The Voice of the Satellite Industry

December 11, 2012

FILED ELECTRONICALLY

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street N.W.
Washington, D.C. 20544

Re: Notice of Written *Ex Parte* Presentation – Petition for Rulemaking RM-11640 ***Amendment of the Commission's Rules to Establish a Next-Generation Air-Ground Communications Service on a Secondary Licensed Basis in the 14.0 to 14.5 GHz Band***

Dear Ms. Dortch:

The Satellite Industry Association ("SIA")[1] hereby provides notice of a written *ex parte* presentation, attached hereto, in Docket #RM-11640. The attached *ex parte*

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[1] SIA is a U.S.-based trade association providing worldwide representation of the leading satellite operators, service providers, manufacturers, launch services providers, and ground equipment suppliers. Since its creation more than fifteen years ago, SIA has become the unified voice of the US satellite industry on policy, regulatory, and legislative issues affecting the satellite business. SIA Executive Members include: Artel, Inc.; The Boeing Company; The DIRECTV Group; EchoStar Satellite Services LLC; Harris CapRock Communications; Hughes Network Systems, LLC; Intelsat, S.A.; Iridium Communications Inc.; Kratos Defense & Security Solutions; LightSquared; Lockheed Martin Corporation.; Northrop Grumman Corporation; Rockwell Collins Government Systems; SES S.A.; and Space Systems/Loral. SIA Associate Members include: AIS Engineering, Inc.; ATK Inc.; Cisco; Cobham SATCOM Land Systems; Comtech EF Data Corp.; DRS Technologies, Inc.; Encompass Government Solutions; Eutelsat, Inc.; GE Satellite; Globecomm Systems, Inc.; Glowlink Communications Technology, Inc.; iDirect Government Technologies; Inmarsat, Inc.; Marshall Communications Corporation.; MTN Government Services; NewSat America, Inc.; Orbital Sciences Corporation; Panasonic Avionics Corporation; Spacecom, Ltd.; Spacenet Inc.; TeleCommunication Systems, Inc.; Telesat Canada; TrustComm, Inc.; Ultisat, Inc.; ViaSat, Inc., and XTAR, LLC. Additional information about SIA can be found at www.sia.org.

presentation responds to certain additional technical information provided by Qualcomm Inc. ("Qualcomm") in its October 30, 2012 *ex parte* submission ("*Ex Parte*") in this docket regarding its proposed secondary Next Generation Air-to-Ground Service ("Next-Gen AG") service in the 14-14.5 GHz band ("Ku-band").

Specifically, SIA updates its previous calculations provided to the Commission concerning the Rise over Thermal ("RoT") threshold into GSO FSS uplinks based on new information in the Qualcomm *Ex Parte*. The updated calculations again show that Qualcomm's Next-Gen AG service would cause excessive levels of interference to a significant number of operational satellites in the Ku-band. In addition, SIA provides a further technical analysis regarding the potential interference into Next-Gen AG receivers from VSAT station uplinks, demonstrating that the Next-Gen AG service would be subject to excessive levels of interference from VSATs operating in the Ku-band.

SIA reiterates its previously filed opposition to Qualcomm's Petition for Rulemaking to create the proposed Next-Gen AG service in the Ku-band for the reasons set forth in the attached *ex parte* written presentation, as well as in its previous filings in the docket. SIA again emphasizes that it is vitally important for the Commission to consider the potential for interference in both directions, *i.e.*, from the secondary into the primary service as well as from the primary into the secondary service. There is an inherent risk to the Commission's initial allocation decisions if a secondary service that is vulnerable to interference from primary services were to become widely deployed and then require interference protection at a later date.

A copy of this notice and attached *ex parte* written presentation are being emailed to the Federal Communications Commission staff identified below.

Please contact Patricia Cooper or Sam Black if you have any questions.

