV service and licensing rules for Ku-band operations as a basis for the service and licensing rules for VMES systems.[9] However, as the Commission acknowledges, the ESV rules cannot be adopted wholesale for VMES given the anticipated nature of VMES services.[10] Technologies that may not have been prevalent in the ESV context may be especially relevant and desirable in the VMES context. The demand and uses for commercial VMES systems are likely to be different than those for ESV systems, and thus, may require smaller, low-profile antennas. Additionally, VMES systems may employ a wide range of antenna and modulation technologies that can prevent harmful interference. The Commission should afford VMES proponents the flexibility to implement these technologies.

In particular, the Commission should tailor the ESV service and licensing rules to account for the capabilities of VMES systems using spread spectrum modulation and aggregate power control. As discussed below, VMES systems can be designed to operate without causing interference, despite the use of small antennas with large beamwidths, by the incorporation of direct sequence spread spectrum ("DSSS") code division multiple accesss ("CDMA")

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[9] *Id.* at ¶ 45.

technology. The application of the rigid existing ESV antenna pointing accuracy requirements to such systems would create an artificial restraint on the capabilities of these systems, while at the same time raising costs to the point that VMES terminals could no longer be offered to end users at reasonable cost, thereby undermining the economic viability of VMES operations. Viasat therefore urges the Commission to build sufficient flexibility into its rules to permit VMES systems using spread spectrum technologies, while at the same time ensuring that adjacent users are adequately protected from interference.

A. The Commission Should Adopt Antenna Pointing Accuracy Requirements That Do Not Restrict VMES Technologies That Adequately Protect Adjacent Satellites Through Other Means

The Commission's proposal to adopt a 0.2º pointing accuracy requirement for all VMES terminals would severely limit the benefits offered by spread spectrum and other technologies that can prevent harmful interference even when mispointed. While a pointing accuracy requirement may be necessary for VMES terminals that operate on narrow beamwidths close to the OAED limit, the VMES rules should not apply unnecessary antenna pointing restrictions to spread spectrum systems. Therefore, ViaSat proposes a two-tiered approach in addressing antenna pointing errors. For individual VMES antennas that operate at a power density level that is sufficiently below the OAED mask, no pointing accuracy requirement should apply. For these antennas, a requirement to operate below the OAED mask, inclusive of pointing errors, is sufficient to protect adjacent satellites. However, a pointing accuracy limit may be appropriate for individual VMES antennas that operate at power density levels that are close to the OAED limit, provided that limit varies in accordance with the beamwidth and input power level of the antenna. ViaSat would be pleased to work with the Commission to develop a

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[10] *Id.* at ¶ 46.

suitable threshold OAED level. This two-tiered approach would balance the need for a pointing accuracy limit for some antennas, and the ability to forgo expensive inertial reference units for antennas that can control off-axis interference through signal modulation.

1. Stringent antenna pointing accuracy requirements are unnecessary for VMES terminals using spread spectrum technologies

In the *NPRM*, the Commission seeks comment on antenna technologies that would protect adjacent satellites without the need for stringent antenna pointing accuracy limits.[11] As an initial matter, regardless of the technology used, the proposed OAED mask alone is sufficient to protect adjacent satellite users from harmful interference, provided that VMES operators ensure that their OAED conforms to the proposed OAED mask *inclusive* of any antenna pointing error. By clarifying that operators must conform to the OAED mask in this fashion, the Commission would avoid altogether the need for separate antenna pointing accuracy requirements.

To the extent that the Commission finds that a separate antenna pointing requirement is necessary for some antennas, the rules should distinguish systems that can manage the potential for harmful interference through the use of spread spectrum technologies or by otherwise ensuring that the system meets the OAED mask on an aggregate basis. Strict antenna pointing requirements are unnecessary with respect to spread spectrum systems operating at high chip rates, with wide signal spread, because the power density transmitted by antennas in such systems is so low that, even when antennas are mispointed, interference will not occur as a result. Such systems operate using antennas emitting wide bandwidth signals at low power density levels that are likely undetectable to adjacent satellites. In these systems, momentary deviations of a single mispointed antenna do not perceptibly increase interference

potential.[12] Qualcomm, Incorporated ("Qualcomm") has successfully operated its OmniTRACS land-based mobile Ku-band system using spread spectrum technology for over fifteen years.[13] Qualcomm's excellent track record in operating this network without causing interference demonstrates that strict antenna pointing restrictions are unnecessary as applied to spread spectrum systems.

Figure 1 of Attachment 1 hereto plots the power density generated by a single 60 cm VMES antenna employing spread spectrum technology across a range of potential topocentric displacement values of an adjacent satellite. The VMES antenna illustrated in this chart is mispointed by 2.0º in the azimuth plane, but operates well below the proposed OAED mask, and thus, mispointing by even 2.0º would not cause harmful interference into adjacent satellites.

In networks that meet the power density limits on an aggregate basis and that use network management control centers ("NCMCs") and CDMA, interference potential is further reduced, because random antenna pointing errors average out across the user population and have little impact on the network aggregate OAED. The contribution of random antenna pointing errors from each terminal is miniscule relative to the overall OAED in a large network.[14] An individual antenna in such a network operates at an extremely low power density

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11 *NPRM* ¶ 55.

12 *Id.* at ¶ 52.

13 *See QUALCOMM, Inc., Application for Blanket Authority to Construct and Operate a Network of 12/14 GHz Transmit/Receive Mobile and Transportable Earth Stations and a Hub Earth Station*, Memorandum Opinion, Order, and Authorization, 4 FCC Rcd 1543 (1989).

14 *See* ViaSat, Inc. Reply Comments at Exh. A, *Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service*, IB Docket No. 05-20 (Aug. 3, 2005) ("ViaSat AMSS Reply Comments").

level because the OAED limit is met on an aggregate basis. Additionally, where network management techniques are employed, network operators can factor into the budget for meeting the OAED mask the increased power resulting from pointing errors. Thus, a single mispointed antenna in such a network would not impact adjacent satellite users.

Figures 2 and 3 in Attachment 1 illustrate a network of fifteen 60 cm VMES antennas operating with a standard deviation pointing error of 0.2º and of 1.0º, respectively. In both plots, each individual antenna operates well below the proposed OAED mask, and thus, individual pointing errors do not cause the system to exceed the mask. Further, on a system-wide basis, the NCMC can control the aggregate OAED level such that the network aggregate OAED level is maintained below the mask, despite the individual pointing errors. As demonstrated by the plots in Figures 2 and 3, there is no significant difference in interference potential resulting from a 1.0º and a 0.2º pointing angle error in a DSSS CDMA network.

Moreover, in a CDMA network of VMES terminals where several antennas are mispointed, the aggregate affect of the pointing errors would only be a small increase in power into adjacent networks. Due to the mobile nature of VMES terminals, the operating environment is constantly changing. Therefore, the likelihood of a pointing error is randomly distributed, and there is no pattern in how errors occur. Random errors that cause terminals to be mispointed are unlikely to result in an increase in power into an adjacent satellite because power from one mispointed antenna is likely to be offset by a decrease in power due to other antennas mispointed in different directions. Thus, even assuming a worst-case scenario of pointing errors, there is very little impact on the aggregate network power into an adjacent satellite. ViaSat submitted a detailed analysis on the effects of pointing errors in DSSS CDMA systems in the context of the

Commission's proceeding to adopt service rules for AMSS.[15] ViaSat incorporates that analysis by reference in this proceeding.

In short, there should be no concern that VMES systems employing spread spectrum technology will cause harmful interference into adjacent satellites, even with high degrees of antenna pointing error. Imposing antenna pointing accuracy requirements on such systems would unnecessarily inhibit their deployment and reduce the ability of VMES operators to provide low-cost, quality service to the public.[16] In order to comply with a 0.2-degree pointing accuracy requirement, VMES terminals employing antennas of less than 1 meter in diameter would need to be installed with precise inertial reference units, costing tens of thousands of dollars apiece. While the high cost of these units might be readily absorbed for government projects, this cost cannot be justified for individual consumer applications of VMES.[17] The Commission should consider rules that allow operators to minimize costs to facilitate the effective development of these services, while still protecting adjacent users from harmful interference. Therefore, while some pointing accuracy limit may be appropriate for certain VMES antennas, antennas and networks employing DSSS CDMA should not be subject to any angular pointing accuracy limit.

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15 *Id.*

16 *NPRM* ¶¶ 50, 66.

