October 23, 2015

**VIA ECFS**

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

**Re: Written *Ex Parte* Presentation – Comprehensive Review of Licensing and Operating Rules for Satellite Services, IB Docket No. 12-267**

Dear Ms. Dortch:

The Satellite Industry Association ("SIA") [1] hereby reiterates and supplements its arguments supporting deletion from the Part 25 rules of the minus 10log(N) formula and all references to the definition of N.[2] SIA submits the attached technical analysis to support its contention that retaining the minus 10log(N) formula is unjustified and that Commission proposals to expand its applicability or redefine its terms would harm the satellite industry without addressing any demonstrated problem.

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[1] SIA is a U.S.-based trade association providing representation of the leading satellite operators, service providers, manufacturers, launch services providers, and ground equipment suppliers. Since its creation twenty years ago, SIA has advocated on behalf of the U.S. satellite industry on policy, regulatory, and legislative issues affecting the satellite business. For more information, visit www.sia.org. SIA Executive Members include: The Boeing Company; The DIRECTV Group; EchoStar Corporation; Intelsat S.A.; Iridium Communications Inc.; Kratos Defense & Security Solutions; LightSquared; Lockheed Martin Corporation; Northrop Grumman Corporation; SES Americom, Inc.; SSL; and ViaSat, Inc. SIA Associate Members include: ABS US Corp.; Airbus DS SatCom Government, Inc.; Artel, LLC; Cisco; Comtech EF Data Corp.; DRS Technologies, Inc.; Eutelsat America Corp.; Glowlink Communications Technology, Inc.; Hughes; iDirect Government Technologies; Inmarsat, Inc.; Kymeta Corporation; Marshall Communications Corporation.; MTN Government; O3b Limited; Orbital ATK; OneWeb; Panasonic Avionics Corporation; Row 44, Inc.; TeleCommunication Systems, Inc.; Telesat Canada; TrustComm, Inc.; Ultisat, Inc.; Vencore Inc.; and XTAR, LLC.

[2] *See* Comments of the Satellite Industry Association, IB Docket No. 12-267, filed Jan. 29, 2015 ("SIA FNPRM Comments") at 10-11 & Annex 1.

In the Further NPRM,[3] the Commission observes that the minus 10log(N) formula is incorporated in a number of rules setting limits on off-axis EIRP density for earth stations eligible for routine processing. The purpose of the formula is to prevent harmful aggregate interference by reducing "the maximum EIRP density that a single station in a GSO network may emit at a given off-axis angle in proportion to the maximum number of network earth stations that can transmit simultaneously in common frequencies in the same satellite receive beam."[4]

The Further NPRM proposes to clarify the formula and to redefine N as the "number of earth stations that will transmit simultaneously in common frequencies to the same target satellite."[5] In addition, the Commission suggests eliminating the language in a number of rules specifying that N equals 1 for purposes of applying the minus 10log(N) formula to FDMA and TDMA transmissions.[6] Finally, the Further NPRM proposes to add the minus 10log(N) formula to certain rules regarding routinely licensed Ku-band and C-band earth stations.[7]

The SIA FNPRM Comments contend that all these changes are unwarranted and that the minus 10log(N) formula should instead simply be deleted from the Part 25 rules. In particular, SIA's pleading argues that a number of factors mitigate the risk that multiple co-frequency transmissions to a spot beam GSO satellite will interfere with an adjacent GSO satellite that has larger beams.[8] SIA notes that spot beam satellites have been operating for some time under the current regulatory framework in which N is assumed to be 1 for FDMA and TDMA networks, and that no problems have been identified to date.[9]

Included in the SIA FNPRM Comments is an analysis showing that no decrease in EIRP density is needed to prevent interference caused by multiple co-frequency transmissions by earth stations communicating with a spot beam GSO satellite.[10] That analysis reflects typical characteristics for two adjacent 20/30 GHz band GSO satellites, one of which has larger beams than the other.