Respectfully submitted,

/s/
SATELLITE INDUSTRY ASSOCIATION

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Attachment
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Brian Butler, Office of Engineering and Technology

The Satellite Industry Association ("SIA") has reviewed Qualcomm's Ex Parte presentation dated October 30, 2012 (hereinafter referred to as the "Ex Parte") concerning the proposed operation of a Next Generation Air-to-Ground Service ("Next-Gen AG") in the 14 – 14.5 GHz band.[1] SIA provides below its comments concerning the information contained in Qualcomm's Ex Parte.

1) <u>Rise over Thermal ("RoT") Threshold into GSO FSS Uplinks</u>

In its Ex Parte, Qualcomm indicated that it computed the minimum Next-Gen AG ground station elevation angle using a 4/3 earth radius model and assuming that the aircraft was located at an altitude of 35,000 feet (10.7 kilometers) at a distance of 300 kilometers from the Next-Gen AG ground station.[2] In this regard, SIA has updated the RoT calculations that it had provided to the Commission as part of its October 22nd Ex Parte by using the aforementioned information provided by Qualcomm. Specifically, the RoTs were calculated for three scenarios: 1) the Next-Gen AG ground station elevation angle is 1°; 2) the Next-Gen AG ground station elevation angle is 1.5°; and 3) the number of cells with a Next-Gen AG ground station is increased to a maximum of 250.

In Exhibit 1, the average GSO satellite G/T value was calculated for each of the specified scenarios so as to achieve an RoT of 0.33%, 0.50% and 1%. For the analysis, it was assumed that the maximum EIRP density of the Next-Gen AG transmission toward the geostationary arc is 2.5 dBW/50 MHz.

As shown in Exhibit 1, for a minimum beam elevation angle of 1°, the average G/T of the GSO satellite must be less than 0.3, 2.1 and 5.1 dB/K in order for the RoT to be equal or less than 0.33%, 0.5% and 1%, respectively. Similarly, for a 250-ground-station architecture (corresponding to a minimum ground station beam elevation angle of 1.85°), the G/T of the GSO satellite must be less than -1.9, -0.1 and 2.9 dB/K in order for the RoT to be 0.33%, 0.5% and 1%.

In its October 22, 2012 Ex Parte, SIA had listed the satellites that provided CONUS service in the 14.0 – 14.5 GHz band within the 45° W.L. to 150° W.L. orbital arc. This information is provided again in Exhibit 2 for completeness. As can be seen from this

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[1] Qualcomm Incorporated, Written *Ex Parte* Presentation, RM-11640 (filed Oct. 30, 2012) ("Ex Parte").

[2] *Id*. at A1.

exhibit, the average G/T of satellites within this orbital arc ranges from -1 dB/K to 6 dB/K.

In updating the information provided by SIA as part of its October 22nd Ex Parte, the RoT was calculated for each of the three aforementioned Next-Gen AG architectures for a satellite having an average G/T of 6 dB/K using the updated Qualcomm data (see Exhibit 3). As shown in this exhibit, the predicted RoT continues to exceed the 1% threshold that Qualcomm favors – and which SIA opposes. For the 250 Next-Gen AG cell architecture, the EIRP density of each Next-Gen AG emission in the direction of the geostationary arc must be no greater than -5.4 dBW/50MHz in order for the RoT to be 0.33% for the satellite having an average G/T of 6 dB/K.

2) <u>Interference Into Next-Gen AG System From VSATs</u>

2.1. <u>Typical Satellite Saturated Flux Density ("SFD") Values Can Be Much Higher Than Those Assumed by Qualcomm</u>

In its July 7, 2011 Petition for Rulemaking and its September 11, 2012 Ex Parte, Qualcomm provided analysis of interference into its Next-Gen AG airborne receivers from FSS VSATs.[3] Qualcomm's analysis was predicated upon the assumption that a typical geostationary satellite transponder could be saturated with an aggregate EIRP of 70 dBW. Using this EIRP, the typical saturated flux density ("SFD") of a geostationary satellite, as assumed by Qualcomm, was calculated to be approximately (70 dBW – 163 dB/m^2 =) -93 dBW/m^2.