17 Contrary to the assertion made by General Dynamics in its Petition for Rulemaking in this proceeding, not all VMES will operate in rugged environments such that antenna pointing limits will be critical to preventing harmful interference to adjacent satellites. Most VMES terminals will see no more off road use than the average sports utility vehicle ("SUV"), and many VMES terminals will be mounted on large recreational vehicles ("RVs") that are not capable of high acceleration rates.

2. To the extent that the Commission adopts any antenna pointing accuracy limits, such limits should be reasonable and a function of antenna beamwidth

Unlike the DSSS CDMA networks discussed above, VMES antennas that operate close to the OAED limit and emit narrow beamwidth signals of high power density may need to be subject to an antenna pointing accuracy requirement in order to prevent harmful interference into adjacent satellites. Figure 4 in Attachment 1 depicts the typical performance of single channel per carrier ("SCPC") antennas of varying sizes under ideal conditions (*e.g.*, in a beam that is in the center of CONUS). Figure 5 plots the power density of the same antennas at the edge of CONUS, where each antenna must operate at a higher power density level to close the link.[18] The plots in these figures illustrate that while the 60 cm and larger antennas meet the proposed OAED limit under ideal conditions, any minor deviations, whether due to degraded operating conditions or antenna mispointing, could result in OAED levels that exceed the mask. Therefore, an antenna pointing accuracy requirement may be appropriate for these types of VMES antennas.[19]

To the extent that the Commission adopts an antenna pointing accuracy requirement for antennas that operate at power density levels that are close to the proposed OAED limit, such a requirement should be a function of antenna beamwidth and input power density, rather than a specific fixed angular limit applied equally to all antennas. All other things being equal, the degree of pointing accuracy required to avoid harmful interference to an adjacent system is an inverse function of beamwidth: the larger the beamwidth, the smaller the

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[18] ViaSat includes in this filing as Attachment 2, link budget calculations for the SCPC antennas depicted in Figures 4 and 5.

[19] On the other hand, Figure 6 illustrates that the same antennas operating with spread spectrum modem. Even a 30 cm antenna can easily meet the OAED mask when employing spread spectrum technology. The link budget calculations for the antennas

increase in OAED for a given angular error off boresight, and the less likely it is that harmful interference will occur. Figure 4 in Attachment 1 shows the power density pattern for antennas of various sizes plotted against the angle from the point of communication (theta). The peak power density at the center of the beam of a 1.2 meter antenna is higher than that of smaller antennas. Therefore, a 0.2º pointing error in a smaller antenna would result in a lower power density toward the adjacent satellite than the same error in a 1.2 meter antenna. Due to the lower power density, adjacent satellites can tolerate higher degrees of mispointing without suffering harmful interference from these smaller antennas. Thus, while a 0.2º angular mispointing limit may be appropriate for a 1.2 meter antenna, it is not appropriate for all antenna sizes; imposing such a limit on smaller antennas may not be necessary to control interference, and would increase costs to the consumer.

Requiring smaller antennas to comply with the same 0.2º angular limit to which a 1.2 meter antenna may be subject would necessitate the use of a very sensitive high performance tracking system that could detect extremely low signal change in a small terminal that is mispointed. Performance tracking systems typically operate by measuring the strength of the signal received by the terminal. As the terminal mispoints by greater angles, the receive signal becomes weaker. The tracking system determines the degree of angular mispointing based on measured signal loss, and the degree of mispointing typically associated with such loss. Figure 7 plots the signal loss of a receive signal for a number of antenna sizes. The chart illustrates that a signal loss level at 0.2º mispointing for a 1.2 meter antenna is 0.3 dBc. On the other hand, the signal loss for smaller antennas at 0.2º may be virtually undetectable. For example, a 30 cm antenna mispointed by 0.2º must be able to detect a signal loss of 0.019 dBc, which would

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depicted in Figure 6 are included in Attachment 2.

require a high-precision performance tracking system that would greatly increase the cost of such an antenna. However, such a result is not mandated by any legitimate interference concern.

Therefore, in order to afford VMES operators the flexibility to use smaller antennas, and to the extent that any limit is deemed necessary, the Commission should adopt a variable pointing accuracy limit based on antenna beamwidth. While there may be other methods of calculating an appropriate limit, ViaSat submits as an initial proposal that the variable limit for antennas that operate close to the proposed OAED limit should be designated in accordance with the formula described in Attachment 3 hereto. As discussed in detail in Attachment 3, if the receive frequency is held constant, the angular pointing limit would be a function of antenna size and the frequency on which the receive terminal operates.

Further, in developing a variable pointing accuracy limit, the Commission should take into account: (i) the difference between angles measured on a geocentric basis (on which the Section 25.209 limits are based) and on a topocentric basis (under which real-world operations occur); (ii) that systems using closed-loop tracking require some small level of mispointing to track the satellite; and (iii) the need to specify a statistical basis upon which to judge compliance, particularly in light of the fact that the Commission's ESV service rules already create a disparity between the point of technical compliance and the point at which transmissions from the underlying terminal must be discontinued.

First, any limit should take into account the difference between angles measured on a geocentric basis and on a topocentric basis. As the Commission recognized in its pending Earth Station Licensing Proceeding, the topocentric angle is always greater than the geocentric

angle. For instance, a 2.0º geocentric angle equates to a topocentric angle of 2.1º to 2.2º or more, depending upon location, thereby providing an "automatic" margin for error.[20]

Second, the Commission should ensure that any antenna pointing accuracy rules permit the use of closed-loop tracking systems that function by pointing to an offset angle from the boresight of the antenna beam to develop an error signal upon which to track the satellite point of communication. Any pointing error limit the Commission may adopt in this proceeding should clarify that the limit represents only the dynamic error over and above the offset used for closed-loop tracking, such that an offset signal used for closed-loop tracking would not trigger the antenna pointing limit. Otherwise, the required angular offset necessary to develop a closed-loop tracking signal for a wide beam antenna could potentially cause the antenna system to violate a narrow angular limit even if the antenna is accurately centered about the tracking offset.

Finally, the Commission's proposed pointing accuracy limit provides an angular limit of 0.2º and requires the mispointed terminal to shut down within 100 ms if the error exceeds 0.5º. Thus, the proposed limit recognizes that mispointing between 0.2º and 0.5º must be tolerated occasionally. The Commission, therefore, should specify the statistical basis upon which compliance with the angular pointing requirement will be measured (*e.g.*, a mean and standard deviation or that the system must comply x% of the time). Such a requirement is particularly critical in circumstances where a terminal transmits a narrow beam at power densities that approach the proposed OAED limit and that have higher potential to cause harmful interference if mispointed.

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[20] *See 2000 Biennial Regulatory Review – Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations*, 20 FCC Rcd 5593, at ¶ 22 (2005).

B. The Commission Should Adopt VMES Power Density Limits That Accommodate Systems Using Advanced Antenna Design and Modulation Technologies

ViaSat generally supports the application of the off-axis EIRP emission limits applicable to ESVs, which are sufficient to protect adjacent satellite users from interference in the vast majority of cases, to VMES systems. However, ViaSat also believes that the application of those limits would fail to accommodate VMES networks employing aggregate system power control. In the *NPRM*, the Commission asks commenters to address the specific changes to the rules that would be required to allow the efficient use of variable power-density spread spectrum systems while still ensuring that VMES systems meet the EIRP density envelope in the aggregate.[21] ViaSat proposes adjustments to the ESV limits that are necessary to allow the use of aggregate system power control. Additionally, ViaSat supports a framework that permits VMES operators using low-profile antennas latitude to transmit at higher power levels outside of the GSO plane.

1. The Commission should allow VMES network operators to meet the off-axis EIRP density limit on an aggregate terminal basis

In order to facilitate the use of CDMA spread spectrum technologies, the Commission should ensure that its OAED rules are technology-neutral. Applying specific limits to specific components of a system could constrain certain network operations or designs. To avoid such a restraint on innovation, the VMES service rules should allow VMES network operators the flexibility to meet the OAED limit on an aggregate basis and provide VMES licensees wide latitude to operate in any manner within the limit. VMES licensing rules should permit networks to meet the OAED limit on an aggregate basis such that all co-frequency VMES

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[21] *NPRM* ¶ 57.

transmissions in a network will not exceed the levels generated by a routinely authorized FSS earth terminal under Section 25.134(a)(1).[22]

VMES systems typically have the flexibility to manage the aggregate OAED of the VMES network through the NCMC. The Commission should allow VMES licensees to determine whether the NCMC manages OAED on a network-wide or individual terminal basis. Management on a network-wide basis is preferable in CDMA networks with a sophisticated network management system because such networks may incorporate a variety of antenna types, operating at various data rates and power levels throughout the satellite footprint. Permitting the NCMC to control the network's total aggregate EIRP density such that the aggregate limit is met for the network would minimize interference potential while ensuring the most efficient distribution of power to terminals throughout the network.[23]

2. The Commission should revise the limit for individual VMES antennas

ViaSat recommends that the Commission also adopt an alternative limit for networks using spread spectrum modulation techniques coupled with CDMA. The Commission's proposed factor of 10*log(N) for the limit on individual VMES antennas in networks using CDMA does not adequately account for variations in power density among transmitters in the network resulting from differences in VMES terminal design, data rates, satellite performance contours and spreading factors. The proposed factor is overly simplistic because it assumes that the network is made up of homogeneous VMES transmitters, each operating on the same channel, transmitting in the same satellite performance contour, *and at the*

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22 47 C.F.R. § 25.134(a)(1).

