Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Comprehensive Review of Licensing	)	IB Docket No. 12-267
And Operating Rules for Satellite Services	)	

COMMENTS OF KYMETA CORPORATION

Kymeta Corporation ("Kymeta"), by its attorneys, hereby submits its Comments in response to the Further Notice of Proposed Rulemaking ("FNPRM") in the above-captioned proceeding.[1] Kymeta applauds the Commission for its continuing efforts to "afford[ ] licensees as much operational flexibility as possible consistent with minimizing harmful interference and easing administrative burdens on licensees, applicants and the Commission."[2]

Kymeta's Comments set forth a proposal for an alternative, technology neutral, mask for Ka-band transmit earth stations. The current mask appears to be based on the pattern of a parabolic antenna, and it imposes unnecessary obstacles to the routine licensing of Ka-band earth stations with flat panel antennas.[3] Due to their unique characteristics, flat panel antennas emit sidelobe patterns that differ from those of parabolic antennas, although they need not pose an additional risk of interference. Kymeta's proposed new mask would be an alternative to the current

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[1] In the Matter of Comprehensive Review of Licensing and Operating Rules for Satellite Services, Further Notice of Proposed Rulemaking, IB Docket No. 12-267, released Sept. 30, 2014, FCC 14-142.

[2] Id. at ¶ 2.

[3] The current mask, set forth in Section 25.138(a) of the Rules, was adopted prior to the development of inexpensive flat-panel antennas. The current mask may also impose unnecessary obstacles to the routine licensing of other antennas developed since the adoption of Section 25.138(a).

mask set forth in Section 25.138(a) of the Rules, and therefore will have no impact on currently licensed earth stations or on future applications filed pursuant to the current rules.

I. BACKGROUND

Kymeta is developing the next generation of antennas for satellite communications that will reduce the cost of broadband deployment and enable entirely new uses of satellite technology. Kymeta's flat panel antennas use software and metamaterials technology to electronically and dynamically steer the antenna beam to track the target satellite. The Kymeta technology will enable thinner, lighter, more efficient, and less expensive antennas compared to traditional satellite antenna technologies. The reduced cost and form factor offers the potential to substantially broaden not only the scope of uses, but also the addressable market for satellite technologies.[4]

Kymeta has focused its initial development efforts on Ka-band antennas. To this end, Kymeta has tested (or plans to test) its antenna technology with many of the leading Ka-band satellite operators, including Inmarsat, O3b, Hughes/EchoStar, and ViaSat. Kymeta has also entered into development agreements with Inmarsat and O3b.

[4] In 2012, Kymeta was spun out of Intellectual Ventures, the technology and patent company based in the Seattle area. Bill Gates, Jr. is co-chair of Kymeta's Board of Directors, and a leading investor along with Lux Capital, Liberty Global, Osage University Partners, and The Kresge Foundation.

II. THE KYMETA PROPOSAL IS RESPONSIVE TO THE FNPRM

Kymeta's proposal for a new mask is appropriate and responsive to the FNPRM, which seeks comment not only on the proposals set forth in the text of that document but also "on any alternative proposal that would improve the efficiency of the satellite licensing or operating rules and make them less burdensome."[5] In Section F of the FNPRM, the Commission examines the "licensing rules for earth stations that transmit to GSO space stations in FSS frequency bands."[6] In Section F, subsection 12, the Commission specifically examines alternative routing licensing criteria for Ka-band earth stations in order to make it "more convenient for some applicants to qualify for routine licensing …."[7] In these Comments, Kymeta offers an alternative proposal that will also make it more convenient for some applicants to qualify for routine licensing. Further, the Commission specifically invites comment on "whether a further requirement should be adopted for measuring the gain patterns of flat-plate antennas and, if so, what requirement would be appropriate for this purpose."[8] Although the Commission's proposal appears to be intended to apply to Section 25.138(d), Kymeta submits that any proposal to adopt new rules for flat-panel antennas must be reviewed more broadly.

Kymeta vigorously opposes any rule that would impose stricter requirements on flat panel antennas than on parabolic antennas.[9] The purpose of the off-axis gain and EIRP density

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[5] Id. at ¶ 4.

[6] Id. at ¶ 55 (capitalization in original has been removed).

[7] Id. at ¶ 80.

