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

In the Matter of	)	
	)	
Expanding Access to Broadband and Encouraging Innovation through Establishment of an Air-Ground Mobile Broadband Secondary Service for Passengers Aboard Aircraft in the 14.0-14.5 GHz Band	)	GN Docket No. 13-114
	)	RM-11640

COMMENTS OF ECHOSTAR SATELLITE OPERATING CORPORATION AND

HUGHES NETWORK SYSTEMS LLC

August 26, 2013

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I. INTRODUCTION

EchoStar Satellite Operating Corporation and Hughes Network Systems, LLC (collectively, "EchoStar") submit these Comments in response to the Commission's *Notice of Proposed Rulemaking* ("NPRM") in GN Docket No. 13-114, which proposes expanding access to broadband service aboard aircraft in the 14.0-14.5 GHz band (Ku band) on a secondary basis. As a major satellite operator and, more specifically, a Commission-licensed Ku band geostationary orbital Fixed Satellite Service ("GSO FSS") licensee, EchoStar has a keen interest in this proceeding because of the primary status FSS in the Ku band. Accordingly, EchoStar, while understanding the Commission's interest in enabling the deployment of new broadband technologies, is also appreciative of the Commission's interests in ensuring that FSS, a critical communications service, is protected from interference from new services.

EchoStar does not oppose secondary use of the 14.0-14.5 GHz band by air-to-ground services ("ATG") if appropriate protections are adopted to ensure that primary FSS is fully

protected so that FSS providers can continue to provide innovative and cost-effective services to U.S. consumers. Therefore, if the Commission authorizes the use of the Ku band by ATG, the Commission should adopt rules that: 1) make clear the limited nature of the secondary rights being afforded to ATG licensees; 2) enact strict technical criteria to protect FSS from the potential for interference; and 3) establish appropriate enforcement mechanisms for any violations of ATG technical rules.

II. BACKGROUND

EchoStar is a diverse, dynamic U.S. company. Founded by Charlie Ergen in 1980, EchoStar is a home-grown U.S. satellite operator, services provider, and technology company. Today EchoStar owns, leases, or operates a fleet of 22 satellites in the Broadcasting-Satellite Service ("BSS"), the Mobile-Satellite Service ("MSS") and the FSS bands, which provide innovative, multi-channel video programming distribution through DISH Network Corporation ("DISH"), and state-of-the-art fixed and mobile broadband services, among other services. EchoStar is also a leading satellite technology and services company, and employs more than 2,000 engineers focused on creating hardware and service solutions for cable, telecommunications, IPTV, and satellite companies worldwide. Hughes Network Systems, LLC ("Hughes") is the global leader in providing broadband satellite networks and services for enterprises, governments, small businesses, and consumers. Having pioneered the very small aperture terminal ("VSAT"), Hughes remains the world's leading provider of enterprise VSAT services, and has built on this expertise to bring high speed satellite broadband service to consumers and small businesses across the United States. This broadband business is expanding with the recently launched EchoStar XVII satellite, a next-generation, Ka band, high-throughput satellite that delivers high-speed Internet access. This high speed broadband service is especially

important to EchoStar's U.S. consumer and small business customers living or working in rural communities, or in markets with limited terrestrial broadband build-out. Further, these services are invaluable during emergencies when the terrestrial infrastructure is unavailable.

III. DISCUSSION

A. The Commission Should Adopt Licensing Rules That Fully Protect FSS Operations

The Ku band is widely used by EchoStar and other satellite communications companies in the United States to provide FSS to U.S. consumers for a number of important services including voice, data, including broadband services, and video programming. The Commission recognizes the importance of these services and their need for protection from harmful interference in its Notice of Proposed Rulemaking.[1] Accordingly, as discussed below, the Commission should adopt appropriate protections, including interference protections, to ensure that the ATG service operates on a truly secondary basis and does not have the potential to cause harmful interference to Ku band FSS.

i. ATG Licensing Rules Should Be Clear As To The Secondary Status Of ATG Licensees

