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

In the Matter of	)	
	)	
SES AMERICOM, INC.	)	File No. SAT-MOD-___________
	)	Call Sign S2445
Application for Modification of AMC-1	)	
Fixed-Satellite Space Station License	)	

APPLICATION OF SES AMERICOM, INC.

SES Americom, Inc. ("SES Americom," doing business as "SES") respectfully requests a modification of its license for the AMC-1 fixed-satellite space station to reassign the spacecraft to 47.5° W.L. with an east-west stationkeeping tolerance of +/- 0.15 degrees. At that location, AMC-1 will be co-located with the NSS-806 satellite operated by SES Americom's affiliate New Skies Satellites B.V. ("New Skies"). New Skies intends to file a separate application to modify the terms of its U.S. market access for NSS-806 to permit both satellites to be flown within the same 47.5° W.L. +/-0.15 degrees box. SES requests authority to perform Telemetry, Tracking and Command ("TT&C") using certain C-band and Ku-band frequencies in order to relocate AMC-1 from 103º W.L. to 47.5° W.L., and authority to operate both the TT&C and Ku-band communications payloads on AMC-1 after it has arrived. SES will operate AMC-1 at 47.5° W.L. in accordance with the International Telecommunication Union ("ITU") filings and coordination agreements of the Netherlands Administration. Grant of the requested authority will serve the public interest by allowing SES to use AMC-1 to respond to customer demand and expand the services available from 47.5° W.L.

A completed FCC Form 312 is attached, and SES incorporates by reference the information previously provided in support of AMC-1.[1] In addition, SES is providing here technical information relating to the proposed modification to the AMC-1 license in Schedule S and in narrative form pursuant to Section 25.114 of the Commission's Rules.

MODIFICATION

AMC-1 is a hybrid C/Ku-band satellite that is currently licensed by the FCC to operate at 103° W.L., with a license term that currently expires October 15, 2016.[2] The replacement for AMC-1, the SES-3 satellite, is in position and ready to begin operations at 103° W.L.[3] Following the transfer of traffic from AMC-1 to SES-3, SES proposes to relocate AMC-1 to 47.5° W.L., where it will operate under the ITU satellite network filings of the Netherlands Administration.

Relocation Authority. Grant of the requested authority to relocate and operate AMC-1 will serve the public interest and is consistent with Commission precedent. The Commission has repeatedly observed that its policy is to allow "satellite operators to rearrange satellites in their fleet to reflect business and customer considerations where no public interest factors are adversely affected."[4] As the International Bureau has explained:

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[1] *See* File Nos. SAT-MOD-20110718-00130; SAT-MOD-19930805-00031; & SAT-MOD-19911114-00033.

[2] *See SES Americom, Inc.*, File No. SAT-MOD-20110718-00130, grant-stamped Oct. 13, 2012 (the "AMC-1 Modification Grant").

[3] *See* File Nos. SAT-RPL-20121228-00227 & SAT-AMD-20131113-00132, Call Sign S2892.

[4] *SES Americom, Inc.*, Order and Authorization, DA 06-757 (IB rel. Apr. 7, 2006) at 4, ¶ 8, *citing Amendment of the Commission's Space Station Licensing Rules and Policies,* Second Report and Order, 18 FCC Rcd 12507, 12509, ¶ 7 (2003).

> the Commission attempts, when possible, to leave spacecraft design decisions to the space station licensee because the licensee is in a better position to determine how to tailor its system to meet the particular needs of its customers. Consequently the Commission will generally grant a licensee's request to modify its system, provided there are no compelling countervailing public interest considerations.[5]

Here, the proposed change will allow SES to make efficient use of AMC-1 in order to expand the available capacity at 47.5° W.L. At that location, AMC-1 will provide Ku-band coverage of the North Atlantic to supplement the service being provided by the C/Ku-band NSS-806 spacecraft. SES will coordinate internally to ensure compatibility of Ku-band operations between AMC-1, NSS-703 and NSS-806, as appropriate.

Reassignment of AMC-1 to 47.5º W.L. will not adversely affect other operators. SES will operate only the TT&C frequencies of AMC-1 during the drift. SES will follow standard industry practices for coordination of TT&C transmissions during the relocation process.