[8] Id. at ¶ 106.

[9] *See* id.

rules is to protect against harmful interference. As Kymeta explains more fully below, flat panel antennas can be as good, if not better, than parabolic antennas at protecting against harmful interference.

III. ADOPTION OF THE CURRENT MASK

As the Commission is well aware, operations in the Ka-band offer advantages for satellite communications services over lower frequency bands, including the use of smaller antennas for end-user earth-station equipment. Smaller antennas typically produce larger beam widths and relatively higher sidelobes, frequently preventing blanket authorization based on the existing antenna performance requirements set forth in Section 25.209. Recognizing these constraints, the Commission adopted alternative blanket licensing criteria for Ka-band earth stations in Section 25.138.

The Commission's rules, in this case Section 25.138, are designed to prevent interference caused by off-axis sidelobes. However, the specific power spectral density ("PSD") off-axis mask adopted in Section 25.138(a) appears to be based on the pattern of a parabolic antenna. Application of this mask to flat panel antennas is unnecessary to prevent harmful interference to adjacent satellites.

IV. THE UNDERLYING GOAL OF THE RULES IS TO PREVENT HARMFUL INTERFERENCE

The underlying goal of the Commission's earth station licensing rules is to prevent harmful interference to other operators in the same band and in adjacent bands. With regard to Ka-band satellite operations, the Commission's rules are designed to ensure that earth stations operate within technical parameters that prevent harmful interference in the 2 degree orbital spacing environment.

As noted above, the small size of many Ka-band antennas prevents compliance with the technical parameters in Section 25.209. As an alternative, the Commission adopted off-axis EIRP spectral density parameters ("off-axis mask") in Section 25.138(a). Ka-band earth stations that comply with the off-axis mask will be routinely processed.

The off-axis mask provides for the co-existence of a large number of earth stations, such that their earth-to-space transmissions do not create harmful interference. Interference is caused when radio-frequency ("RF") energy from one or more transmit earth stations reaches a satellite (or satellites) other than the target satellite. There are two primary ways in which earth stations can create such interference. First, interference can be caused when the transmit antenna is not pointed correctly. For example, consider an earth station which is intended to transmit to a satellite at 101° W.L. but is actually pointed at 100.7° W.L. Such mis-pointing can occur for various reasons, including initial installation error, or movement of the antenna due to high winds, shifting buildings, or degradation in the integrity of the mount. The resulting beam, with peak energy at 100.7° W.L. may sufficiently illuminate the satellite at 101° W.L. such that no significant link degradation is observed, and thus, no pointing correction is pursued. But, that same beam may

illuminate the satellite at 99° W.L. with substantially more power than intended, causing an increased noise floor against which planned services on that satellite are forced to operate.

Second, interference can be caused by the antenna pattern itself, where off-axis sidelobes are not sufficiently suppressed compared to the main beam. Smaller antennas have relatively higher sidelobes. Also, flat panel antennas sometimes produce sidelobe patterns that have several high, narrow peaks, rather than a more circularly-symmetric distribution of energy common to parabolic antennas -- although these peaks are not necessarily concentrated near the main beam.

V. FLAT PANEL ANTENNAS MITIGATE THE RISK OF HARMFUL INTERFERENCE WHILE OFFERING IMPORTANT BENEFITS TO SATELLITE OPERATORS, SERVICE PROVIDERS AND END-USERS

The unique characteristics of electronically steerable flat panel antennas can be a benefit in an overall interference management strategy. Kymeta's antenna simplifies installation, because the transmit beam can electronically locate and lock onto the target satellite. Similarly, in the event the antenna assembly is disrupted, the transmit beam will automatically adjust itself to remain locked onto the target satellite. There is no need for manually adjusting the antenna assembly, and thus, no need to dispatch a technician and no delay in making the adjustment. This prevents mis-pointing, which has traditionally contributed to harmful interference.

Electronically steerable flat panel antennas offer service providers the ability to shift the beam to a different satellite to maximize the efficient use of its satellite fleet, to offer different programming (in the receive mode), and to offer rapid recovery in the event of a satellite outage. Such antennas will also be valuable in extending the useful life of satellites. In the past, satellites in inclined orbit were of limited value because of the need to mechanically track the satellite. By

contrast, an electronically steerable flat panel antenna will track a satellite in inclined orbit without the need for a motorized mechanism. As a result, such satellites will remain useful for nearly all applications, including end-user consumer applications.