If the Commission adopts its proposal to award ATG licenses in the 14.0-14.5 GHz band through competitive bidding, it must ensure that the licensing and technical rules expressly provide that ATG is a secondary service. This should include making clear through any Public Notices, or any proceeding establishing auctions or other licensing mechanisms, that the rights of

[1] *Expanding Access to Broadband and Encouraging Innovation through Establishment of an Air-Ground Mobile Broadband Secondary Service for Passengers Aboard Aircraft in the 14.0-14.5 GHz* Band, Notice of Proposed Rulemaking, 28 FCC Rcd 6765, ¶ 27 (2013) ("*ATG NPRM*").

ATG licensees are strictly limited to secondary use.[2] Failure to provide clear notice could result in auction bidders and licensees making licensing choices based on a misunderstanding of their operational rights, or worse—licensees might become emboldened to seek or even expect additional protections beyond those afforded through this proceeding.[3] While the Commission "do[es] not contemplate any way to entertain a future request to elevate the status to primary…,"[4] EchoStar urges the Commission to emphasize this limitation.

The prospect of a secondary licensee seeking higher priority in the future could negatively impact the provision of FSS services in the band by creating uncertainty and discouraging new investment in these services. Ultimately, consumers would be harmed. Accordingly, the Commission should adopt rules, licensing conditions and provide adequate notice to potential licensees and bidders that any ATG license provides for use solely on a secondary basis to FSS. And, as discussed *supra*, these rules must be strictly enforced.

ii. ATG Licenses Should Not Be Based On Band Segmentation

Most satellites utilizing the 14.0-14.5 GHz band are designed with receive beams that cover, at a minimum, the entire continental United States. If the Commission were to adopt a proposal to allow either co-frequency regional licenses or multiple national licenses that share the same band, the FSS will be subject to the potential from interference from multiple ATG licensees in any given part of the band. Additionally, two or more licensees would have to share

[2] As an additional safeguard, EchoStar recommends the FCC require ATG licensees to provide notice to their users that the service is subject to preemption from primary incumbents. This will ensure that ATG service providers are on notice with respect to their obligations as users of secondary licensed services.

[3] *See, e.g.*, Ex Parte Letter from Patricia Cooper, President, Satellite Industry Association, to Marlene H. Dortch, Secretary, FCC, RM-11640, RM-11341 (May 2, 2013) ("[S]uch a scenario would be far more likely to encourage any ATG licensee to simply seek additional regulatory protections beyond secondary status, further eroding the performance and flexibility of existing and future satellite services.").

[4] *ATG NPRM* at ¶ 27.

the interference allocation between them which could yield an aggregate interference threshold that precluded any ATG system from succeeding. Furthermore, under such a licensing regime, it would be impossible for the primary incumbent licensee to attribute the interference to an individual interferer, as each network (or the combination of two or more networks) could potentially be the cause of the interference. Until such time as ATG systems coordinators (as discussed below) achieve appreciable experience operating in the same band as FSS systems, the Commission should avoid utilizing band segmentation as a licensing approach.

iii. ATG Licensees Must Be Restricted From Assigning Or Leasing Spectrum Through Secondary Markets

The introduction of ATG service in the 14.0-14.5 GHz band may result in more users in the Ku band. It is therefore critical that ATG licensees be able to monitor and limit any interference toward the GSO arc, so as not to exceed prescribed limits. However, this requirement would become more difficult to monitor if ATG licensees were to lease, or otherwise partition or disaggregate their spectrum, since no mechanisms have been put forth to limit simultaneous co-frequency transmissions from ATG licensees in different geographic regions. In such an environment, the aggregate interference at the GSO arc from all authorized users could be exceeded. Further, as a secondary user in the band, it is critical that the potential ATG licensee maintain a clear chain of responsibility and operational control of the ATG system being deployed. This accountability would play a key role were the Commission to allow spectrum leasing of the ATG spectrum.[5] Spectrum leasing adds complexity and opacity to the management of a network and has the possibility of causing severe harm to primary users in the band. If the FSS is to be successfully protected, the ATG licensee must ensure adequate