Proposed Operations at 47.5º W.L.: At the 47.5° W.L. orbital location, SES will operate AMC-1 under Netherlands ITU satellite network filings and coordination agreements. The Technical Appendix demonstrates that the AMC-1 network is compliant with Commission rules for operation in a two-degree spacing environment and is compatible with co-frequency satellites adjacent to the 47.5º W.L. orbital location.

Co-location of AMC-1 and NSS-806: As explained in the Technical Appendix, SES plans to operate both AMC-1 and NSS-806 within the same 47.5° W.L. +/- 0.15 degrees east-west station keeping box. As noted above, SES intends to file for a modification of its U.S. market access authority for NSS-806 to permit such co-location. The proposed stationkeeping

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5 *AMSC Subsidiary Corp.*, Order and Authorization, DA 98-493, 13 FCC Rcd 12316 (IB 1998) at 12318, ¶ 8 (footnote omitted).

volume for AMC-1 and NSS-806 will not overlap with the stationkeeping volume of any other spacecraft.[6] This relaxed stationkeeping tolerance will enable both spacecraft to be operated safely while conserving fuel for future operations. SES herein seeks a waiver of Section 25.210(j) of the Commission's rules to permit AMC-1 to operate with a +/- 0.15 degree stationkeeping tolerance at 47.5º W.L.

WAIVER REQUESTS

SES requests limited waivers of the Commission's requirements in connection with the instant modification application. Grant of the waivers is consistent with Commission policy:

> The Commission may waive a rule for good cause shown. Waiver is appropriate if special circumstances warrant a deviation from the general rule and such deviation would better serve the public interest than would strict adherence to the general rule. Generally, the Commission may grant a waiver of its rules in a particular case if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.[7]

Section 25.114(d)(3): SES requests a limited waiver of Section 25.114(d)(3) of the Commission's rules. That provision requires submission of predicted antenna gain contours for each transmit and receive antenna beam. The rule as revised in the Part 25 reform proceeding specifies that for geostationary orbit satellites, the information must be provided either in a .gxt format or in GIMS container files. As discussed in Section 4 of the Technical Appendix, SES has provided antenna gain information in the .gxt format except with respect to the global horn antenna. For that antenna, gain versus off-set angle information is provided as a figure in

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[6] *See* Technical Appendix at Section 8.

[7] *PanAmSat Licensee Corp*., 17 FCC Rcd10483, 10492 (Sat. Div. 2002) (footnotes omitted).

Annex A to the Technical Appendix because the .gxt data is not available from the spacecraft manufacturer.

The Commission has previously waived the requirements of Section 25.114(d)(3) in similar factual circumstances.[8] In acting on these requests, the Commission recognized that the purpose of the rule is to ensure that adequate information is available to allow evaluation of the potential for harmful interference.[9] Here, in lieu of the single .gxt file that cannot be provided, SES has submitted alternative data sufficient to permit the Commission and any interested party to evaluate the antenna's interference potential. Accordingly, SES requests that the Commission grant a limited waiver of Section 25.114(d)(3).

Section 25.202(g): SES also requests any necessary waiver of Section 25.202(g) of the Commission's rules. That rule provides that "[t]elemetry, tracking and telecommand functions for U.S. domestic satellites shall be conducted at either or both edges of the allocated band(s)."[10] The Commission has explained that:

> The purpose of this rule is to simplify the coordination process for satellite systems, to provide an incentive for an operator to maximize the efficiency of its system's TT&C operations, and to minimize the constraints placed on other satellite operations.[11]

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[8] *See, e.g.*, *SES Americom, Inc.*, File No. SAT-MOD-20120524-00087, grant-stamped July 25, 2012, Attachment at ¶ 5 (waiving Section 25.114(d)(3) with respect to AMC-2 global horn antenna); *PanAmSat Licensee Corp*., File No. SAT-RPL-20061219-00155, grant stamp dated April 24, 2007 ("*Galaxy 17 Grant*") at ¶ 5 (waiving Section 25.114(d)(3) to allow submission of gain information for omni antenna in non-.gxt format where manufacturer did not provide .gxt data); *see also Spectrum Five*, *LLC*, Order and Authorization, DA 06-2439, 21 FCC Rcd 14023, 14033 at ¶ 17 (IB 2006) (conditionally accepting antenna gain information not filed in .gxt format).