Exhibit 2 shows the minimum and maximum beam peak SFD values for geostationary satellites operating in the 45° W.L. to 150° W.L. orbital arc and providing CONUS service in the 14.0 – 14.5 GHz band. Additionally, for each satellite, the minimum and maximum SFD values at its average G/T contour has been provided. As can be seen from this exhibit, there is a wide range of SFD values at which a spacecraft can operate. For example at the average G/T contour, the SFD can vary anywhere from -57 dBW/m^2 to -117.1 dBW/m^2. The specific SFD value that is associated with a spacecraft transponder is primarily dependent on the level of adjacent satellite interference, the various types of carriers that are transmitted through the transponder, and the characteristics of each carrier. Accordingly, the SFD value Qualcomm has used in its

[3] Qualcomm Incorporated, *Petition for Rulemaking*, RM-11640, 17-18 and A-28-31 (filed July 7, 2011); Qualcomm Incorporated, Written *Ex Parte* Presentation, RM-11640, A4-5 (filed Sept. 11, 2012).

analysis to show that its Next-Gen AG ground-to-aircraft link can accommodate VSAT-to-airborne interference is not necessarily representative of the performance of operational satellites, as presented in Exhibit 2.

2.2. Typical VSAT Uplink Power Densities Are Higher Than Assumed by Qualcomm

With regard to the uplink power density level of VSAT carriers, Qualcomm indicated in its Ex Parte of September 11, 2012 that SIA's assumption that each VSAT carrier would operate at the maximum power density level permitted by the Commission in Section 25.212 of its rules (for routine licensing) was incorrect. According to Qualcomm, under such an operational scenario, the aggregate EIRP of all VSAT carriers being transmitted to a single satellite transponder would over-saturate/over-drive the transponder by approximately 18 dB (assuming that the SFD of a typical satellite was -93 dBW/m^2 and that the transponder is operated with 6 dB of input back-off, i.e., the effective flux density of a typical satellite transponder operating in a multi-carrier mode is -99 dBW/m^2).

As previously indicated by SIA, however, it is appropriate to assume that VSAT carrier uplinks are operating with the power density level specified in Section 25.212 (and Section 25.134) of the Commission's rules for the 14.0 – 14.5 GHz band because these are the applicable requirements. The calculations provided by SIA in its Ex Parte of August 31, 2011 and that of October 22, 2012 clearly lead to a flux density value that falls well within the ranges provided in Exhibit 2 even when an additional 6 dB input back-off is applied to these ranges to account for the multi-carrier mode of operation of a satellite transponder.

For the specific example described in SIA's Ex Parte of August 31, 2012, it was assumed that: 1) there were 743 VSATs that uplink simultaneously in a given 50 MHz segment within the 14.0 – 14.5 GHz band within the geographic area seen by a single receiving Next-Gen AG aircraft; 2) the bandwidth of a typical satellite transponder was 36 MHz; 3) there were 40 satellites operating within the domestic arc and utilizing the 14.0 – 14.5 GHz band; 4) $1/40^{th}$ of the number of (the 743) VSATs within the geographic area visible to a Next-Gen AG aircraft were transmitting to a single (36 MHz wide) transponder of a given satellite; 5) the area visible to a single receiving Next-Gen AG receiving aircraft operating at an altitude of 10 kilometer altitude is $1/20.2^{th}$ of the total area of the contiguous United States; and 6) each VSAT carrier was uplinked to the satellite with an EIRP of 56.2 dBW. With the above characteristics, the aggregate EIRP within two MHz of VSAT transmissions toward any given satellite within the area visible by a single receiving Next-Gen AG aircraft was computed (in SIA's Ex Parte of October 22, 2012) to be (56.2 dBW + 10Log[743] – 10Log[40] – 10Log[50/36] =) 67.5 dBW. Accordingly, the aggregate EIRP of all VSAT uplinks that operate within a given 50 MHz segment of the 14 – 14.5 GHz band and which are transmitted to the same satellite is (67.5 dBW + [10Log(20.2)]) = 80.6 dBW. This corresponds to a flux density (at the satellite) of (80.6 dBW – 163 dB =) -82.4 dBW/m^2. Using Qualcomm's assumption that when operating in multi-carrier mode, a satellite's transponder operates with at least 6 dB of input back-off, the saturated flux density of the satellite would be (-82.4 dBW/m^2 + 6 dB =) -76.4 dBW/m^2, which is within the SFD ranges provided in Exhibit 2 and would not imply oversaturation of a satellite's transponder.