[5] *See ATG NPRM* at ¶¶ 90-91.

supervision of the interference the licensee's network generates be in a position to remedy any possible issues, and remain accountable to the Commission for these operations.[6]

B. The Commission Must Adopt Clear and Enforceable Technical Rules To Protect FSS Operations From The Potential For Harmful Interference

If the Commission adopts rules to allow ATG operations on a secondary basis in the Ku band, it must also adopt additional technical rules for the service to ensure that FSS communications are fully protected from the potential for harmful interference. As a primary user in the band, EchoStar provides innovative services such as its VSAT enterprise solutions, which provide voice and data communications to thousands of businesses across the United States. Other services offered in the band, including Earth Stations on Vessels, Vehicle-Mounted Earth Stations, and Earth Stations Aboard Aircraft, provide vital communications for U.S. consumers. Therefore, it is critical that the Commission continues to afford these primary services the interference protection to which they are entitled through the adoption of strict technical criteria for ATG operations

i. The Commission Must Adopt A Threshold Bar For Acceptable Interference That Is Constant, Measurable And Enforceable

While EchoStar generally supports the Commission's proposal to utilize ITU Recommendation S.1432[7] as the starting point in establishing a threshold for acceptable interference, relying on this recommendation alone will not fully protect FSS and is therefore insufficient. This is because the recommendation uses as a threshold *all* secondary users in the aggregate. However, under the Commission's proposal, ATG licensees would be just one of a

[6] Accordingly, EchoStar recommends implementing additional technical rules and safeguards, discussed *infra* at pp. 12-13.

[7] Recommendation ITU-R S.1432-1(4) (2006) (stating that one percent of $\Delta T/T$ is the recommended limit for all sources of interference from non-primary services).

group of secondary licensees. The U.S. Table of Allocations provides other secondary users in the band, including the federal Fixed Service ("FS") and Mobile Service ("MS"), as well as the Mobile Satellite Service ("MSS"). As a result, even if Qualcomm's calculations are correct and the total aggregate interference from all ATG service remained at 0.5% ΔT/T, the ATG service could not account for interference generated by any other secondary users, nor would the service be required to do so under the proposed rules. Thus, adoption of the ITU Recommendation does not sufficiently protect primary incumbents from the potential for harmful interference.

Further, adoption of this Recommendation could severely impede innovation in FSS development as satellite receivers become more sensitive. As the Commission recently noted, aggregate interference power and satellite performance are directly correlated.[8] Yet, satellites can vary with respect to their particular sensitivity to thermal noise levels, meaning that the aggregate interference from all ATG services could affect two satellites differently. As a result, in order to maintain compliance with the Recommendation, ATG operators would be required to meet protection levels that varied depending on their geographic location and the direction towards the sky that the interference is radiated. This would become unmanageable quickly. Additionally, without assurances that ATG services avoided unacceptable interference levels, the satellite industry would be discouraged from innovating in satellite technology because of the risk that developing more sensitive receivers could lead to encountering more unacceptable interference. Innovation by primary incumbents, as well as potential future primary users,

[8] *ATG NPRM* at ¶ 103. *See also Utilities Telecom Council and Winchester Cator, LLC Petition for Rulemaking to Establish Rule Governing Critical Infrastructure Industry Fixed Service Operations in the 14.0-14.5 GHz Band*, Order, 28 FCC Rcd 7051, ¶ 6 (IB, OET, WTB 2013) ("UTC/Winchester Order") ("[T]he level of the 'harmful' interference strictly depends on the aggregate interference power *and* the receiver performance of the FSS satellite in orbit.") (emphasis added).

should not be impeded by such uncertainty, nor dictated by in an interference metric that fails to set a constant and measurable allowable interference limit.