VI. TECHNICAL DETAILS OF KYMETA'S PROPOSED MASK

In order to facilitate the routine licensing of new antenna technologies, Kymeta proposes to add a new Section 25.138(b) that will offer an alternative technical standard to Section 25.138(a) for the routine licensing of Ka-band earth stations. Exhibit 1 -- a red-line mark-up of Section 25.138, using the text proposed in the FNPRM as the starting point -- sets forth Kymeta's proposed modifications. Exhibit 2 sets forth a technical showing for Kymeta's proposal.

Electronically steerable flat panel antennas have unique far-field sidelobe patterns that vary based on orientation to the target satellite. Multiple terminals with such antennas will have a statistical distribution of peak sidelobes relative to each other, resulting in a substantial reduction in the probability of the overlap of peak sidelobes in any direction. Kymeta's proposed alternative to Section 25.138(a) would therefore allow for relatively higher peak sidelobes without introducing harmful interference or requiring a reduction in transmit power that would undermine the utility of such earth stations.

Specifically, Kymeta proposes two changes to Section 25.138(a) for the alternative mask in the new Section 25.138(b):

Remove the "wings" for off-axis PSD, thus "flattening" the mask for the off-axis range from 19.1° - 180°.

At the time of adoption of Section 25.138(a), parabolic antennas were widely used, while inexpensive flat-panel antennas had not yet been developed. The shape of the off-axis mask codified in Section 25.138(a) appears to trace the natural shape of the radiated pattern produced by a typical parabolic reflector antenna. In all events, there is no readily apparent justification for the "wings" (or the steep valley) that begins at 19.1° and abruptly ends at 48°. Accordingly, Kymeta's proposal removes the "wings" for off-axis PSD beyond 19.1°.

Require that the average PSD of co-polarized signals emitted by any earth station from 19.1° - 180° not exceed -10 dBW/MHz EIRP.

Removing the "wings" beyond 19.1° could result in nominally higher PSDs than permitted by Section 25.138(a). In order to minimize any risk of increased interference to non-target satellites, Kymeta proposes to add a new requirement: that the average sidelobe PSD in the entire region beyond 19.1° from the main beam must not exceed -10 dBW/MHz. Kymeta submits that the value of -10 dBW/MHz will provide a level of interference protection equivalent to the existing rule.

Kymeta's proposal will remove unnecessary obstacles -- imposed by the current mask -- to the routine licensing of Ka-band earth stations with alternative antenna technologies. If adopted, this proposal will accomplish the stated goals of the Commission by creating a more efficient, more convenient, and less burdensome licensing process for new technologies.

VII. CONCLUSION

Kymeta urges the Commission to adopt its proposed alternative, technology neutral, mask for Ka-band earth stations. The current mask imposes unnecessary obstacles to the routine licensing of Ka-band earth stations with flat panel antennas. Due to their unique characteristics, flat panel antennas emit sidelobe patterns that differ from those of parabolic antennas, although they need not pose an additional risk of interference. The alternative technical rules proposed by Kymeta provide a level of interference protection equivalent to the existing rules. Routine licensing of the next generation of earth stations for satellite communications will serve the public interest by expediting the deployment of technology that will reduce the cost of broadband deployment and enable entirely new uses of satellite technology.

Respectfully submitted,

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EXHIBIT 1

Kymeta's Proposed Changes to Section 25.138 of the FCC's Rules

Kymeta's proposed changes to Section 25.138 are based on the proposed rules set forth in the Further Notice of Proposed Rulemaking in IB Docket No. 12-267, FCC 14-142, released September 30, 2014.

In proposed Section 25.138, move paragraph (b) to paragraph (c) – which had been reserved, and substitute a new paragraph (b) as set forth below.

§ 25.138 Licensing requirements for GSO FSS Earth Stations in the 20/30 GHz bands.