2.3. Qualcomm's Calculations Underestimate the Interference to Next-Gen AG Aircraft Receivers

The calculations provided by SIA in Table 3 of its August 31, 2012 Ex Parte showed that the simultaneous uplink transmissions of 743 VSAT stations located within the field of view of a receiving Next-Gen AG aircraft would cause excessive levels of interference to the Next-Gen AG system. Given that in its calculations SIA incorporated the various antenna off-axis gain advantage factors used by Qualcomm in its July 7, 2011 submission, the interference should not be considered as short-term but rather as long-term interference.

As previously stated in its July 7, 2011 filing, Qualcomm assumed that the SFD necessary to saturate a typical GSO satellite transponder was -93 dBW/m^2. Qualcomm did not specify the satellite antenna gain contour to which this SFD value corresponded to, e.g., at beam peak, or at -2 dB relative to the beam peak, etc. If the assumption is that the -93 dBW/m^2 corresponds to an average G/T contour that is 2 dB below the beam peak, then the beam peak SFD of the satellite would be -95 dBW/m^2.

In its July 7th filing, Qualcomm also assumed that the typical VSAT (user) terminal uplink EIRP was 40 dBW. Qualcomm did not provide any data in support of this value.

As noted above, the specific SFD setting of any transponder is dependent on the adjacent satellite interference environment as well as the specific characteristics of the various carriers that are transmitted or expected to be transmitted through the transponder. In Table 1, below, the beam peak SFD values that were used for multi-carrier operation of a number of satellites listed in Exhibit 2 are provided as well as the associated VSAT (return link) carrier (400KG7W) uplink EIRP. The information contained in this figure was obtained from the FCC filing of the specific satellite listed.

Table 1

Satellite	FCC File Number	Beam Peak SFD For Multi-Carrier Operation of Transponder (dBW/m^2)	VSAT Terminal Uplink EIRP (dBW)
Galaxy 17	SAT-AMD-20070123-00013	-89.1	47.5
Galaxy 25	SAT-MOD-20080825-00159	-88.0 & -91.0	47.3 & 44.6
Galaxy 3C	SAT-AMD-20020111-00004	-87.5 & -83.4	Not Available
Galaxy 16	SAT-RPL-20051118-00233	-91.1	45.9
Galaxy 18	SAT-RPL-20070222-00035	-78.9 & -85.9	55.0
Horizons 1	SAT-PPL-20110211-00030	-86.0	49.0

As can be seen from the above table for the limited number of spacecraft considered, the beam peak SFD associated with multi-carrier operation varies greatly, ranging from -78.9 to -91.0 dBW/m^2. Moreover, the EIRP level of the VSAT (return link) carriers specified in these calculations is much higher than those assumed by Qualcomm. Further, these are 400 kHz carriers.