[9] *Galaxy 17 Grant* at n.5.

[10] 47 C.F.R. § 25.202(g).

[11] *Orbcomm License Corp*., 23 FCC Rcd 4804 at ¶ 20 (IB & OET 2008).

Here, SES does not propose to operate the AMC-1 C-band communications payload while the spacecraft is located at 47.5º W.L., but does propose to use limited C-band frequencies for TT&C. SES submits that this configuration conforms to Section 25.202(g), which does not require TT&C to be conducted in a space station's active operating bands but simply in "either or both ends of the allocated bands for the service."[12] SES's intention to perform TT&C functions at the edge of the C-band, which is allocated for FSS service and for which AMC-1 has been licensed, is therefore consistent with the plain language of Section 25.202(g).[13]

SES is aware, however, that in some decisions the Commission has characterized Section 25.202(g) as requiring "FSS systems to operate their tracking, telemetry, and command (TT&C) links at the edges of the frequency bands *in which they are providing service*."[14] Accordingly, SES requests grant of any necessary waiver of Section 25.202(g) to allow use of AMC-1 C-band channels for TT&C at 47.5º W.L.

Grant of a waiver will not undermine the objectives of the rule, which include facilitating coordination, avoiding undue constraints on other satellite operations, and ensuring efficient use of spectrum for TT&C. As discussed in the Technical Appendix, the proposed AMC-1 TT&C operations in the C-band are compatible with adjacent C-band spacecraft and will

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12 *DIRECTV Enterprises, LLC*, DA 06-1493, 21 FCC Rcd 8028 (Sat. Div. 2006) at ¶ 11.

13 It is also consistent with the Commission's prior action in a similar factual scenario involving the AMC-2 spacecraft. Specifically, the Commission authorized SES to use C-band channels for TT&C during interim operations of AMC-2 at 105º W.L. but did not authorize use of the spacecraft's C- band communications payload. *See SES Americom, Inc.*, DA 03-2197, 18 FCC Rcd 13143 (Sat. Div. 2003). There is no suggestion in that decision that the use of C-band for TT&C only required a waiver of Section 25.202(g).

14 *See, e.g., Northrop Grumman Space & Mission Systems Corp.*, DA 09-428, 24 FCC Rcd 2330 (IB 2009) at ¶ 94 (emphasis added).

be individually coordinated consistent with industry practice. Thus, no concerns about coordination or constraining other satellite operations are raised here.[15] Furthermore, AMC-1 was designed to operate with both service links and TT&C functions in the C-band. As a result, SES had every incentive to ensure that the AMC-1 TT&C subsystem uses spectrum efficiently, and grant of a waiver now will not impair that efficiency.

Grant of a waiver will also serve the public interest. By allowing SES to use diverse TT&C frequencies, the waiver will enhance the reliability of TT&C functions, facilitating the safe operation of AMC-1 at 47.5º W.L.

Section 25.210(j): Section 25.210(j) specifies that geostationary space stations "must be maintained within 0.05º of their assigned orbital longitude in the east/west direction, unless specifically authorized by the Commission to operate with a different longitudinal tolerance."[16] Here, SES is seeking authority to operate AMC-1 together with NSS-806 in an expanded stationkeeping box of +/- 0.15°. The Commission has previously waived Section 25.210(j) based on a finding that allowing an increased stationkeeping volume would "not adversely affect the operations of other spacecraft, and would conserve fuel for future operations."[17] For example, SES was granted waivers of this rule to allow AMC-2 and AMC-4 to operate together at 100.95° W.L. within a total east-west stationkeeping range of

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15 *See, e.g.*, *INTELSAT LLC*, FCC 00-287, 15 FCC Rcd 15460 (2000) at ¶¶ 95-100 (granting a waiver of § 25.202(g) where TT&C operations were already coordinated with adjacent operators).

16 47 C.F.R. § 25.210(j).

17 *See, e.g., SES Americom, Inc. Application for Modification of Satcom SN-4 Fixed Satellite Space Station License*, 20 FCC Rcd 11542, 11545 (Sat. Div. 2005).