Accordingly, rather than use the Recommendation as the sole criterion in setting aggregate interference levels, the Commission should establish a conservative maximum interference aggregate power flux density ("PFD") for all ATG services equal to *-230 dbW/m^2/Hz* toward the GSO arc. [9] This approach would set a clear, independent bar for all ATG transmissions, and avoid the necessity of adjusting protection levels based on geographic area or location on the GSO arc. It is also preferable to a $\Delta T/T$ aggregate interference threshold because specific satellite sensitivities do not factor in, which allows FSS operators to continue to innovate and offer services uninhibited by secondary users. Further, adopting a hard limit provides ATG operators with increased certainty as to the level of protection they must provide in a manner that is clear and useable in the development of such systems. A clear metric also provides the Commission with a useable interference threshold during the licensing process or if an enforcement action is ever contemplated. Accordingly, the Commission should establish the above-mentioned maximum interference PFD for ATG licensees.

ii. The Commission Should Expressly Limit ATG licenses To ATG Service

EchoStar supports the Commission's proposed requirement that licensees under the new allocation use the spectrum for air-ground mobile broadband only.[10] As many primary users' services in the band are ubiquitously deployed, very few types of applications can effectively

[9] *See* Annex A.

[10] *ATG NPRM* at ¶ 5.

share the band with FSS.[11] Additionally, FSS earth stations transmit at extremely high equivalent isotropically radiated power ("EIRP") density levels in order to reach satellite receivers located at a great distance from the transmitter. Even if an application were capable of successfully deploying under these constraints, its use would be inhibited by the fact that service areas covered by FSS satellite receive beams cover wide geographic areas. Because of this, the interference allocation for secondary services would need to be met jointly by the ATG licensee as well as the additional services operating in the band. In such case, rather than reducing the ATG service's allocated interference threshold, or attempting to experiment with the deployment of multiple services in the band (at the FSS licensee's expense), EchoStar urges the Commission to adopt rules limiting ATG licenses to ATG service. [12]

iii. The Commission Should Implement Service Rules For ATG Based On Current Service Rules For VMESs And ESAAs

The potential for unacceptable interference to primary users in the band is heightened by the proposed ATG secondary service because of the adverse impact that the implementation of multiple, co-frequency transmitters will have on primary, GSO-FSS networks. The Commission addressed similar interference concerns recently when it adopted rules covering blanket licensing provisions for domestic, U.S. Vehicle-Mounted Earth Stations (VMESs) transmitting in the 14.0-

[11] *See e.g.*, Opposition of Global VSAT Forum and European Satellite Operators Ass'n, RM-11429, at 9 (filed June 26, 2008) (explaining FSS band sharing difficulties with radar detectors).

[12] The Commission has also acknowledged that broad, varied use of services by secondary licensees could lead to an unworkable problem with band-sharing. *See* UTC/Winchester Order at ¶ 10 ("[UTC-Winchester's] proposal offers no limitation on the types of CII uses that the nationwide licensee may authorize[,]" and accordingly "[g]iven the broad scope of potential uses UTC-Winchester proposes, the challenges of preventing harmful interference to incumbent services, and the potential for unpredictable interference to CII services, we are not persuaded that UTC-Winchester's proposal is viable in this band.").

14.5 GHz band[13] as well as for Earth Stations Aboard Aircraft (ESAA).[14] These rules were modeled on service rules governing the use of Earth Stations on Vessels (ESVs), which were adopted to address the "challenge of protecting other FSS satellites from the mobile unit's potential harmful interference."[15] Similarly, ATG interference to GSO FSS networks will come from multiple, mobile co-frequency transmitters under the control of a single licensee, increasing the likelihood of unacceptable interference unless the interference caused by the network is carefully managed. Accordingly, the Commission should adopt rules for ATG service that require careful management of the interference in order to minimize the impact that these transmitters have on GSO FSS networks.

For instance, VMES networks are authorized to operate under the Section 25.226 of the Commission's rules, which address the deployment of multiple co-frequency transmitters operating under a single licensee. The VMES rules are comprehensive in addressing requirements for effective aggregate EIRP-density limits, [16] emergency points of contact,[17] retention of data,[18] material which must be included with the license application,[19] and time

[13] *See Amendment of Parts 2 and 25 of the Commission's Rules to Allocated 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*, Report and Order, 24 FCC Rcd 10414, ¶ 78 (2009).