In summary, the SFD value assumed by Qualcomm is not typical. Such a low SFD would constrain the satellite operator to operate the transponder in an inefficient manner, when considering all the different carriers that the transponder has to potentially support in addition to VSATs. Additionally, the uplink EIRP level that Qualcomm has assumed for VSAT uplinks is low compared to the values listed in Table 1 above, which are typical values. The uplink EIRP levels assumed by Qualcomm would underestimate the level of interference that the Next-Gen AG system may be subjected to from the uplink transmissions of VSAT user terminals. The 40 dBW value assumed by Qualcomm is 4.6 to 15 dB lower than the EIRP levels in Table 1. Moreover, if the 40 dBW EIRP is associated with a two MHz carrier, the interfering VSAT levels are actually being underestimated by 11.6 to 22 dB, as the carriers in Table 1 have a 400 kHz bandwidth.

2.4. VSAT Interference to Next-Gen AG Aircraft Receiver is Not Short Term

Qualcomm has indicated in its previous submissions to the Commission in this proceeding that should its links experience excessive levels of interference, its service could continue to operate at a reduced capacity, presumably until such time that the transient or short-term interference condition is dissipated. However, as demonstrated by SIA in its August 31, 2011 Ex Parte, the level of interference that Next-Gen AG ground-to-air links would encounter from VSATs would not be short term in duration, but rather long term. Accordingly, the system would be forced to operate at reduced capacity on a long-term basis, which presumably is not the manner that Qualcomm intends to operate its system.

In its July 31, 2012 submission to the FCC, as well as in its September 11th and October 30, 2012 Ex Partes, Qualcomm indicated that in its network design it assumed that VSATs would typically use the ALOHA protocol and that any user (return) link would be active 10% of the time. Based on this activity factor, Qualcomm indicated that in the case where a two MHz (RA) transmission between the Next-Gen AG ground terminal and aircraft terminal is subjected to excessive levels of interference, the system is robust enough such that it would frequency hop to another (two MHz) frequency segment and retransmit the data packet until such time that it eventually finds a free/suitable two MHz band segment where the data packet is successfully received. With respect to interference from wider bandwidth FSS transmission, Qualcomm indicated that it could tolerate the loss of capacity – in its October 30th Ex Parte, Qualcomm stated that it could potentially tolerate a 30% reduction in capacity.

As indicated in SIA's Ex Parte of October 22, 2012, the 10% activity (or duty) factor assumed by Qualcomm for VSATs that use the ALOHA protocol does not take into account the cases where there are collision of transmission between two or more return links. Accordingly, the 10% duty factor is too low. More importantly, VSAT network architecture is not primarily predicated upon the ALOHA architecture. Specifically, many VSAT networks employ FDMA- and TDMA-based transmissions. In particular with regard to TDMA, the return link (as well as the forward link) is for all practical purposes continuously active. Indeed, several satellite operators have indicated that many of their VSAT customers use TDMA or FDMA rather than ALOHA. Hence, it would be incorrect to base interference calculations on the assumption that the ALOHA protocol is widely used by VSAT networks. In this respect, even the 25% activity factor used in deriving the number of VSATs that uplink simultaneously in a given 50 MHz segment within the geographic area seen by a single receiving Next-Gen AG aircraft

(743) may lead to an underestimated number. Therefore, even the SIA interference calculations may be underestimating the actual interference.

It is also worth noting that satellite Ku-band transponder utilization is close to saturation. According to the Northern Sky Research ("NSR") report "Global Assessment of Satellite Demand" of August 2012, 89% of on-orbit Ku-band transponder capacity with coverage of North America is in use. Given the heavy usage of on-orbit Ku-band transponder capacity, it would appear to be difficult for the Next-Gen AG system to easily identify a two MHz or larger band segment in the case that its transmissions are subjected to excessive levels of interference. Note in this respect that not all operating satellites would be using the exact same frequency segments (i.e. leaving a common frequency segment unused). Therefore, it is highly probable that there is no unused frequency segment in the 14.0 – 14.5 GHz band.