23 In many contexts, the Commission permits operators the flexibility to dynamically allocate system resources in the most efficient fashion. For example, the Commission

same time. Essentially, this factor provides for a proportionate reduction in power, based only on the maximum number of simultaneously operating terminals in the network. But such an approach does not adequately account for any variables in operating conditions[24] and would result in an inefficient distribution of power among the terminals in the network. Adopting the overly-simplistic 10*log(N) factor would not allow a CDMA network operator to maximize the throughput of its network and would severely reduce the broadband traffic capacity of the network as a whole.

The network controller must account for the various factors that affect the level of power required to be transmitted from a VMES terminal and the resulting power density to be received at the spacecraft. These include, for example, the satellite performance in the direction of the VMES terminal, range to the satellite, rain and atmospheric attenuation,[25] antenna pointing, transmitted data rate, chip rate of the spreading code, and number of simultaneous transmitters. If all VMES terminals in a CDMA network were required to transmit at a power setting equal to the limit reduced by 10*log(N), the assumed power level for each VMES terminal would be that of the smallest antenna operating in the most technically disadvantaged part of the satellite footprint (*i.e.*, the area with the worst G/T (Gain-to-Temperature ratio)). If the VMES terminals each transmit just enough power to arrive at the hub demodulator at the nominal level, then the extra power that would have been allotted to better-performing VMES

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does not require FDMA operators to divide total system power or share spectrum among users in equal units.

24 For example, Figures 4 and 5 in Attachment 1 illustrates the difference in power density required in a scenario where the terminal is operating in a beam in the center of CONUS versus a beam on the edge of CONUS, where higher power is necessary to close the link with the satellite.

25 Rain and atmospheric attenuation must be factored into the VMES uplink EIRP, but do not impact the off-axis EIRP density received at the spacecraft because the extra power is "burned off" through signal attenuation by the time it reaches the satellite arc.

terminals could instead be reallocated to more disadvantaged VMES terminals, used to increase the throughput of more advantaged VMES terminals, or used to add additional VMES terminals to the network. However, the 10*log(N) approach would prevent a network operator from reallocating this available network power in such a manner.

Thus, the power density limit for a single VMES terminal as applied to a network of VMES terminals employing CDMA should reflect the variables mentioned above in order to allow VMES licensees to use the available network capacity in the most efficient manner. The Commission therefore should define the aggregate OAED of a non-homogeneous network of "N" technically different VMES terminals, each operating at different parameters, as the sum of the individual VMES off-axis EIRP densities, represented by the following formula:

$$Aggregate_OAED = 10 * \log\left[\sum_{i=1}^{N_{AES}} 10^{AES_OAED_i/10}\right]$$

where Aggregate_OAED is network aggregate off-axis EIRP density and AES_OAED_i is the off-axis EIRP density from the *i*th VMES terminal n the network. The aggregate OAED of the network as calculated by this formula would not be permitted to exceed the proposed FCC OAED mask. The individual antenna limit that ViaSat proposes here takes into consideration satellite performance and the terminal's operating conditions and does not artificially restrict individual antenna power density in a CDMA network.

3. The Commission should allow greater power density outside of the GSO plane

In the *NPRM*, the Commission seeks comment regarding the possibility of modifying the current ESV NGSO plane EIRP-density envelopes to accommodate small VMES

antennas.[26] The commercial success and wide deployment of VMES depend in part upon the ability of manufacturers and service providers to market small, low-profile antennas that can be mounted on standard cars and trucks. Low-profile antenna designs are a greater necessity for VMES operations than for ESV due to the relative size of the vehicles. Low-profile antennas typically perform comparably to larger, circular antennas in the horizontal plane, and can adequately protect adjacent GSO satellites. However, these antennas are likely to emit at higher OAED levels outside the GSO elevation plane (*i.e.*, north and south of the GSO arc) than for circular or modestly elliptical antennas.

Although VMES operators using low-profile antennas could reduce the input power density of these antennas to meet the proposed OAED limits in the elevation plane, constraining the input power density could severely limit the capacity of the individual antenna or conversely the aggregate network capacity. Indeed, without an increased allowance for OAED outside the GSO elevation plane, VMES service and technology, which exists today, would be unduly constrained in favor of NGSO systems that may never be deployed; there are no commercial NGSO Ku-band systems in operation, and none are planned to be deployed in the foreseeable future.

ViaSat urges the Commission to allow flexibility in its licensing procedures to consider non-interfering, non-protected operations in the regions near the GSO plane.

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[26] *NPRM* ¶ 69.

III. THE COMMISSION SHOULD PERMIT BLANKET LICENSING OF VMES TERMINALS ON AN "ALSAT" BASIS

ViaSat supports the Commission's proposal to allow both blanket licensing and individual licensing of VMES terminals.[27] VMES networks incorporating spread spectrum technologies are likely to be comprised of widely-deployed terminals, and blanket licensing is the most efficient way to license these networks. As long as the operation and management of terminals comply with the rules, it should not matter whether an operator desires a license to operate a single terminal or to deploy numerous identical terminals over the U.S. As discussed above, the Commission should use a technology-neutral approach in developing rules for VMES operations. Thus, licensing rules for this service should be flexible enough to accommodate a wide range of applications for VMES technology. However, in applications for a single VMES terminal, the Commission should evaluate whether the antenna will be operated within a network of separately licensed terminals to determine how the OAED limit of the network will be met on an aggregate basis.

Additionally, ViaSat supports the proposal to allow VMES licensees operating in the Ku-band to receive authority to operate with any U.S. licensed satellite and non-U.S. satellite on the Permitted Space Station List ("ALSAT" authority), provided that the operating parameters of single terminals and networks are consistent with a two-degree spacing environment, including compliance with the proposed OAED limits.[28] Granting ALSAT authority would help ensure the viability of broadband services by allowing VMES operators the flexibility to negotiate with multiple satellite capacity providers, and would enhance competition and reduce the costs of providing VMES services because the VMES network operators would have the

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[27] *Id.* at ¶ 79.

[28] *Id.* at ¶ 81.

ability to negotiate market-based prices for transponder capacity. The Commission adopted rules to permit ESV operators to obtain ALSAT authority based on similar reasoning,[29] and ViaSat encourages the Commission, likewise, to do so here.

IV. THE COMMISSION SHOULD APPLY THE ESV DATA TRACKING REQUIREMENTS TO VMES SYSTEMS

In the ESV context, the Commission requires Ku-band hub operators to have the capability to track and maintain certain data, including terminal locations, for potential review in the event interference issues arise.[30] Tracking capabilities would serve the same purpose in the VMES context.[31] ViaSat generally supports a requirement that an operator track terminal locations to enforce interference protections, and believes that the Commission should apply the data tracking requirements of Section 25.222(c) of the Commission's rules to VMES.[32] Tracking the locations of VMES terminals is currently the most effective way to identify the source of harmful interference in order to allow users of Ku-band spectrum to resolve incidents of interference. Existing interference location systems are not able to track the locations of mobile transmitters using reduced input power density. Further, VMES terminals will be operated in a transient and intermittent fashion, making them difficult to locate. VMES operators should be required to maintain their own tracking data and make available any information that is relevant to resolving specific instances of interference through a point of contact in the U.S. ViaSat supports an exception to any requirement to share tracking information for certain government

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29 *ESV Order* at ¶¶ 105, 106.

30 *Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands*, Report and Order, 20 FCC Rcd 674, ¶ 112 (rel. Jan. 6, 2005).

31 *See* ViaSat AMSS Reply Comments at 19-21.

and law-enforcement applications where disclosure of such information could have security considerations.