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[3] *Comprehensive Review of Licensing and Operating Rules for Satellite Services,* Further Notice of Proposed Rulemaking, IB Docket No. 12-267, 29 FCC Rcd 12116 (2014) ("Further NPRM"), ¶¶ 66-70.

[4] *Id.* at ¶ 66.

[5] *Id.* at ¶ 67.

[6] *Id.* at ¶ 69.

[7] *Id.* at ¶ 70.

[8] SIA FNPRM Comments at 10.

[9] *Id.* at 10-11.

[10] *Id.* at Annex 1.

Attached hereto is a similar analysis performed using typical characteristics for two Ku-band GSO satellites, one with multiple spot beams and the other with a CONUS beam. The attached analysis concludes that no reduction in EIRP density is required to address the situation in which multiple earth stations could be transmitting in the same frequencies at the same time to a spot beam satellite positioned adjacent to a CONUS-beam spacecraft.

Thus, the record before the Commission demonstrates that including the minus 10log(N) formula in Commission rules is not necessary to prevent harmful aggregate interference. Moreover, the changes the Commission is proposing in the application of the rule would significantly adversely affect satellite operators who have been operating successfully under the current regulatory framework. Accordingly, SIA urges the Commission to delete from the Part 25 rules all references to the minus 10log(N) formula.

Respectfully submitted,

**SATELLITE INDUSTRY ASSOCIATION**

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# Evaluation of the Minus 10log(N) Formula for Ku-band Satellites

## 1. Introduction

In paragraphs 66 through 70 of the Part 25 Further NPRM,[1] the Commission proposes changes that would redefine and expand the applicability of the minus 10log(N) formula, which imposes limits on off-axis EIRP density when multiple earth stations may be transmitting on the same frequencies simultaneously within a single beam of an adjacent GSO satellite. SIA opposes these changes because they would unnecessarily limit the input power density for earth stations communicating with spot beam satellites and ultimately thwart satellite operators' ability to provide and expand innovative services.[2] Instead, the FCC should delete the minus 10log(N) formula from the Part 25 rules.

In support of its position, SIA previously submitted an analysis for the 20/30 GHz band determining the relative delta T/T impact between two spot beam GSO satellite networks with different size spot beams.[3] That analysis concluded that no reduction in EIRP density is needed to address the situation in which multiple beams from one satellite are visible within a larger beam on an adjacent victim satellite.

Using a similar methodology, SIA has prepared the below analysis for the Ku-band to determine the relative impact in delta T/T between a spot beam GSO satellite network and a CONUS beam GSO satellite. This analysis employs typical technical parameters for Ku band satellite systems. Similar to the prior 20/30 GHz band analysis, it demonstrates that no reduction in EIRP density is needed in the case of multiple beams from one satellite being visible within the single beam of an adjacent victim satellite. Accordingly, the FCC should delete the minus 10log(N) formula from its Part 25 rules for both Ku-band and 20/30 GHz band satellite systems.

## 2. Assumptions

In performing the analysis the following assumptions were used:

- Each network will use the same class earth stations operating at the 25.218 off-axis EIRP density limit of 15 – 25*log(θ) – 10*log(N) dBW/40 kHz, or -29.6 dBW/Hz for a topocentric angle of 2.2°.
- Satellite A will use 1.3° spot beams, as a representative beam size. Satellite B will use a beam providing service to CONUS, based on the in-orbit SES-1 satellite at 101° W.L.
- Satellite A uses a four color frequency reuse pattern as depicted in Figure 1; in this case, five to six spots of the same color fall inside or partially inside the -6 dB/K G/T contour of Satellite B's CONUS beam. The analysis will be based on six spots using the same color. It is worth noting that satellites in practice may use less intensive re-use schemes, such as a six color scheme.
- Satellite A's peak G/T is 16.5 dB/K and Satellite B's peak G/T (based on SES-1 at 101° W.L.) is 6.8 dB/K. These are typical values for Ku band spot beams and operational CONUS beams.