2.5 Carriers Other than VSATs Will Also Cause Interference to Next-Gen AG Aircraft Receivers

As previously stated, VSATs only comprise a portion of satellite transmissions; consequently, the level of interference that the Next-Gen AG air-to-ground link would encounter from non-VSAT communication links such as video and other SCPC carriers would exacerbate the interference environment beyond the levels calculated by SIA. Accordingly, a major issue centers on how much reduction in capacity Qualcomm is willing to accept, and whether the design of the Next-Gen AG system needs to be modified further in order to be consistent with such operation.

3. Conclusion

SIA has updated the results of its previous analysis concerning interference into a receiving Ku-band satellite from the Next-Gen AG ground-to-air transmissions, by using an Earth radius of 4/3 as recommended by Qualcomm. The updated calculations continue to show that a significant number of operational satellites would be subjected to excessive levels of interference from the Next-Gen AG system.

SIA has also demonstrated that the assumed carrier parameters used in the interference analysis contained in Table 3 of its August 31, 2011 Ex Parte, would not result in excessive levels of flux density at the satellite. Specifically, the calculated flux density is shown to be within the flux density range of satellites currently in orbit. Based upon the results of its interference analysis, SIA has demonstrated that the Qualcomm Next-Gen AG system would be subject to excessive levels of interference from VSATs that operate in the 14.0 – 14.5 GHz. The actual level is likely to be even higher than that calculated by SIA (TDMA/FDMA plus Aloha systems) and certainly higher than that calculated by Qualcomm.

In addition, it has been shown that interference would not be short-term in duration, but rather persist over the long term. Moreover, in view of the heavy usage of Ku-band satellite transponders in North America, it is unlikely that the Next-Gen AG system could operate at the nominal or even at the reduced capacity levels stipulated by Qualcomm.

Exhibit 1: Interference Calculations

Number of Next-GEN GS Cells	150.0	202.3	250.0
Ground Radius of Cell (km)	149.8	129.0	116.0
Area of Next-Gen GS Cell (km2)	58301.0	43234.6	34980.8
Aggregate Area of Next-Gen GS Cells (km2)	8745149.0	8745149.0	8745149.0
Aircraft Altitude (km)	10.7	10.7	10.7
Radius of Earth (km)	8504.2	8504.2	8504.2
Ground Distance Between Next-Gen GS and Aircraft (km)	299.6	258.0	232.1
Central Angle (ßo) -- (°)	2.0185	1.7382	1.5635
Central Angle (ßo) -- (radians)	0.0352	0.0303	0.0273
Slant Range Between Next-Gen GS and Aircraft (km)	300.0	258.4	232.5
Next-Gen AG GS Elevation Angle (radians)	0.0180	0.0261	0.0323
Next-Gen AG GS Elevation Angle (degrees)	1.03	1.50	1.85
Reference Bandwidth of Next-Gen GS (MHz)	50	50	50
Maximum EIRP Density of A Single Next-Gen GS Beam In The Direction of The Geostationary Arc (dBW/50 MHz)	2.5	2.5	2.5
Maximum EIRP Density of A Single Next-Gen GS Beam In The Direction of The Geostationary Arc (dBW/Hz)	-74.5	-74.5	-74.5
Number of Beams Per Next-Gen GS	4	4	4
Aggregate EIRP Density From All Next-Gen GS Cells In The Direction of Any Point on The Geostatioarny Arc (dBW/50 MHz)	30.3	31.6	32.5
Aggregate EIRP Density From All Next-Gen GS Cells In The Direction of Any Point on The Geostatioarny Arc (dBW/Hz)	-46.7	-45.4	-44.5
Average GSO FSS Satellite G/T Over CONUS (dB/K)	2	2	2
Polarization Discrimination (dB)	0	0	0
Path Loss @ 14 GHz (dB)	207	207	207
I/N (dB)	-23.1	-21.8	-20.9
I/N (%)	0.49	0.66	0.81