(a) Applications for earth station licenses in the GSO FSS in the 20/30 GHz bands that indicate that the following requirements will be met and include the information required by relevant provisions in §§ 25.115 and 25.130 may be routinely processed:

(1) The EIRP spectral density of co-polarized signals in the plane tangent to the GSO arc, as defined in § 25.103, will not exceed the following values under clear sky conditions:

32.5-25log(θ)-10log(N)	dBW/MHz	for 2.0° ≤θ ≤7°
11.35-10log(N)	dBW/MHz	for 7° ≤θ ≤9.23°
35.5-25log(θ)-10log(N)	dBW/MHz	for 9.23° ≤θ ≤48°
3.5-10log(N)	dBW/MHz	for 48° <θ ≤180°

where θ is the angle in degrees from a line from the earth station antenna to the assigned location of the target satellite. For stations in networks that allow multiple terminals to transmit simultaneously in shared frequencies with equal on-axis EIRP, "N" is the maximum number of network earth stations transmitting simultaneously in the same frequencies to the same target satellite, not counting burst collisions resulting from operation with a contention protocol. N=1 for any station not transmitting simultaneously with others on common frequencies to the same target satellite and stations in networks that permit such simultaneous co-frequency transmission only in contention protocol operation.

(2) In the plane perpendicular to the GSO arc, as defined in § 25.103, the EIRP density of co-polarized signals will not exceed the following values under clear sky conditions:

35.5-25log(θ)-10log(N)	dBW/MHz	for 3.5° ≤θ ≤7°
14.35-10log(N)	dBW/MHz	for 7° <θ ≤9.23°
38.5-25log(θ)-10log(N)	dBW/MHz	for 9.23° <θ ≤48°
6.5-10log(N)	dBW/MHz	for 48° <θ ≤180°

where: θ and N are as defined in paragraph (a)(1) of this section.

(3) The EIRP density levels specified in paragraphs (a)(1) and (2) of this section may be exceeded by up to 3 dB, for values of θ >10°, over 10% of the range of theta (θ) angles from 10-180º on each side of the line from the earth station to the target satellite.

(4) The EIRP density of cross-polarized signals will not exceed the following values in the plane tangent to the GSO arc or in the plane perpendicular to the GSO arc under clear sky conditions:

22.5-25log(θ)-10log(N)	dBW/MHz	For	2.0° <θ ≤7.0°
1.35-10log(N)	dBW/MHz	For	7.0° <θ ≤9.23°

where θ and N are as defined in paragraph (a)(1) of this section.

(5) A license application for a network using variable power-density control of earth stations transmitting simultaneously in shared frequencies to the same target satellite may be routinely processed if the applicant demonstrates the following:

(i) EIRP density from each station in the network will not exceed a level 1 dB below the levels specified in paragraphs (a)(1), (a)(2), and (a)(4) of this section, with the value of N=1.

(ii) Aggregate EIRP density toward any co-frequency space station other than the target satellite not resulting from colliding data bursts transmitted pursuant to a contention protocol will not exceed the limit specified in paragraph (a)(5)(i) above.

(b) In the alternative to paragraph (a), applications for earth station licenses in the GSO FSS in the 20/30 GHz bands that indicate that the following requirements will be met and include the information required by relevant provisions in §§ 25.115 and 25.130 may be routinely processed:

(1) The EIRP spectral density of co-polarized signals in the plane tangent to the GSO arc, as defined in § 25.103, will not exceed the following values under clear sky conditions:

32.5-25log(θ)-10log(N)	dBW/MHz	for 2.0° ≤θ ≤7°
11.35-10log(N)	dBW/MHz	for 7° ≤θ ≤9.23°
35.5-25log(θ)-10log(N)	dBW/MHz	for 9.23° ≤θ ≤19.1°
3.5-10log(N)	dBW/MHz	for 19.1° <θ ≤180°

where θ is the angle in degrees from a line from the earth station antenna to the assigned location of the target satellite. For stations in networks that allow multiple terminals to transmit simultaneously in shared frequencies with equal on-axis EIRP, "N" is the maximum number of network earth stations transmitting simultaneously in the same frequencies to the same target satellite, not counting burst collisions resulting from operation with a contention protocol. N=1 for any station not transmitting simultaneously with others on common frequencies to the same target satellite and stations in networks that permit such simultaneous co-frequency transmission only in contention protocol operation.