[14] *See Revisions to Parts 2 and 25 of the Commission's Rules to Govern the Use of Earth Stations Aboard Aircraft Communicating with Fixed-Satellite Service Geostationary-Orbit Space Stations Operating in the 10.95-11.2 GHz, 11.45-11.7 GHz,11.7-12.2 GHz and 14.0-14.5 GHz Frequency Bands*, Notice of Proposed Rulemaking and Report and Order, 27 FCC Rcd 16510, ¶ 41 (2012) ("*ESAA R&O*").

[15] *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, ¶ 12 (2005).

[16] 47 C.F.R. § 25.226(a)(3)(i).

[17] *Id.* § 25.226(a)(5).

[18] *Id.* § 25.226(a)(6), (b)(3)(iii).

[19] *Id.* § 25.226(b)(3)(i).

constraints for shut-off if the licensee's threshold interference is exceeded.[20] In addition to meeting the above rule, an applicant for an ATG license should be obligated to provide measured antenna performance data for both base stations and aircraft in a manner compliant with section 25.132. This provision of measured antenna performance data is critical for verifying compliance with the interference limit at the GSO arc.

Further, in establishing rules recently to govern Earth Stations Aboard Aircraft in the 14.0-14.5 GHz band, the Commission adopted similar monitoring rules, reasoning that "[monitoring] requirements would ensure that the…licensee is capable of controlling all aspects of its…network, which in turn would allow [the Commission] to ensure that other licensees are protected from unacceptable interference."[21] The Commission should adopt similar monitoring requirements for ATC because it will further protect GSO FSS operators from the increased potential for harmful interference by requiring ATG licensees to ensure that their systems' interference levels are well within established limits for ATG licensees.

iv. The Commission Should Apportion Interference Among Users If Multiple ATG Licenses Are Awarded

In the event that the Commission decides to create co-frequency regional or national ATG licenses, it will be necessary to apportion the interference threshold among co-frequency licensees. As satellite antennas in this frequency band encompass the entire continental United States, interference from all ATG licensees would be simultaneously received at the satellite. Without rules governing how the allocation is to be divided, GSO FSS licensees are at risk that each ATG licensee may either just meet or exceed the aggregate limit. As satellite operators

[20] *Id.* § 25.226(b)(3)(ii)(E).

[21] *ESAA R&O* at ¶ 106.

would not be able to ascertain the source of the interference, ATG licensees could avoid compliance by blaming the other operators for the interference. While EchoStar does not support the use of regional licenses, it is imperative that rules establishing the sharing and verification of compliance be put in place before multiple regional licenses are authorized.

Accordingly, EchoStar urges the Commission to initiate a Further Notice of Proposed Rulemaking to examine other mechanisms to protect primary Ku band users from interference including establishing a database that ATG services must use to dynamically obtain information on the availability of accessible sub-bands and designate an entity operate this database, whose duties will include ensuring that ATG licensees are not interfering with primary users.

The Commission recently adopted rules to establish a TV band database to coordinate opportunistic unlicensed use of TV white spaces,[22] as well as several database administrators to oversee coordination of unlicensed users.[23] In doing so, the Commission reasoned that establishing these databases was important "to minimize the possibility that TV bands devices will operate on occupied channels and cause interference to licensed services…."[24] Additionally, the Commission adopted rules in 2004 to establish database managers in the 71-76 GHz, 81-86 GHz and 92-95 GHz bands purposed with "jointly developing and managing databases of link registrations by Commission licensees."[25] Accordingly, the Commission should consider a Further Notice of Proposed Rulemaking to establish secondary service band

[22] *See Unlicensed Use in the TV Broadcast Bands,* Second Memorandum Opinion and Order, 25 FCC Rcd 18661, ¶¶ 97-100 (2010).

[23] *Id.* at ¶¶ 104-07.