Average GSO Satellite G/T In Which The Next-Gen GS Interference Into GSO FSS Would Result In I/N of 0.33% (dB/K)	0.3	-0.1	-1.9
Average GSO Satellite G/T In Which The Next-Gen GS Interference Into GSO FSS Would Result In I/N of 0.50% (dB/K)	2.1	1.7	-0.1
Average GSO Satellite G/T In Which The Next-Gen GS Interference Into GSO FSS Would Result In I/N of 1.00% (dB/K)	5.1	4.7	2.9

Exhibit 2: GSO Satellites Within the 45° W.L - 150° W.L. Orbital Arc That Utilize The 14 – 14.5 GHz Frequency Band

Satellite	Nominal Orbital Location (° WL)	Beam Peak G/T (dB/K)	Beam Peak Minimum SFD (dBW/m²)	Beam Peak Maximum SFD (dBW/m²)	Edge of Coverage Relative Gain Contour Below Beam Peak (dB)	Assumed Average Relative Gain Contour Below Beam Peak (dB)	Assumed Average G/T (dB/K)	Minimum SFD At Average G/T Contour (dBW/m²)	Maximum SFD At Average G/T Contour (dBW/m²)
Horizons 1	127	5.3	-106.3	-76.3	4.0	2.0	3.3	-104.3	-74.3
AMC-21	125	8.2	-101.2	-81.2	6.0	3.0	5.2	-98.2	-78.2
Galaxy 18	123	8.3	-107.9	-76.9	8.0	4.0	4.3	-103.9	-72.9
Echostar 9	121	Unknown	Unknown	Unknown	-	-	-	Unknown	Unknown
Anik F3	118.7	9.3	-103.7	-83.7	8	4	5.3	-99.7	-79.7
Satmex 5	116.8	Unknown	Unknown	Unknown	-	-	-	Unknown	Unknown
Satmex 6	113	6.0	-96.0	-60.0	6.0	3.0	3.0	-93.0	-57.0
Anik F2	111.1	8.6	-95.6	-65.6	10.0	5.0	3.6	-90.6	-60.6
Anik F1R	107.3	8.9	-106	-86	9.0	4.5	4.4	-101.5	-81.5
Anik F1	107.3	Unknown	Unknown	Unknown	-	-	-	Unknown	Unknown
AMC-15	105.05	5.4	-98.4	-80.4	4.0	2.0	3.4	-96.4	-78.4
SES-3	103	Unknown	Unknown	Unknown	-	-	-	Unknown	Unknown
AMC-1	103	6.7	-98.6	Unknown	9.7	4.8	1.9	-93.8	Unknown
SES-1	101	7.0	-100	-79	5.0	2.5	4.5	-97.5	-76.5
Galaxy 16	99	6.1	-104.1	-73.1	5.0	2.5	3.6	-101.6	-70.6
Galaxy 19	97	4.5	-96.0	-75.0	2.0	1.0	3.5	-95.0	-74.0
Galaxy 3C	95.05	5.3	-106.3	-76.3	4.0	2.0	2.5	-104.3	-74.3
Galaxy 25	93.1	2.7	-98.0	-77.0	2.0	1.0	1.7	-97.0	-76.0
Galaxy 17	91	7.1	-119.1	-72.1	4.0	2.0	5.1	-117.1	-70.1
Galaxy 28	89	5.0(4)	-100.6(4)	-79.6(4)	3.0	1.5	3.5	-99.1	-78.1
SES-2	87	8.0	-102.0	-81.0	4.0	2.0	6.0	-100.0	-79.0
AMC-16	85	5.6	-98.6	-80.6	4.0	2.0	3.6	-96.6	-78.6
AMC-9	83	4.8	Unknown	Unknown	3.0	1.5	3.3	Unknown	Unknown

Exhibit 2: GSO Satellites Within the 45° W.L - 150° W.L. Orbital Arc That Utilize The 14 – 14.5 GHz Frequency Band (continued)