(2) In the plane perpendicular to the GSO arc, as defined in § 25.103, the EIRP density of co-polarized signals will not exceed the following values under clear sky conditions:

35.5-25log(θ)-10log(N)	dBW/MHz	for 3.5° ≤θ ≤7°
14.35-10log(N)	dBW/MHz	for 7° <θ ≤9.23°
38.5-25log(θ)-10log(N)	dBW/MHz	for 9.23° <θ ≤19.1°
6.5-10log(N)	dBW/MHz	for 19.1° <θ ≤180°

where: θ and N are as defined in paragraph (a)(1) of this section.

(3) The EIRP density levels specified in paragraphs (b)(1) and (2) of this section may be exceeded by up to 3 dB, for values of θ >10°, over 10% of the range of theta (θ) angles from 10°-180° on each side of the line from the earth station to the target satellite.

(4) The average power spectral density of co-polarized signals emitted by any earth station for 19.1° <θ ≤180° will not exceed -10 dBW/MHz EIRP.

(5) The EIRP density of cross-polarized signals will not exceed the following values in the plane tangent to the GSO arc or in the plane perpendicular to the GSO arc under clear sky conditions:

22.5-25log(θ)-10log(N)	dBW/MHz	for 2.0° <θ ≤7.0°
1.35-10log(N)	dBW/MHz	For 7.0° <θ ≤9.23°

where θ and N are as defined in paragraph (a)(1) of this section.

(c) Operation with off-axis EIRP density exceeding a relevant envelope specified in paragraph (a) or (b) of this section and applications proposing such operation are subject to coordination requirements in § 25.220.

(d) [Reserved]

(e) [Reserved]

(f) The earth station licensee shall not transmit towards a GSO FSS satellite unless it has prior authorization from the satellite operator or a space segment vendor authorized by the satellite operator. The specific transmission shall be conducted in accordance with the operating protocol specified by the satellite operator.

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EXHIBIT 2

Technical Showing for Kymeta's Proposal for an Alternative Mask for Section 25.138
Prepared by: Bruce Rothaar, Chief Architect, Kymeta

1 Proposal

Kymeta is developing electronically steerable, flat panel antennas for satellite earth stations. Due to their unique characteristics, these antennas emit sidelobe patterns that differ from those of parabolic antennas, although they need not pose an additional risk of interference.

Kymeta proposes that an applicant for an earth station authorization would be eligible for routine licensing under the existing criteria set forth in Section 25.138(a), or under the proposed alternative criteria:

Power spectral density (PSD) for co-polarized signals in the plane tangent to the geostationary arc:

$32.5 - 25\times\log_{10}(\theta) - 10\times\log_{10}(N)$	dBW/MHz for $2° < \theta <= 7°$
$11.35 - 10\times\log_{10}(N)$	dBW/MHz for $7° < \theta <= 9.23°$
$35.5 - 25\times\log_{10}(\theta) - 10\times\log_{10}(N)$	dBW/MHz for $9.23° < \theta <= 19.1°$
$3.5 - 10\times\log_{10}(N)$	dBW/MHz for $19.1° < \theta <= 180°$

PSD for co-polarized in the plane perpendicular to the geostationary arc:

$35.5 - 25\times\log_{10}(\theta) - 10\times\log_{10}(N)$	dBW/MHz for $2° < \theta <= 7°$
$14.35 - 10\times\log_{10}(N)$	dBW/MHz for $7° < \theta <= 9.23°$
$38.5 - 25\times\log_{10}(\theta) - 10\times\log_{10}(N)$	dBW/MHz for $9.23° < \theta <= 19.1°$
$6.5 - 10\times\log_{10}(N)$	dBW/MHz for $19.1° < \theta <= 180°$

While allowing the higher peak PSDs set forth above, Kymeta proposes a new, additional requirement to ensure protection for all satellite operators. Namely, the average sidelobe PSD in the entire region beyond 19.1° from the main beam may not exceed -10 dBW/MHz. Kymeta has determined, through statistical simulation, that the value of -10 dBW/MHz, in conjunction with the mask proposed above, will provide an equivalent level of interference protection as provided by Section 25.138(a).

A graphical depiction of the current and proposed regulations is shown in Figure 1 below.