Although ViaSat is in favor of a requirement to track terminal locations to enforce interference protections, ViaSat does not support a publicly-accessible database containing tracked data or public disclosure of vehicle locations. In other mobile services, network operators have demonstrated that parties are able to cooperate and often voluntarily provide the information necessary to resolve incidents of interference. Therefore, a public database of tracked locations may raise privacy and security concerns without adding benefit to a process that works sufficiently today. Furthermore, ViaSat is opposed to the adoption of a requirement to use automatic transmitter identification systems ("ATIS") as an identifying mechanism.[33] As discussed in detail in these comments, spread spectrum technologies prevent the potential for adjacent satellite interference by transmitting extremely low-density signals that are not detectable to adjacent satellites, even when mispointed. Requiring terminals to radiate an identifying signal strong enough to be detected would render moot the many benefits of using spread spectrum technology.

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32 *NPRM* ¶ 64.

33 *See id.* at ¶ 76.

V. CONCLUSION

For the foregoing reasons, ViaSat respectfully requests that the Commission adopt service rules for VMES operations consistent with these comments.

Respectfully submitted,

VIASAT, INC.

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August 17, 2007

Attachment 1

Figure 1: Pointing Error Effects Across GEO Arc for a single ES mispointed by 2º in Azimuth

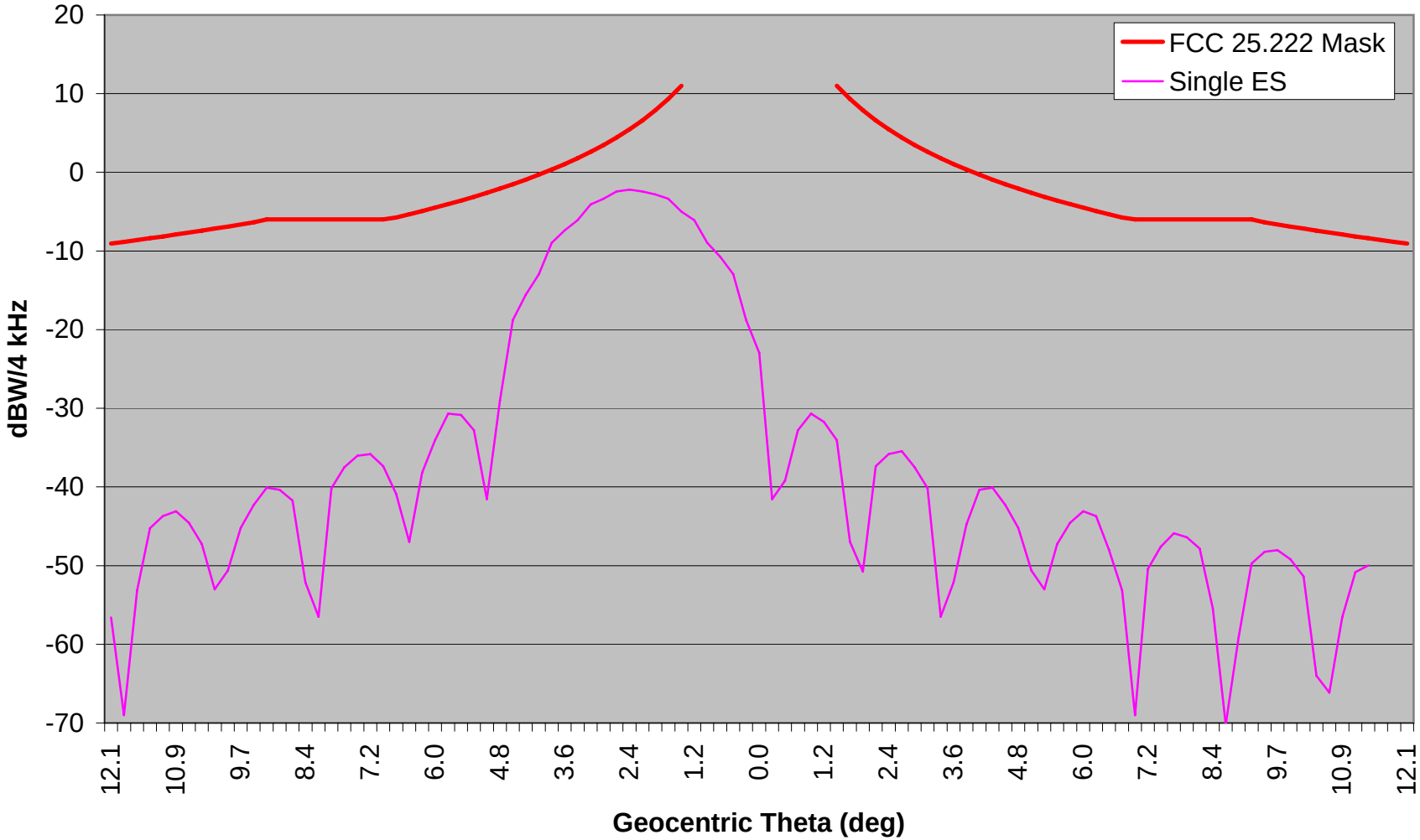


Figure 2: Aggregate Off-axis EIRP Density for 15 ES with 0.2º Stdev Pointing Error and 0.4º Conscan

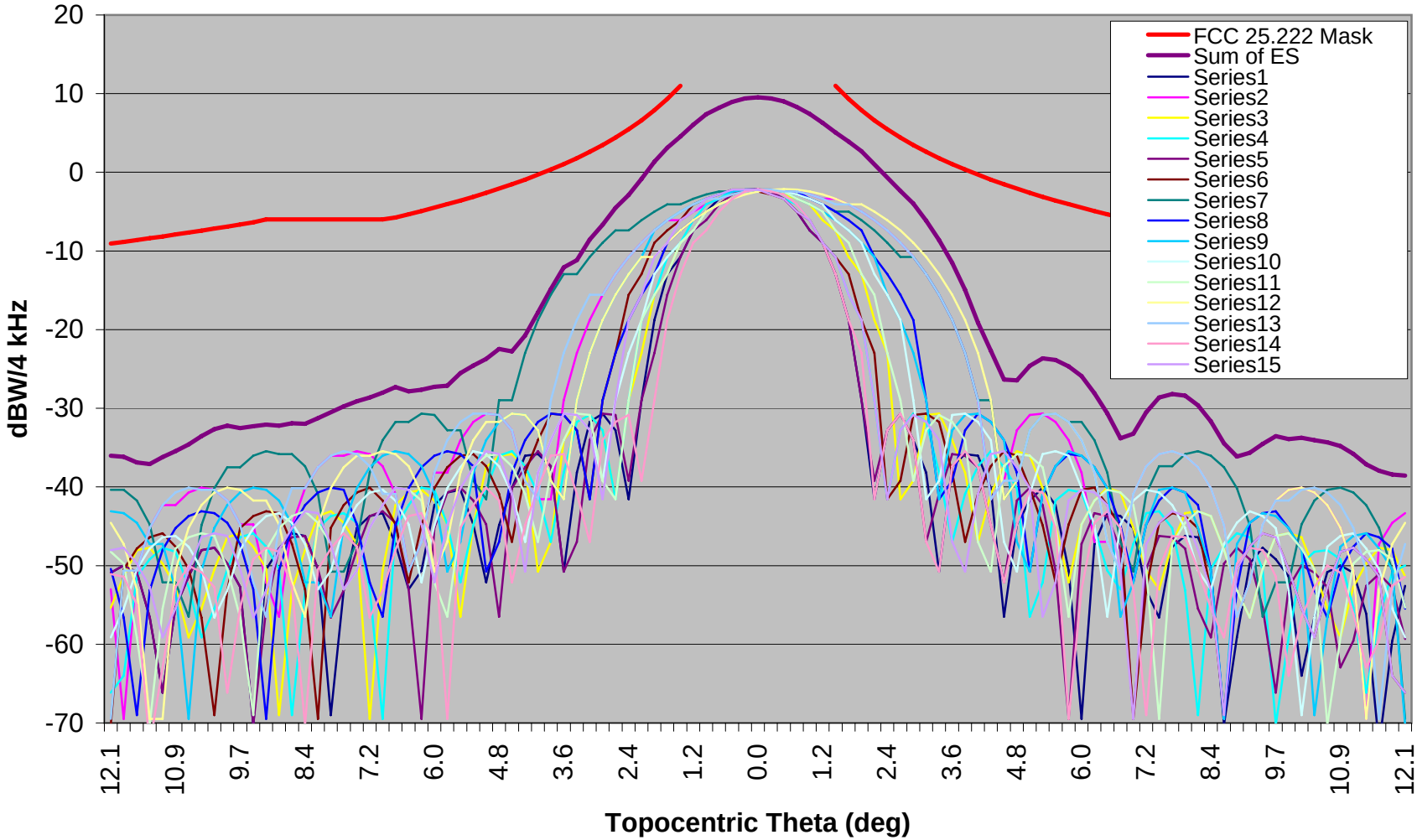


Figure 3: Aggregate Off-axis EIRP Density for 15 ES with 1.0º Stdev Pointing Error and 0.4º Conscan