Satellite	Nominal Orbital Location (° WL)	Beam Peak G/T (dB/K)	Beam Peak Minimum SFD (dBW/m²)	Beam Peak Maximum SFD (dBW/m²)	Edge of Coverage Relative Gain Contour Below Beam Peak (dB)	Assumed Average Relative Gain Contour Below Beam Peak (dB)	Assumed Average G/T (dB/K)	Minimum SFD At Average G/T Contour (dBW/m²)	Maximum SFD At Average G/T Contour (dBW/m²)
AMC-5	81	7.7	-104.3	-83.3	4.0	2.0	5.7	-102.3	-81.3
AMC-6	72	6.0	-100.0	-82.0	4.0	2.0	4.0	-98.0	-80.0
Telstar 14R	63	5.9	-102.9	-82.9	2.0	1.0	4.9	-101.9	-81.9
Amazonas-1	61	1.0(5)	Unknown	Unknown	3.0(6)	1.5	-0.5	Unknown	Unknown
Amazonas-2	61	6.7	-98.7	-80.7	3.0(6)	1.5	5.2	-97.2	-79.2
Intelsat 9	58	0.0	-93.1	-77.1	2.0	1.0	-1.0	-92.1	-76.1

Notes:

1) Data obtained from www.lyngsat.com.
2) Only those satellites having non-steerable beams in the 14 – 14.5 GHz band that provided approximately 70% or greater coverage of CONUS are listed.
3) Beam peak G/T and SFD values obtained from FCC filings of the spacecraft unless otherwise noted.
4) FCC filed data could not be found. Specified values obtained from Intelsat's Technical Users Guide.
5) Data obtained from http://www.tbs-satellite.com/tse/online/REG/main_index.html.
6) Uplink coverage pattern not available. Listed value is an assumed value.

Exhibit 3: Interference From Next-Gen AG Ground Stations Into A Receiving Satellite Having An Average G/T of 6 dB Within Its Coverage Area

Number of Next-GEN GS Cells	150.0	202.3	250.0
Ground Radius of Cell (km)	149.8	129.0	116.0
Area of Next-Gen GS Cell (km2) see note	58301.0	43234.6	34980.8
Aggregate Area of Next-Gen GS Cells (km2)	8745149.0	8745149.0	8745149.0
Aircraft Altitude (km)	10.7	10.7	10.7
Radius of Earth (km)	8504.2	8504.2	8504.2
Ground Distance Between Next-Gen GS and Aircraft (km)	299.6	258.0	232.1
Central Angle (ßo) -- (°)	2.0185	1.7382	1.5635
Central Angle (ßo) -- (radians)	0.0352	0.0303	0.0273
Slant Range Between Next-Gen GS and Aircraft (km)	300.0	258.4	232.5
Next-Gen AG GS Elevation Angle (radians)	0.0180	0.0261	0.0323
Next-Gen AG GS Elevation Angle (degrees)	1.03	1.50	1.85
Reference Bandwidth of Next-Gen GS (MHz)	50	50	50
Maximum EIRP Density of A Single Next-Gen GS Beam In The Direction of The Geostationary Arc (dBW/50 MHz)	2.5	2.5	2.5
Maximum EIRP Density of A Single Next-Gen GS Beam In The Direction of The Geostationary Arc (dBW/Hz)	-74.5	-74.5	-74.5
Number of Beams Per Next-Gen GS	4	4	4
Aggregate EIRP Density From All Next-Gen GS Cells In The Direction of Any Point on The Geostationary Arc (dBW/50 MHz)	30.3	31.6	32.5
Aggregate EIRP Density From All Next-Gen GS Cells In The Direction of Any Point on The Geostationary Arc (dBW/Hz)	-46.7	-45.4	-44.5
Average GSO FSS Satellite G/T Over CONUS (dB/K)	6	6	6
Polarization Discrimination (dB)	0	0	0
Path Loss @ 14 GHz (dB)	207	207	207
I/N (dB)	-19.1	-17.8	-16.9
I/N (%)	1.23	1.66	2.05