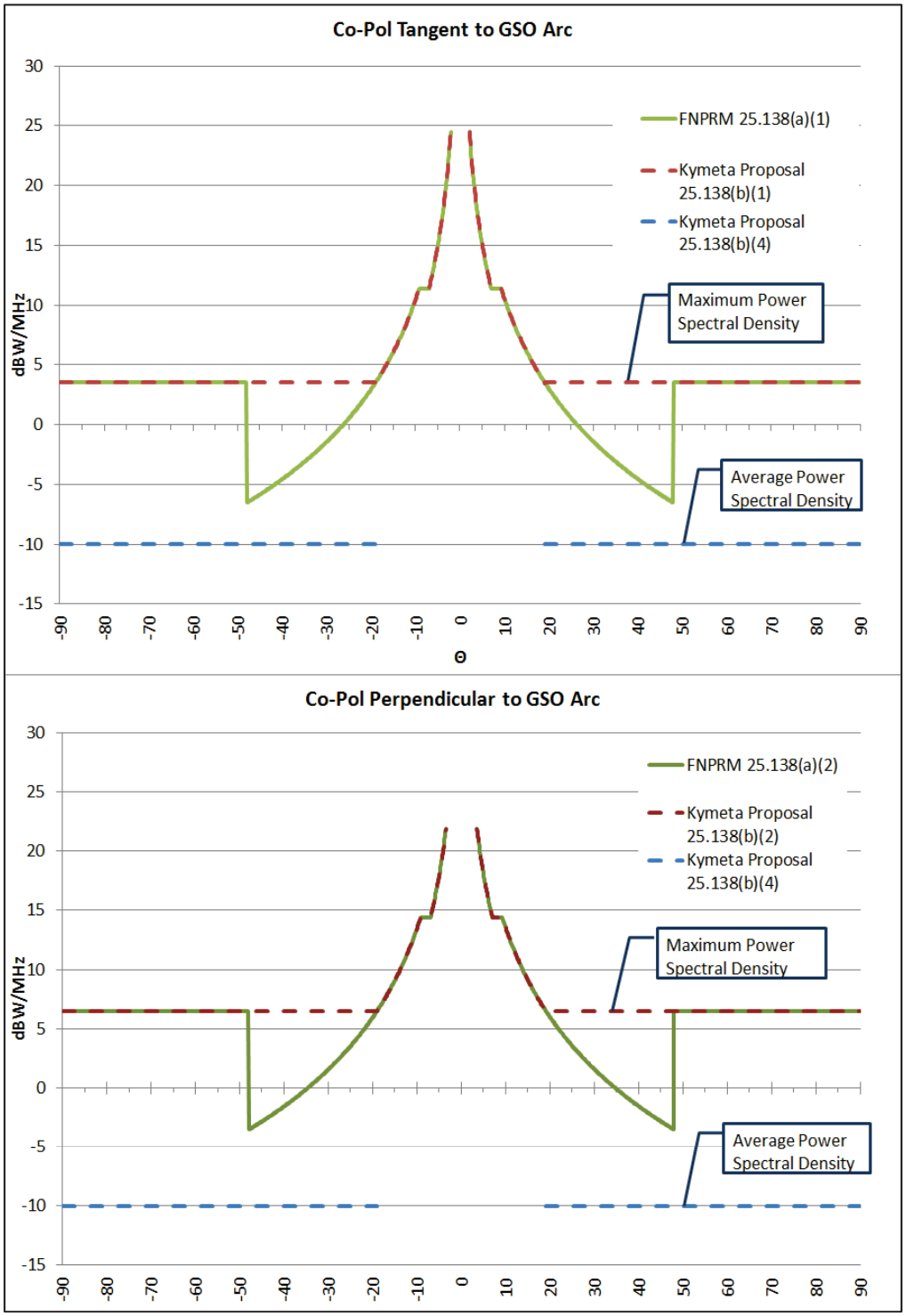

Figure 1. Current and proposed regulatory masks.

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2 Discussion

The existing provisions specified in Section 25.138(a) attempt to prevent harmful interference to fixed satellite service (FSS) operators with satellites in geo-synchronous orbit (GSO) by limiting the peak sidelobe power emitted by each earth station. These PSD requirements appear to be derived from the radiated pattern of a parabolic reflector antenna. As such, they do not allow for the different sidelobe characteristics produced by flat panel and electronically steered antennas. Kymeta therefore urges the Commission to modify the regulations to be technology agnostic.