[24] *Id*. at ¶ 97. The Commission additionally noted that providing for multiple band managers "could provide an incentive for database operators to provide additional services beyond those required by the rules and could result in lower costs to consumers." *Id.* at ¶ 104.

[25] *Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands,* Order, 19 FCC Rcd 20524, ¶ 1 (WTB 2004), *petition for reconsideration granted in part, denied in part,* 20 FCC Rcd 4889, ¶¶ 1-2 (WTB 2005).

management and illicit comments from industry participants *before* it auctions licenses to operate these secondary services. This will provide more certainty for primary and secondary users in the band.

v. The Commission Should Ensure Continued Protections For Non-Geostationary Orbital FSS Systems

Currently, the Commission's rules for the 14.0-14.5 GHz band provide for the use of Non-Geostationary Orbital ("NGSO") FSS systems. While EchoStar is not presently an NGSO FSS licensee, it has applied for NGSO licenses in the past and may do so again in the future. As such, EchoStar has an interest in ensuring the continued availability of NGSO networks in the band. However, ATG service in the 14 GHz band threatens the implementation of potential NGSO networks. As proposed, the ATG service is designed to minimize the impact of harmful interference on satellites along the GSO arc. The service is not, however, designed to protect NGSO systems. While protection of NGSO systems is identified as a priority by the Commission, the material in the NPRM and the overall record to ensure such protection is incomplete. Since NGSO FSS systems can be deployed using different orbital parameters and satellite designs, the task of examining their protection is more complex than in the analysis of the GSO FSS environment. Since NGSO satellites are in constant motion relative to the interference source, a complete analysis of the interference situation requires a computer simulation that captures and presents the interference as a statistic relative to time. The only NGSO analysis currently on the record was done by Qualcomm and is woefully insufficient in ensuring that NGSO constellations can be operated with minimal interference from ATG licensees.

Two additional factors increase the likelihood that NGSO systems will receive harmful interference from the proposed ATG system. First, NGSO satellites tend to be operated at a far lower altitude than GSO satellites, resulting in the distance between the satellite and the interference source being significantly reduced, and the likelihood of interference magnified. Second, the NGSO FSS must protect GSO FSS systems by meeting demanding emission limits towards the GSO arc.[26] As a result, most NGSO system designs have located the NGSO satellites away from the GSO arc.[27] As both NGSO FSS earth stations and ATG gateways try to avoid the GSO arc, they risk pointing to the same portion of the sky, with inevitable consequences for harmful interference. A simple analysis in Annex B reveals the interference to a NGSO satellite from a single, ATG gateway pointing north at 10 degrees elevation.[28] For various orbital altitudes, the resultant interference always well exceeds the interference threshold $\Delta T/T$ value of 0.5%.[29]

If, in the future, the Commission were to receive an application for a NGSO system, it would risk having to either eviscerate or relocate a thriving ATG service, or change how NGSO is treated with respect to other users in the band. To avoid such a difficult situation, EchoStar proposes that the Commission, at a minimum, adopt a further notice of proposed rulemaking to address the compatibility of NGSO FSS and ATG deployments in the 14.0-14.5 GHz band

[26] *See* ITU-R Radio Regulation, Table 22-2. *See also* 47 C.F.R. § 25.146.

[27] *See e.g. O3b Application to Operate a Gateway Earth Station with a Non-U.S. Licensed Non-Geostationary Orbit Ka-Band Space Station System*, SES-LIC-20100723-00952 (filed July 23, 2010); *see also Application of SkyBridge, LLC for Authority to Launch and Operate a Global Network of Low-Earth Orbit Communications Satellites Providing Broadband Services in the Fixed-Satellite Service*, SAT-AMD-20040719-00135 (filed July 19, 2004).

[28] These calculations are based on the maximum elevation angle provided by Qualcomm for ATG service ground stations. *See* Annex A, Qualcomm, Petition for Rulemaking, RM-11640, at A-3 (filed July 7, 2011).

[29] *See* Annex B.

before issuing any ATG service rules. Based on a more complete record, the Commission will be better able to decide how to address compatibility between these two types of deployments.