0.15 degrees[18] and subsequently to permit AMC-2 and AMC-5 to operate together at 80.85° W.L. within a total east-west stationkeeping range of 0.15 degrees.[19]

The facts here fit squarely within this precedent. As discussed above, allowing AMC-1 to be maintained within an increased stationkeeping volume together with NSS-806 will not harm other operators. AMC-1's stationkeeping volume will not overlap with that of any other satellites except for NSS-806. Allowing AMC-1 and NSS-806 to be flown at 47.5° W.L. in an expanded east-west stationkeeping volume of +/-0.15 degrees will facilitate safe co-location of the satellites and help conserve fuel for the spacecraft. SES and its affiliates have significant experience in flying multiple spacecraft in close formation and will carefully control the two satellites to ensure their safe joint operation. Under these circumstances, grant of any necessary waiver of Section 25.210(j) will serve the public interest.

Other Waivers: The Commission has previously granted waivers of Sections 25.114(d)(14) and 25.283(c) in connection with the inability of the AMC-1 spacecraft to vent all stored energy at the end of the spacecraft's life.[20]

As noted in Section 2 of the attached Technical Appendix and consistent with the policy announced in an International Bureau public notice issued earlier this year,[21] SES requests a limited waiver of Section 25.114(c)(4) to the extent it requires submission of information that the Commission has deemed unnecessary. Pursuant to the terms of that public notice, SES has

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18 *See* File Nos. SAT-MOD-20080124-00030, SAT-AMD-20080311-00070, grant-stamped May 19, 2008, Attachment at ¶ 1.

19 *See* File No. SAT-MOD-20130225-00024, grant-stamped May 9, 2013, Attachment at ¶ 7; File No. SAT-MOD-20130325-00054, grant-stamped June 4, 2013, Attachment at ¶ 3.

20 *See* AMC-1 Modification Grant, Attachment to Grant at ¶ 2.

21 *See* Public Notice, International Bureau Adopts Policy of Granting Interim Waiver of Certain Requirements for Space Station Applications, DA 14-90 (Jan. 28, 2014).

omitted certain data elements from the attached Schedule S, or where necessary to permit validation of the Schedule S file, has entered a "1" as a placeholder.[22] The International Bureau has determined that there is good cause to waive rule provisions requiring submission of these data elements and that omission of this data will not be deemed grounds for dismissal.[23]

CONCLUSION

For the foregoing reasons, SES seeks a modification of the AMC-1 license to reassign the spacecraft to 47.5° W.L. +/- 0.15 degrees, as described in the attached materials.

Respectfully submitted,

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22 *See id*. at 2 n.6 (instructing applicants to enter a "1" in data fields that cannot be left blank using the Schedule S software). The public notice refers specifically to Table S7, columns q and r, and Table S10, column b as places where a "1" would need to be entered for validation purposes, but SES found that the software also required entry of a "1" in columns k, l, and n of Table S7. SES specifies that these "1" data entries are outside the scope of the certifications herein regarding accuracy of the information provided with this modification application. *See id.*

23 *See id*. at 1.

TECHNICAL APPENDIX

AMC-1 AT 47.5° W.L.

1.0 Overall Description (§25.114(d)(1))

This technical appendix is submitted in support of the modification application of SES Americom, Inc. ("SES Americom" doing business as SES) seeking reassignment of AMC-1 to 47.5° W.L. from its current orbital position of 103.0º W.L. SES hereby incorporates by reference the technical information it has already provided with respect to AMC-1,[1] and provides here technical information relating to operation of AMC-1 at 47.5° W.L. consistent with the proposed modification.

AMC-1 is equipped with twenty-four 36 MHz C-band transponders and twenty-four 36 MHz Ku-band transponders. At 47.5° W.L., the spacecraft's Ku-band transponders will provide coverage of the North Atlantic. The C-band transponders will not be used at 47.5° W.L. The TT&C frequencies of AMC-1 are in C-band with a beacon in Ku-band.

2.0 Schedule S (§25.114(c))

The Schedule S database is included with this filing. This section describes the main elements of the Schedule S relating to the proposed operation of AMC-1 at 47.5° W.L., considering that no previous Schedule S has been submitted for this spacecraft, and addresses some items not covered in the Schedule S. As noted in the narrative section of this modification application, the Schedule S does not contain the information for which the requirement was waived in Table A of Public Notice DA 14-90 dated 28 January 2014.