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[1] *Comprehensive Review of Licensing and Operating Rules for Satellite Services,* Further Notice of Proposed Rulemaking, IB Docket No. 12-267, 29 FCC Rcd 12116 (2014) ("Further NPRM"), ¶¶ 66-70.
[2] *See, e.g.*, Comments of the Satellite Industry Association, IB Docket No. 12-267, filed Jan. 29, 2015 at 10-11.
[3] *See id.,* Annex A.

- Satellite A's peak receive gain is 44.5 dBi, and Satellite B's peak receive gain (based on SES-1 at 101° W.L.) is 33.6 dBi.

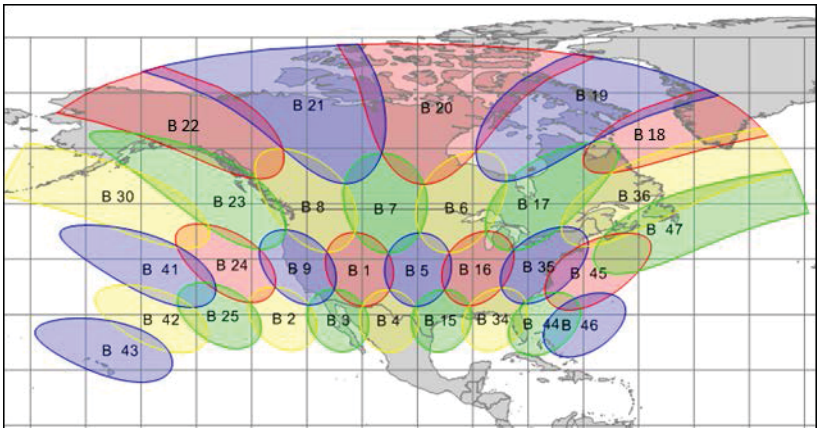


Figure 1. Satellite A Spot beams (four color frequency re-use scheme)