CONCLUSION

So long as the Commission adopts appropriate protections for primary GSO FSS users in the band, EchoStar does not oppose allowing secondary use of the Ku band by ATG. Accordingly, any regulatory regime that is adopted for ATG must include clear notice that ATG is a secondary service, technical rules that protect against interference, and strict enforcement measures to ensure compliance.

Respectfully submitted,

EchoStar Satellite Operating Corporation
Hughes Network Systems, LLC

By: /s/ Dean A. Manson
Dean A. Manson
Executive Vice President, General Counsel and Secretary
11717 Exploration Lane
Germantown, MD 20817

Date: August, 26 2013

Annex A

Derivation of a Power Flux Density Figure

ITU-R Recommendation S.1432 suggests that FSS links should make an interference allocation equivalent to 1% of the satellite system noise in order to take into account all non-primary sources of interference. From this value it is possible to derive an equivalent interferer's power flux density (pfd_I) limit at the GSO resulting from non-primary services in the Earth-to-space Ku band allocation. This shall be accomplished through classical communications link analysis.

In radio communications, a signal transmitted from a transmitter produces a power density at a receiver that is a function of the radiated power and the distance between the transmitter and receiver (d). Power flux density describes the spread of transmitted power over the area of a hypothetical sphere radially defined by the distance between the transmitter and receiver. It is thus represented in units of Watts/m^2 and given by the following generalized equation:

$$pfd = \frac{P}{4\pi d2}$$

When antennas with high directivity are used, as is the case for satellite communications, the transmitted power to be used in the analysis of the received power density is scaled by the gain of the transmitting antenna, to provide the effective radiated power figure of interest, called Equivalent Isotropic Radiated Power (EIRP).

$$EIRP = G_T P_T$$

EIRP := Equivalent Isotropic Radiated Power (Watts or dBW)

G_T := Gain of the transmitting antenna

P_T := Transmitted signal power at the antenna flange (Watts)

The power extracted by the received antenna is a function of its effective area for power absorption, or aperture (A_R), in units of squared meters. For the purposes of link analysis, the antenna aperture is determined by the received antenna gain (G_R) and the signal's wavelength (λ) as follows:

$$A_R = G_R \lambda^2 / 4\pi$$

These terms are put together into what is known as the range equation to predict the received power for any signal as a function of distance between transmitter and receiver.

$P_R = EIRP \times \frac{A_R}{4\pi d^2} = G_R G_T P_T \left(\frac{\lambda}{4\pi d} \right)^2$ Similarly, the received interference to noise power ratio may be represented as the amount of unwanted (or interference) signal power collected by the receiver divided by the receiver's thermal noise power. The maximum thermal noise power that could be coupled into the receiver front end is defined as:

$$N = \kappa T_N B$$

where,

κ := Boltzmann's constant = 1.38 x 10^{-23} W/K-Hz = -228.6 dBW/K-Hz

T_N := Receiver noise temperature (Kelvin)

B := Receive bandwidth (Hz)

Thus, the received interference to noise ratio is given by

$$\frac{I}{N} = \frac{P_{IR}}{N} = \frac{EIRP_I \times \frac{A_{RI}}{4\pi d^2}}{\kappa T_N B} = \frac{G_R G_I P_I}{\kappa T_N B} \left(\frac{\lambda}{4\pi d} \right)^2$$

Now the terms of the equation may be rearranged to solve for the interferer's power flux density as follows:

$$pfd_I = \frac{G_I P_I}{4\pi d^2} = \left(\frac{4\pi \cdot \kappa \cdot B}{\lambda^2 G/T} \right) \frac{I}{N}$$

In the case of the Ku band allocation, the received bandwidth is 500 MHz and the wavelength is given by the center frequency of the allocated earth to space band, 14.25 GHz (*f*) and the speed of light (*c*).

$$\lambda = \frac{c}{f} = \frac{3 * 10^8}{14.25 * 10^9}$$

Then the equation in decibels becomes:

$$PFD_I = \left(\frac{I}{N} \right)_{dB} - \left(\frac{G}{T} \right)_{dB} - 97.1$$

A recent survey of Ku-band FSS stations currently in service over North-America[30] revealed that the maximum assumed average G/T value is 6.0 dB/K. Considering the 1% system noise constraint, the calculated limit for the interferer's PFD towards the GSO satellite should be -123.1 dBW/m^2. Provided the interference power is to be uniformly spread over the 500 MHz bandwidth, we obtain the limit of -210.1 dBW/m^2/Hz toward the GSO satellite.