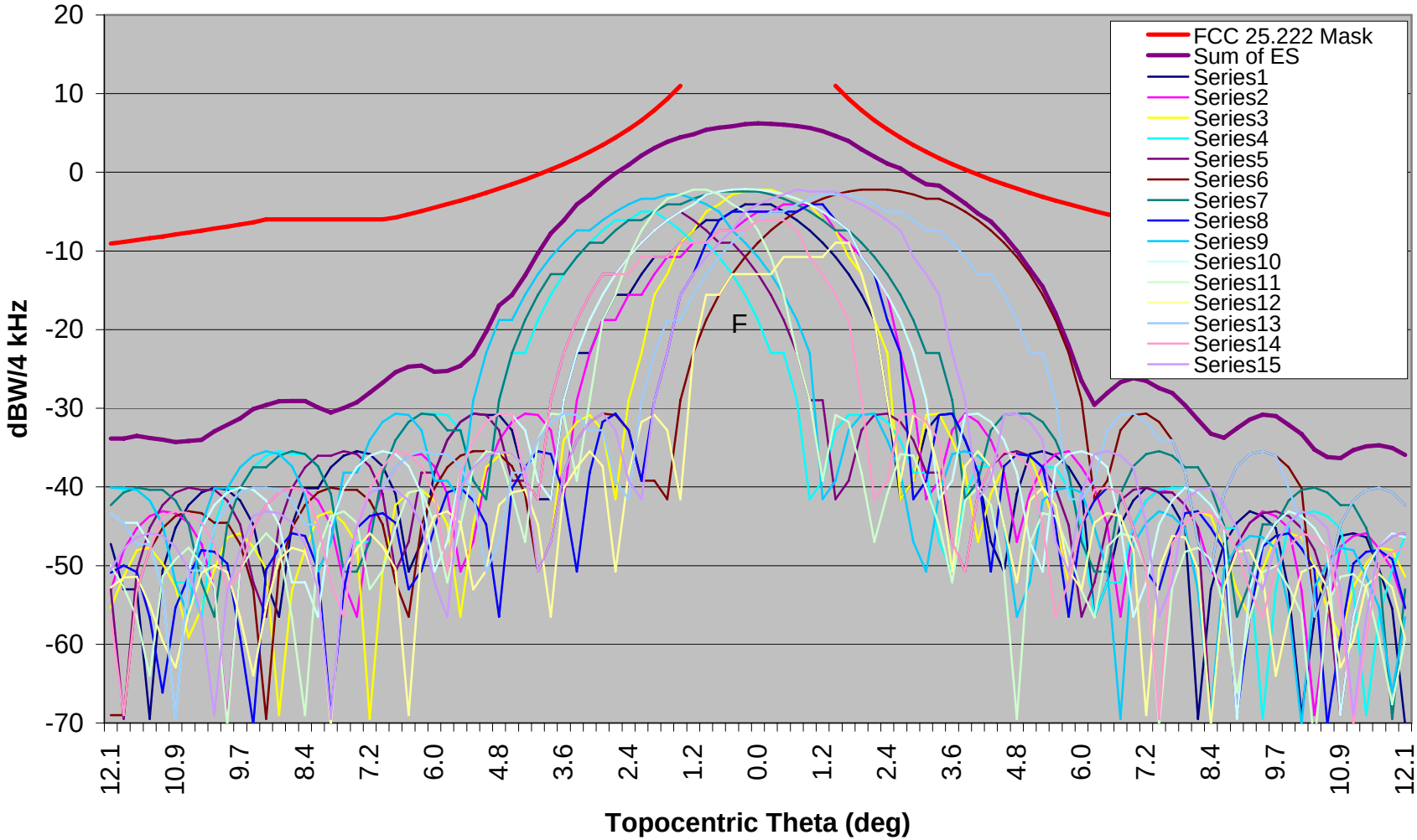


Figure 4: EIRP Density vs Theta
Typical Satellite Performance at Beam Center of CONUS