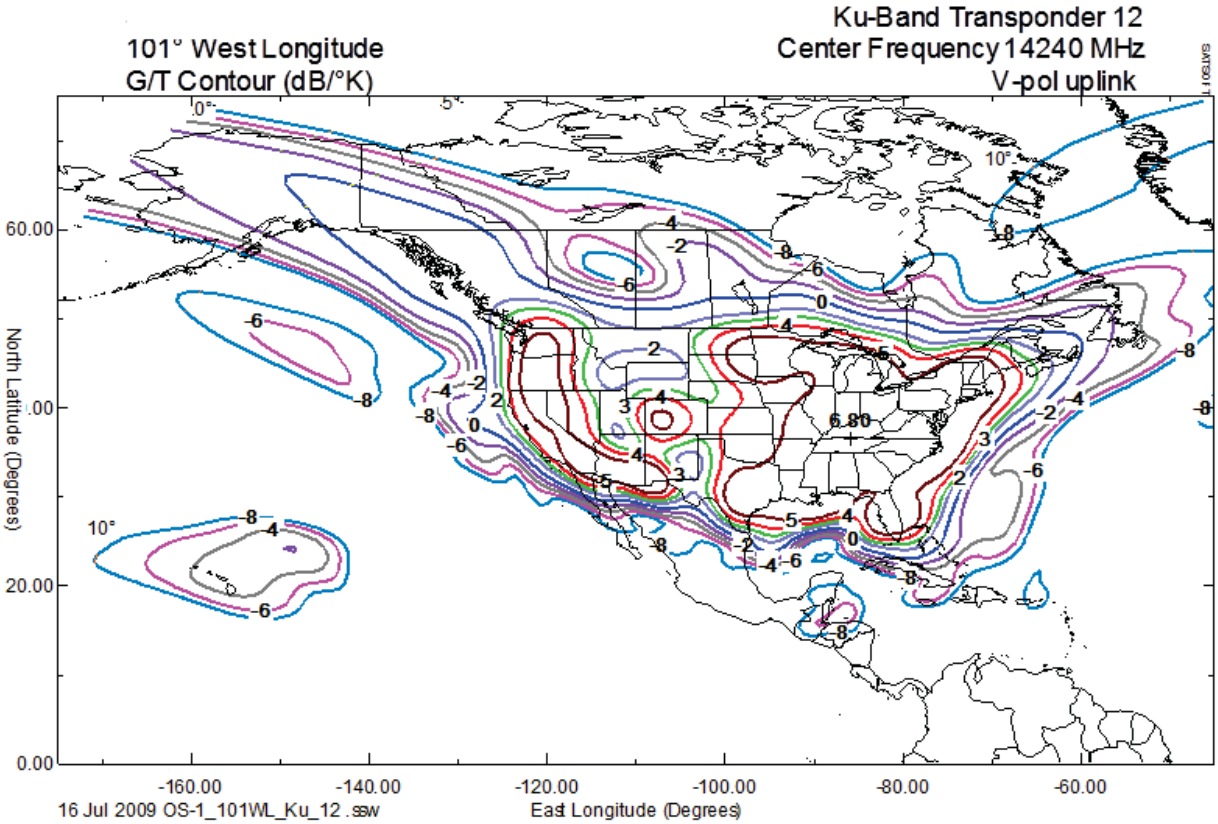


Figure 2. Satellite B CONUS Beam

For both networks, the analysis uses the maximum allowable off-axis EIRP density from each network toward the other for N = 1 to find the interfering input level at each satellite. Next, the N value is determined for each satellite and the delta T/T values recalculated taking into account the actual G/T of Satellite B's CONUS beam towards each earth station potentially transmitting to Satellite A at the same time on the same frequencies.

### 3. Four Color Frequency Re-use Scheme

The input power density to the victim satellite is calculated as (off-axis EIRP density* G)/$L_{path}$ .

$L_{path}$ is calculated as $\left(\frac{4*\pi*r}{\lambda}\right)^2$, which for 14.25 GHz and 36000 km is 206.6 dB.

Taking into account the peak G/Ts and receive gains for each satellite specified in Section 2 above, the receive noise temperature for each satellite, $T_{sat}$, is 631 K for Satellite A and 478.6 K for Satellite B.

For earth stations in Satellite A's network, the interfering input power density $I_o$ to Satellite B is:

$I_o$ = off-axis EIRP density + $G_r$ – $L_{path}$

= -29.6 dBW/Hz + 33.6 dBi – 206.6 dB = -202.6 dBW/Hz

For earth stations in Satellite B's network, the interfering input power density $I_o$ to Satellite A is:

$I_o$ = -29.6 dBW/Hz + 44.5 dBi – 206.6 dB = -191.7 dBW/Hz

The noise $N_o$ at the satellite is calculated as $N_o = k * T_{sat}$ , so $N_o$ for Satellite A is equal to:

$N_o = 10 * \log(\left[1.38 * 10^{-23} \frac{W}{Hz*K}\right] * 631\ K)$, or -200.6 dBW/Hz

For Satellite B, $N_o$ is equal to:

$N_o = 10 * \log(\left[1.38 * 10^{-23} \frac{W}{Hz*K}\right] * 478.6\ K)$, or -201.8 dBW/Hz

Delta T/T is calculated by ($I_o/N_o$) * 100 or, for $I_o/N_o$ in dB form: $10^{\frac{\mathrm{Io - No}}{10}} * 100$

For N = 1 earth stations in Satellite A's network transmitting in Satellite B's receive beam, the delta T/T is:

$$\frac{\Delta T}{T} = 10^{\frac{-202.6\frac{dBW}{Hz} - -201.8\frac{dBW}{Hz}}{10}} * 100 = 83\%$$

For N = 1 earth stations in Satellite B's network transmitting into Satellite A's receive beam, the delta T/T is:

$$\frac{\Delta T}{T} = 10^{\frac{-191.7*\frac{dBW}{Hz} - -200.6\frac{dBW}{Hz}}{10}} * 100 = 776\%$$

The above results are for N = 1. Next, we perform an analysis of the maximum number of co-frequency spots within Satellite B's -6 dB/K G/T contour.