Emerging technologies, such as flat-panel antennas that may be circular, hexagonal, square, or other, and electronically steerable flat panel antennas, which have sidelobe patterns that vary as pointing changes, can offer substantial public interest benefits if not constrained by regulations designed for legacy technologies. These new antenna technologies need not pose a greater risk of interference to satellite operators.

The proposal set forth above is not simply a relaxation of the current rules that reduces the technical criteria at the expense of degraded link performance guarantees. Instead, Kymeta's proposal introduces a new metric -- average sidelobe level – to be applied to earth station performance. Average sidelobe level is a sufficient condition, when properly combined with the peak PSD regulations, to maintain equivalent link performance and interference protection while providing an alternative criteria, appropriate for authorization of earth stations using new antenna technologies.

3 Technical Justification for Proposed Criteria

As evidence that the above proposed qualification criteria does not materially increase the expected interference observed by any satellite, Kymeta provides a calculation based on a simple and representative near-worst-case scenario.

This simplified near-worst-case scenario is described by the following:

1. Satellites are located every two (2) degrees along the geostationary arc over a range of ±40 degrees relative to the target satellite, and all satellites within this range are simultaneously receiving co-channel, co-polarized Ka-band transmissions. The sidelobes from earth stations transmitting to all but one (the target) satellite impinge upon the target, forming the total interference to which the target satellite is susceptible.

2. All earth stations, transmitting to all of the above satellites, are collocated at the center of the target satellite's receiving footprint.

3. Interfering earth stations have arbitrary equivalent isotropically radiated power (EIRP) and PSD in the direction of their intended orbital slot, but their sidelobes are at the maximum level permitted by the proposed regulatory criteria.

4. Identical and minimum path loss is assumed for all links -- interferers and target -- of 213 dB.

5. The main beam PSD of the earth station intending to reach the target satellite is 41 dBW/MHz. The target satellite has a gain-over-temperature (G/T) of 15 dB/°K, providing a satellite link with carrier-to-noise ratio (C/N) of 11.6 dB.[1] This C/N represents a robust digital link when used with common, commercially available satellite modems.

6. There are no spurious emissions, pointing errors, or on-axis cross-polarization emissions contributing to the interference levels at the target satellite.

Next, we calculate the aggregate interference seen at the target satellite due to interferers. The permissible PSD for an earth station transmitting to a satellite in the orbital slot 2 degrees away from the target satellite, under both the existing and proposed regulations, is 23.2 dBW/MHz. With the main beam PSD of 41 dBW/MHz in the direction of the target satellite, the carrier-to-interference ratio (C/I) at the target satellite due to this first adjacent interferer is 41 dBW/MHz - 23.2 dBW/MHz = 17.8 dB. The permissible PSD of an earth station transmitting to a satellite 4 degrees away from the target is 15.7 dBW/MHz, resulting in a C/I of 25.3 dB.

Continuing to follow this logic in the region of specific interest in Kymeta's proposal, the C/I guaranteed by the existing regulations due to <u>all</u> interferers in the region of 19.1 - 48 degrees away from, and on both sides of, the main beam is 28.5 dB. Thus, the predicted carrier-to-interference-plus-noise (C/(N+I)) permitted under the existing regulations is 11.5 dB. Under the proposed peak PSD requirement, the predicted C/(N+I) in this region of 19.1 - 48 degrees away from the main beam is 11.3 dB, which represents a degradation of 0.15 dB.

Further analysis using more realistic assumptions reduces this predicted degradation. For example, if only half of the orbital slots in the 80 degree range are receiving an interfering carrier then the C/I increases by 3 dB and the resulting C/(N+I) degradation is reduced to 0.07 dB. Or, if the interfering earth stations have, on the average, a 3 dB margin relative to the mask, then the C/(N+I) degradation would again drop to 0.07 dB.

The introduction of an average PSD limit for theta > 19.1 degrees bounds the predicted interference from sidelobes emitted by multiple simultaneous co-channel, co-polarized earth stations, thereby providing incremental protection for the target satellite. This also beneficially affects the predicted interference to NGSO satellites.

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[1] C/N = EIRP – (path loss) + G/T – (Boltzmann constant) – (receive bandwidth)
= PSD (in dBW/MHz) – (path loss) + G/T – (Boltzmann constant) + $10*\log_{10}$(1 MHz) = 11.6 dB