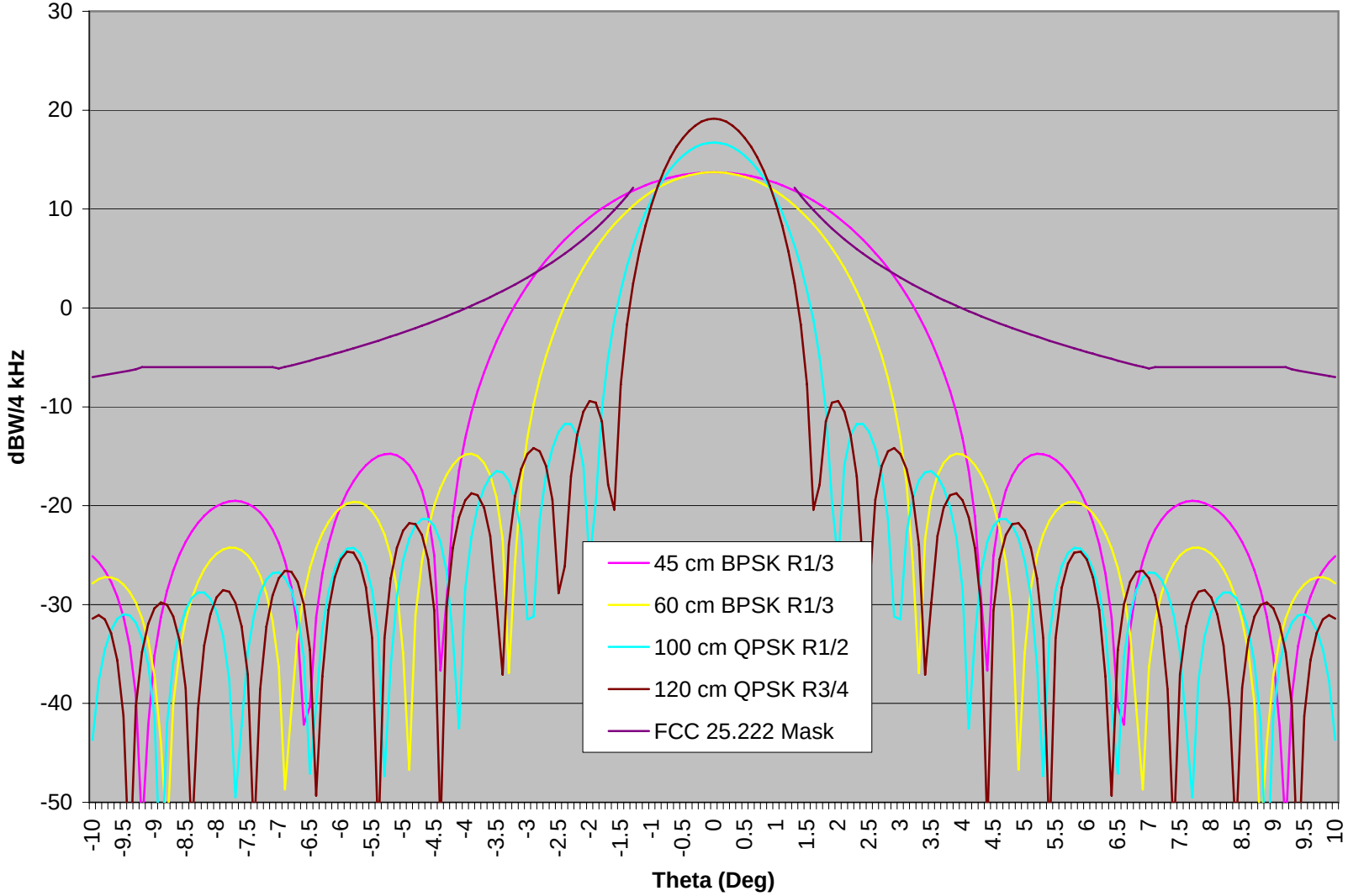


Figure 5: EIRP Density vs Theta
Typical Satellite Performance at Edge of CONUS

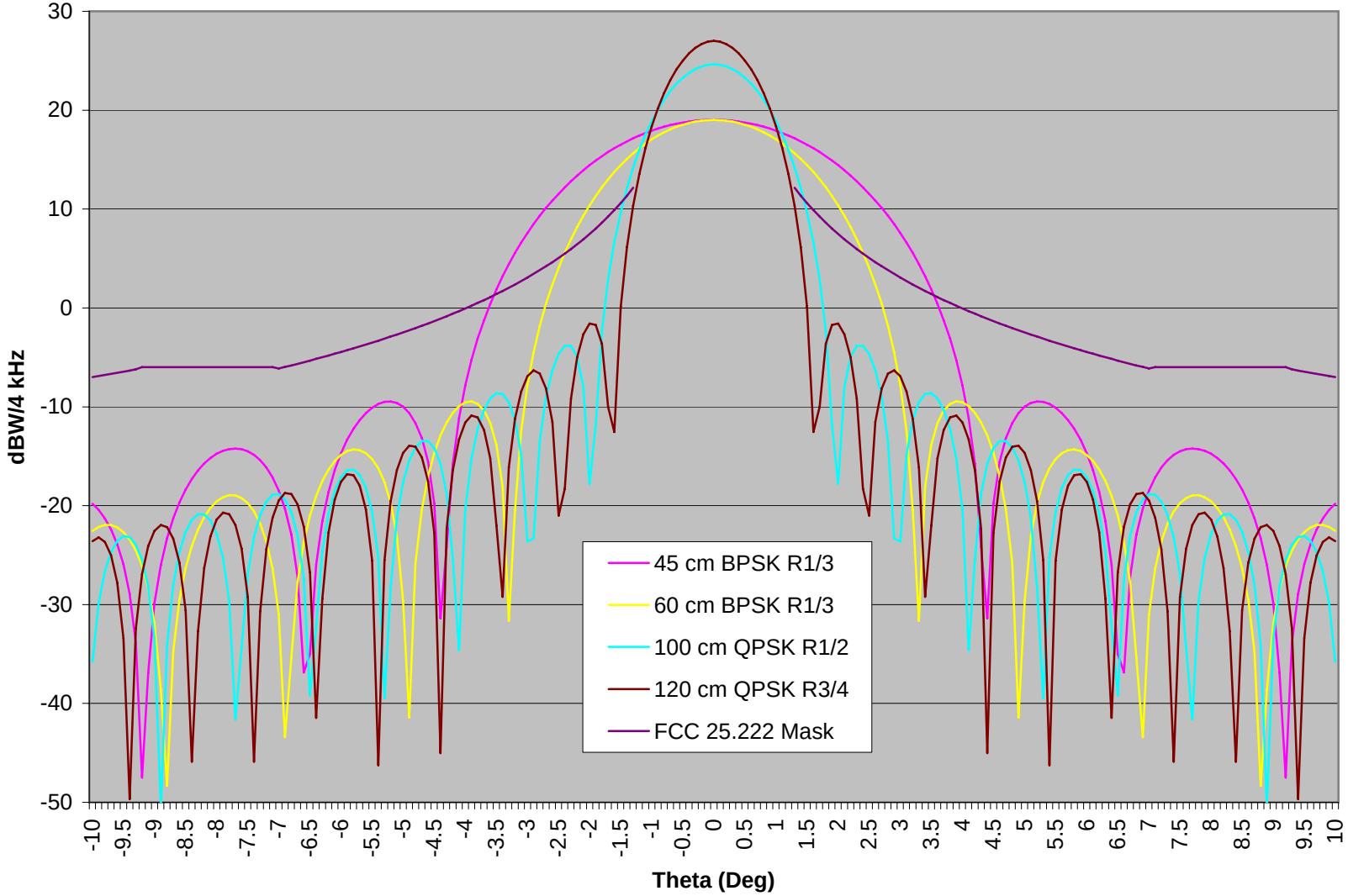


Figure 6: EIRP Density vs Theta
Typical Satellite Performance at Beam Center of CONUS

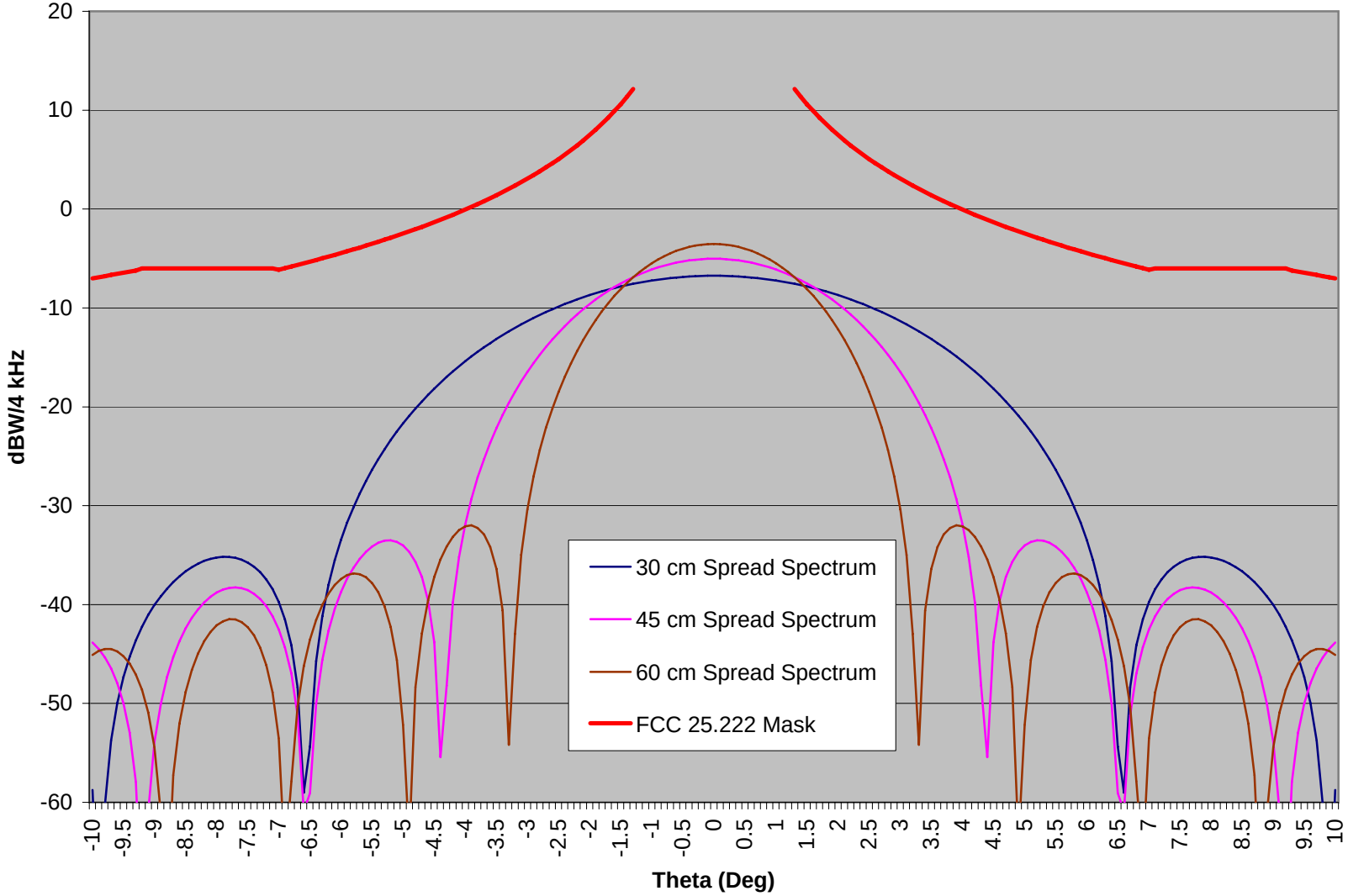
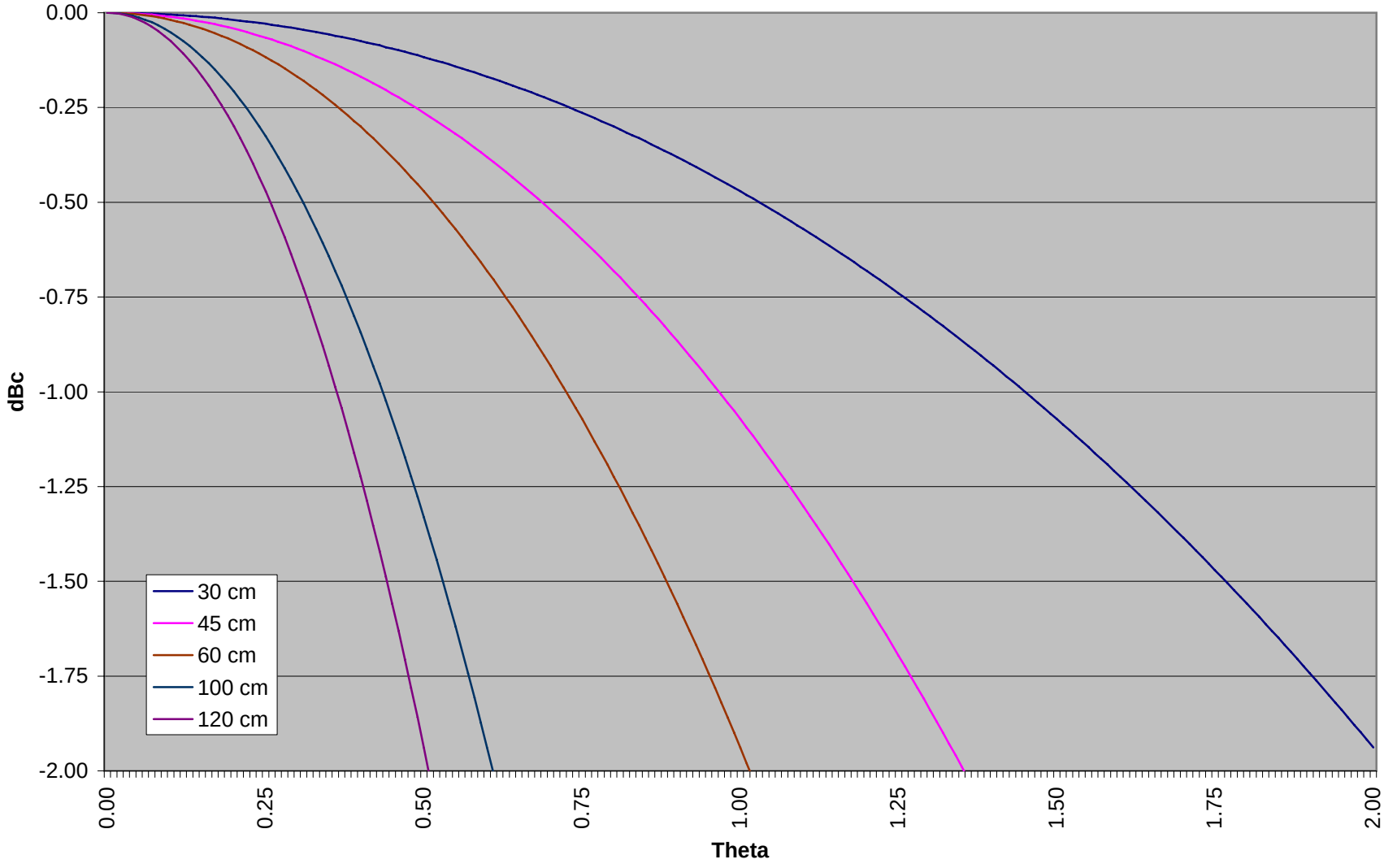