Examining the spot beams for Satellite A, it can be seen that the worst case set of spot beams vis a vis the Satellite B CONUS beam are the yellow colored beams. For the yellow beams, approximately six spots fall inside or partially inside the -6 dB/K G/T contour of the CONUS beam of Satellite B. The six yellow spots of Satellite A and the single CONUS beam of Satellite B use the same frequency and polarization and thus in the case of Satellite A, N = 6 because there are potentially six possible co-frequency and co-polarization transmissions that may fall inside Satellite B's CONUS beam. The other color spots either use a different frequency or operate in the cross-pol and are not counted against N.

To determine the delta T/T impact to Satellite B when N = 6 for Satellite A, it would appear that 10*log(6) could simply be added to the $I_o$ value for Satellite A into Satellite B. However, this would overstate the aggregate interference into Satellite B because many of the uplink spot beams of Satellite A fall well outside the peak of Satellite B's beam and therefore some gain roll-off must be factored in. Examining Figures 1 and 2, it is clear that some reasonable weighting can be applied to the additional co-frequency transmissions.

For this example, the following weightings (reduction in received interference power for the individual contributions based on the actual Satellite B beam gain in the area of each co-frequency Satellite A spot beam) will be used for each of the co-frequency spot beams for the previously determined $I_o$: $\Delta G_{B30}$ = $G/T_{peak}$ - -5 dB, $\Delta G_{B8}$ = $G/T_{peak}$ -3 dB, $\Delta G_{B6}$ = $G/T_{peak}$ - 3.5 dB, $\Delta G_{B36}$ = $G/T_{peak}$ - 2.5 dB, $\Delta G_{B4}$ = $G/T_{peak}$ - 3 dB, and $\Delta G_{B34}$ = $G/T_{peak}$ - 5 dB. The six individual simultaneous transmissions are combined as follows:

$$I_{o_agg} = 10^{\frac{Io-\Delta Gb30}{10}} + 10^{\frac{Io-\Delta Gb8}{10}} + 10^{\frac{Io-\Delta Gb6}{10}} + 10^{\frac{Io-\Delta Gb36}{10}} + 10^{\frac{Io-\Delta Gb4}{10}} + 10^{\frac{Io-\Delta Gb34}{10}}$$

The result is an aggregate $I_o$ of –198.8 dBW/Hz.

The resulting new delta T/T is 10^((-198.8 dBW/Hz – -201.8 dBW/Hz)/10) * 100 = 199%

So, even when N = 6 for Satellite A's network, the resulting delta T/T impact to Satellite B's network is less than 1/3 the impact from Satellite B's earth station into Satellite A's network.

## 4. Summary

This analysis demonstrates that the impact of multiple Ku-band earth stations transmitting at the same time and on the same frequency to a spot beam GSO satellite results in substantially less interference than a single earth station in a CONUS beam located near the beam peak of the spot beam satellite. Based on this analysis, it is unnecessary to consider reductions in the allowed input power density for earth stations communicating with spot beam GSO satellites. A significant mitigating factor is the G/T roll-off of the CONUS beam towards the various spot beams operating on the same frequency. This analysis did not take into account other potentially mitigating factors and can therefore be considered a worst-case scenario. For example, a major application of Ku-band spot beam GSO satellites is

aeronautical traffic, which is transient in nature, producing a low likelihood that all the co-frequency spot beams would in fact have earth stations operating simultaneously at any given point in time.

The satellite industry's current generation of satellites operates successfully in the existing off-axis EIRP density environment, and new satellites are being designed based on the expectation that they will be allowed to operate at those uplink EIRP density levels as well. The changes in the definitions and scope of the minus 10log(N) formula proposed in the Further NPRM would disrupt these expectations and force operators using spot beam satellites to implement unwarranted reductions in operating power, undermining the quality and availability of existing services and causing disastrous economic consequences. Satellite operators coordinating operations under the current framework have not expressed any difficulty with the status quo, and SIA's analysis shows that application of the minus 10log(N) formula is not needed to prevent harmful aggregate interference. Rather than revising the minus 10log(N) formula and applying it to additional bands, the Commission should delete all references to the minus 10log(N) formula from the Part 25 rules.