[30] Exhibit 2 of SIA's October 22, 2012 written ex-parte presentation in Docket #RM-11640

Annex B

Interference Analysis from ATG to NGSO FSS

The following technical characteristics were used for the victim:

Table B-1 - Victim Parameters

Noise Temperature	500^{o}	Kelvin
Antenna Gain	20	dBi
Orbit Type	Circular	
Orbit Altitude 1	1000	km
Orbit Altitude 2	8000	km

The following characteristics were used for the interference source, which in this case is a single ATG gateway station (GS):

Table B-2 - Transmitter Parameters

ATG Gateway EIRP	39.5	dBW
ATG Gateway elevation angle	10	Degrees
Bandwidth	50	MHz

For an ATG GS station pointing due north, the beam will intersect the NGSO FSS satellite orbital plane with a slant range of 2764 km. Using the equation derived in Annex A:

$$\frac{I}{N} = \frac{EIRP_I \times \frac{A_{RI}}{4\pi d^2}}{\kappa T_N B} = \frac{G_R EIRP_I}{\kappa T_N B}\left(\frac{\lambda}{4\pi d}\right)^2$$

Where:

κ := Boltzmann's constant = 1.38 x 10^{-23} W/K-Hz = -228.6 dBW/K-Hz

T_N := Receiver noise temperature (Kelvin) = 500 ^oK

B := Receive bandwidth = 50 MHz

EIRP := Equivalent Isotropic Radiated Power (dBW) = 39.5 dBW (50 MHz carrier)

G_R := Gain of the NGSO receiving antenna

d := Slant range = 2764 km (1000 km altitude case)

:= Slant range = 11,828 km (8000 km altitude case)

Substituting the values above into the equation yields the results in Table B-3 below.

Table B-3 – Interference Levels

Case	I/N	Receiver contour for I/N = 0.5%
1000 km altitude	94.8 %	-3 dBi
8000 km altitude	5.2 %	10 dBi

Results

NGSO satellites at low altitude receive high levels of interference from ATG GS due to the short slant path. The interference from one single ATG GS can be as high as 94.8% $\Delta T/T$

when main lobe coupling occurs between the ATG GS and the NGSO satellite. For the interference to be below 0.5% ΔT/T, the ATG GS must never point towards the NGSO satellite while the ATG GS site is within the -3 dBi receive contour of the NGSO satellite.

For NGSO satellites operating at higher altitude, the interference received is lower due to the longer slant path. In the case considered, the interference from one single ATG GS can be as high as 5.2% ΔT/T when the main lobe coupling occurs between the ATG GS and the NGSO satellite. For the interference to be below 0.5% ΔT/T, the ATG GS must never point towards the NGSO while the ATG GS site is within the 10 dBi receive contour of the NGSO.

This static analysis of man lobe coupling cases does not quantify the duration of time of such events. A dynamic simulation is necessary to obtain data of ΔT/T versus percentage of time.

ENGINEERING CERTIFICATION

I, Steven Doiron, hereby declare, under penalty of perjury, that the following statements are true and correct to the best of my information and belief:

(i) I am the technically qualified person responsible for the engineering information contained in the foregoing Pleading,

(ii) I am familiar with Part 25 of the Commission's Rules, and

(iii)I have either prepared or reviewed the engineering information contained in the foregoing Application and found it to be complete and accurate.

Steven Doiron,
Senior Director,
Regulatory Affairs
Hughes Network Systems, LLC
Dated: August 22, 2013