Figure 7: RX Pattern dBc vs Theta



Attachment 2

Unspread

Typical Satellite Performance at Beam Center CONUS

VMES to Satellite Uplink					
VMES Uplink Antenna Size (cm)	30.00	45.00	60.00	100.00	120.00
VMES Uplink Antenna Gain (dBi)	31.50	35.10	37.60	42.00	43.60
VMES Data Rate (kbit/s)	256.00	256.00	256.00	256.00	256.00
Required Eb/No (dB)	2.70	2.70	2.70	2.70	3.60
Modulation Type (BPSK, QPSK, etc.)	BPSK	BPSK	BPSK	QPSK	QPSK
FEC Type (Rate 1/2, Rate 1/3, etc.)	Rate 1/2	Rate 1/2	Rate 1/2	Rate 1/2	Rate 3/4
Required C/No (dB-Hz)	56.78	56.78	56.78	56.78	57.68
Required Bandwidth (kHz)	691.20	691.20	691.20	345.60	230.40
Uplink PA Output Power (dBW)	5.10	1.50	-1.00	-5.40	-6.35
Uplink Output Circuit Loss (dB)	0.50	0.50	0.50	0.50	0.50
VMES Antenna Input Power Density (dBW/4 kHz)	-17.78	-21.38	-23.88	-25.27	-24.45
VMES Uplink EIRP (dBW)	36.10	36.10	36.10	36.10	36.75
Uplink Rain Attenuation (dB)	0.75	0.75	0.75	0.75	0.75
Uplink Misc Losses (radome, pointing, etc.) (dB)	1.00	1.00	1.00	1.00	1.00
Uplink Spreading Loss (dB (m^2))	162.49	162.49	162.49	162.49	162.49
Uplink Path Loss (dB)	207.01	207.01	207.01	207.01	207.01
Satellite Input level (dBW)	-172.66	-172.66	-172.66	-172.66	-172.01
Satellite G/T in direction of UL ES (dB/K)	6.00	6.00	6.00	6.00	6.00
Carrier Uplink C/No (dB-Hz)	61.94	61.94	61.94	61.94	62.59
Uplink Interference C/Io (dB-Hz)	60.18	60.18	60.18	60.18	61.17
Carrier Uplink C/(No+Io) (dB-Hz)	57.96	57.96	57.96	57.96	58.81
Uplink Margin (dB)	1.18	1.18	1.18	1.18	1.13
Satellite Input level (dBW/m^2)	-128.14	-128.14	-128.14	-128.14	-127.49
Effective Operating SFD (dBW/m^2)	-93.00	-93.00	-93.00	-93.00	-93.00
Carrier Input Back Off (dB)	35.14	35.14	35.14	35.14	34.49
Transponder Gain Transfer Delta (dB)	2.80	2.80	2.80	2.80	2.80
Carrier Output Back Off (dB)	32.34	32.34	32.34	32.34	31.69
Satellite Saturated DL EIRP (dBW)	48.00	48.00	48.00	48.00	48.00
Carrier Downlink EIRP (dBW)	15.66	15.66	15.66	15.66	16.31
Satellite to Hub Downlink					
Carrier Downlink EIRP (dBW)	15.66	15.66	15.66	15.66	16.31
Downlink Path Loss (dB)	205.49	205.49	205.49	205.49	205.49
Downlink Rain Loss (dB)	0.45	0.45	0.45	0.45	0.45
Hub Antenna G/T (dB/K)	31.50	31.50	31.50	31.50	31.50
Carrier Downlink C/No (dB-Hz)	69.83	69.83	69.83	69.83	70.48
Downlink Interference C/Io (dB-Hz)	67.86	67.86	67.86	67.86	69.34
Carrier Downlink C/(No+Io) (dB-Hz)	65.72	65.72	65.72	65.72	66.86
Downlink Margin (dB)	8.94	8.94	8.94	8.94	9.18
Overall Link Performance					
Carrier Total C/(No+Io) (dB-Hz)	57.29	57.29	57.29	57.29	58.18
Total Link Margin (dB)	0.50	0.50	0.50	0.50	0.50

	Unspread				
	Typical Satellite Performance at Edge of CONUS				
VMES to Satellite Uplink					
VMES Uplink Antenna Size (cm)	30.00	45.00	60.00	100.00	120.00
VMES Uplink Antenna Gain (dBi)	31.50	35.10	37.60	42.00	43.60
VMES Data Rate (kbit/s)	256.00	256.00	256.00	256.00	256.00
Required Eb/No (dB)	2.70	2.70	2.70	2.70	3.60
Modulation Type (BPSK, QPSK, etc.)	BPSK	BPSK	BPSK	QPSK	QPSK
FEC Type (Rate 1/2, Rate 1/3, etc.)	Rate 1/2	Rate 1/2	Rate 1/2	Rate 1/2	Rate 3/4
Required C/No (dB-Hz)	56.78	56.78	56.78	56.78	57.68
Required Bandwidth (kHz)	691.20	691.20	691.20	345.60	230.40
Uplink PA Output Power (dBW)	13.00	9.40	6.90	2.50	1.50
Uplink Output Circuit Loss (dB)	0.50	0.50	0.50	0.50	0.50
VMES Antenna Input Power Density (dBW/4 kHz)	-9.88	-13.48	-15.98	-17.37	-16.60
VMES Uplink EIRP (dBW)	44.00	44.00	44.00	44.00	44.60
Uplink Rain Attenuation (dB)	0.75	0.75	0.75	0.75	0.75
Uplink Misc Losses (radome, pointing, etc.) (dB)	1.00	1.00	1.00	1.00	1.00
Uplink Spreading Loss (dB (m^2))	162.49	162.49	162.49	162.49	162.49
Uplink Path Loss (dB)	207.01	207.01	207.01	207.01	207.01
Satellite Input level (dBW)	-164.76	-164.76	-164.76	-164.76	-164.16
Satellite G/T in direction of UL ES (dB/K)	2.00	2.00	2.00	2.00	2.00
Carrier Uplink C/No (dB-Hz)	65.84	65.84	65.84	65.84	66.44
Uplink Interference C/Io (dB-Hz)	59.00	59.00	59.00	59.00	60.17
Carrier Uplink C/(No+Io) (dB-Hz)	58.18	58.18	58.18	58.18	59.25
Uplink Margin (dB)	1.40	1.40	1.40	1.40	1.57
Satellite Input level (dBW/m^2)	-120.24	-120.24	-120.24	-120.24	-119.64
Effective Operating SFD (dBW/m^2)	-84.00	-84.00	-84.00	-84.00	-84.00
Carrier Input Back Off (dB)	36.24	36.24	36.24	36.24	35.64
Transponder Gain Transfer Delta (dB)	2.80	2.80	2.80	2.80	2.80
Carrier Output Back Off (dB)	33.44	33.44	33.44	33.44	32.84
Satellite Saturated DL EIRP (dBW)	48.00	48.00	48.00	48.00	48.00
Carrier Downlink EIRP (dBW)	14.56	14.56	14.56	14.56	15.16
Satellite to Hub Downlink					
Carrier Downlink EIRP (dBW)	14.56	14.56	14.56	14.56	15.16
Downlink Path Loss (dB)	205.49	205.49	205.49	205.49	205.49
Downlink Rain Loss (dB)	0.45	0.45	0.45	0.45	0.45
Hub Antenna G/T (dB/K)	31.50	31.50	31.50	31.50	31.50
Carrier Downlink C/No (dB-Hz)	68.73	68.73	68.73	68.73	69.33
Downlink Interference C/Io (dB-Hz)	66.70	66.70	66.70	66.70	66.70
Carrier Downlink C/(No+Io) (dB-Hz)	64.59	64.59	64.59	64.59	64.81
Downlink Margin (dB)	7.80	7.80	7.80	7.80	7.12
Overall Link Performance					
Carrier Total C/(No+Io) (dB-Hz)	57.29	57.29	57.29	57.29	58.18
Total Link Margin (dB)	0.50	0.50	0.50	0.50	0.50

Spread Spectrum

VMES to Satellite Uplink			
VMES Uplink Antenna Size (cm)	30.00	45.00	60.00
VMES Uplink Antenna Gain (dBi)	31.50	35.10	37.60
VMES Data Rate (kbit/s)	256.00	256.00	256.00
Required Eb/No (dB)	2.25	2.25	2.25
Modulation Type (BPSK, QPSK, etc.)	GMSK	GMSK	GMSK
FEC Type (Rate 1/2, Rate 1/3, etc.)	Rate 1/3	Rate 1/3	Rate 1/3
Required C/No (dB-Hz)	56.33	56.33	56.33
Required Bandwidth (kHz)	35624.45	35624.45	35624.45
Uplink PA Output Power (dBW)	1.75	-0.13	-1.13
Uplink Output Circuit Loss (dB)	0.50	0.50	0.50
VMES Antenna Input Power Density (dBW/4 kHz)	-38.25	-40.13	-41.13
VMES Uplink EIRP (dBW)	32.75	34.47	35.97
Uplink Rain Attenuation (dB)	0.75	0.75	0.75
Uplink Misc Losses (radome, pointing, etc.) (dB)	1.00	1.00	1.00
Uplink Spreading Loss (dB (m^2))	162.49	162.49	162.49
Uplink Path Loss (dB)	207.01	207.01	207.01
Satellite Input level (dBW)	-176.01	-174.29	-172.79
Satellite G/T in direction of UL ES (dB/K)	6.00	6.00	6.00
Carrier Uplink C/No (dB-Hz)	58.59	60.31	61.81
Uplink Interference C/Io (dB-Hz)	60.89	58.89	57.88
Carrier Uplink C/(No+Io) (dB-Hz)	56.58	56.53	56.40
Uplink Margin (dB)	0.24	0.20	0.07
Satellite Input level (dBW/m^2)	-131.49	-129.77	-128.27
Effective Operating SFD (dBW/m^2)	-99.00	-99.00	-99.00
Carrier Input Back Off (dB)	32.49	30.77	29.27
Transponder Gain Transfer Delta (dB)	2.00	2.00	2.00
Carrier Output Back Off (dB)	30.49	28.77	27.27
Satellite Saturated DL EIRP (dBW)	49.52	49.52	49.52
Carrier Downlink EIRP (dBW)	19.03	20.75	22.25
Satellite to Hub Downlink			
Carrier Downlink EIRP (dBW)	19.03	20.75	22.25
Downlink Path Loss (dB)	205.49	205.49	205.49
Downlink Rain Loss (dB)	0.45	0.45	0.45
Hub Antenna G/T (dB/K)	31.50	31.50	31.50
Carrier Downlink C/No (dB-Hz)	73.20	74.92	76.42
Downlink Interference C/Io (dB-Hz)	91.61	92.21	93.06
Carrier Downlink C/(No+Io) (dB-Hz)	73.13	74.84	76.32
Downlink Margin (dB)	16.80	18.50	19.99
Overall Link Performance			
Carrier Total C/(No+Io) (dB-Hz)	56.48	56.47	56.36
Total Link Margin (dB)	0.15	0.13	0.03

Attachment 3

Attachment 3
Technical Proposal for Variable Pointing Accuracy Limit

ViaSat submits, as an initial proposal, the following formula to calculate an appropriate angular pointing limit for antennas that are smaller than 1.2 meters in diameter. The variable limit for antennas that operate close to the OAED limit could be designated as $Limit = R \bullet 0.5 \bullet HPBW$, where Limit is the variable antenna pointing accuracy limit, HPBW is half power beamwidth (the width of the antenna beam in degrees between the -3 dB points on either side of boresight),[1] and R is a constant equal to the ratio between the 0.2° fixed antenna pointing accuracy limit for ESV and one-half the HPBW of a 1.2 meter antenna (the base line antenna used to derive the ESV limit[2]).

To specify an exact formula to be used in determining the variable limit with respect to any given antenna size, it is first necessary to determine an exact value for R, where

$$R = \frac{Limit_{1.2m}}{0.5 \bullet HPBW_{1.2m}}.$$

As a baseline, the limit with respect to a 1.2 meter antenna is fixed at 0.2°.

A commonly accepted formula for determining the HPBW of a reflector antenna is given as

$$HPBW = \frac{70 \bullet \lambda}{D},$$

where λ is the wavelength of the operating frequency in meters (*i.e.*, 300 / frequency in MHz), D is the antenna diameter in meters, and HPBW is the width of the antenna beam in degrees

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1 $0.5 \bullet HPBW$, therefore, is equal to the width in degrees of the antenna beam between the boresight and either of the -3 dB points.

2 *See ESV Order* at ¶ 104 and n.270.

between the -3 dB points on either side of boresight.[3] Using this formula, and assuming a receive frequency of 11950 MHz (the mid-band receive frequency), the HPBW of a 1.2 m antenna is 1.464°, or $\frac{70 \bullet 300}{1.2 \bullet 11950}$.

Using these values for $Limit_{1.2m}$ and $HPBW_{1.2m}$, $R = \frac{0.2}{0.5 \bullet 1.464} = 0.273$, or 27.3%. The variable limit for antennas of other diameters, then, can be found using the formula $Limit = 0.273 \bullet 0.5 \bullet HPBW$. Table 1 sets forth the antenna pointing accuracy limits for various antenna diameters based on this formula, along with the associated increase in the shut down limit.

Table 1: Derived Antenna Pointing Accuracy Limits for Various Antenna Sizes

Diameter	**HPBW**	**Pointing Limit**	**Shutdown Limit**
1.2 m	1.464	0.2°	0.5°
1.0 m	1.757	0.24°	0.6°
60 cm	2.929	0.4°	1.0°
45 cm	3.905	0.53°	1.33°
30 cm	5.858	0.8°	2.0°

[3] *See, e.g.,*Thomas Milligan, MODERN ANTENNA DESIGN 44 (2005); Roger Freeman, REFERENCE MANUAL FOR TELECOMMUNICATIONS ENGINEERING 14-15 (2d Ed. 1993).

ENGINEERING INFORMATION CERTIFICATION

I hereby certify that I am the technically qualified person responsible for reviewing the engineering information contained in the foregoing submission, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this pleading, and that it is complete and accurate to the best of my knowledge and belief.

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Dated: August 17, 2007