1. *Transponder frequency plan.* AMC-1 is equipped with twenty-four 36 MHz C-band transponders and twenty-four 36 MHz Ku-band transponders. Both the C-band and Ku-band transponders have a staggered transponder plan with the odd transponders having

[1] The original application for the AMC-1 satellite (then called Satcom H-1) was filed in 1987 (File No. 6012-DSS-P/LA-87), and information regarding reassignment of the satellite (then called GE-1) to 103° W.L. was submitted in 1993 (File No. 54-DSS-MP/ML-93). More recently, the SES application to extend the license term for AMC-1 (IBFS File No. SAT-MOD-20110718-00130) included a complete orbital debris mitigation statement for the satellite.

the linear vertical polarization in the Earth-to-space direction, and having the linear horizontal polarization in the space-to-Earth direction. The Ku-band transponders have a 26° polarization shift away from nominal linear 0° and 90° polarizations.[2]

2. *Telemetry and Telecommand (TT&C) frequencies and beams.* The TT&C link budgets are included in the Schedule S. The communications antenna ("CRV") is used for receiving C-band telecommand carriers. The communications antennas ("CTH", "CTV", and "KTH") are used for transmitting telemetry carriers. Table 1 below shows the TT&C carrier center frequencies and bandwidths.

Table 1: TT&C Carrier Frequencies

	Frequency, MHz	Nominal polarization
Command carriers (bandwidth: 800KHz, 1.2 MHz capture range)		
C-band	6423.5	V
Beacons/Telemetry (bandwidth: 300 KHz)		
C-band pair	3700.5	V
	4199.5	H
Ku-band	12198	H

Note: C-band telemetry carriers can also be transmitted through the horn antenna (in this case, the 4199.5 MHz carrier is vertically polarized) or an omni antenna (in this case, the 3700.5 MHz is horizontally polarized). The C-band telecommand carrier can also be received through the horn antenna (in this case, the 6423.5 MHz is horizontally polarized) or an omni antenna.

3. *PFD limits in C-band.* The C-band PFD values are provided in Section S8 of Schedule S, and Section 3.0 below (Table 2) demonstrates that these values comply with §25.208.

4. *Conversion of G/T values to Saturation Flux Density values.* No change.

5. *Transponder frequency response of C- and Ku-transponder*. No change.

[2] *See GTE Spacenet Corp. and GE American Communications, Inc.*, 9 FCC Rcd 1271, 1273-74 (Com. Car. Bur. 1994).

6. *Carrier parameters and link budgets.* The carrier parameters and link budgets as displayed in Sections S11 and S13 have been updated based on the planned operations of AMC-1 at 47.5° W.L. C-band link budgets are not provided, except for TT&C, as the C-band communications payload is not planned to be used.
7. *Beam diagrams.* The attached beam diagrams in Section S8 have been updated to reflect the projected coverage areas at 47.5° W.L.
8. *TT&C Station Locations.* Information is provided in Section S14 regarding the TT&C earth stations in the United States that will be used with AMC-1 at 47.5° W.L.

3.0 PFD limits (§25.114(d)(5) and §25.208)

Table 2 demonstrates that the PFD values for the C-band carriers from AMC-1 at 47.5° W.L. comply with §25.208.

Table 2: Maximum PFD values and margins relative to permissible limits of §25.208

Beam: CTV				
Elevation angle (°)	Max. EIRP density (dBW/4 kHz)	Max. PFD (dBW/m^2-4 kHz)	Permissible PFD (dBW/m^2-4 kHz)	Margin (dB)
5	-5.3	-168.5	-152.0	16.5
10	-5.2	-168.3	-149.5	18.8
15	-4.9	-167.9	-147.0	20.9
20	-4.6	-167.5	-144.5	23.0
25	-4.3	-167.1	-142.0	25.1

Beam: CTH				
Elevation angle (°)	Max. EIRP density (dBW/4 kHz)	Max. PFD (dBW/m^2-4 kHz)	Permissible PFD (dBW/m^2-4 kHz)	Margin (dB)
5	-5.2	-168.4	-152.0	16.4
10	-5.1	-168.2	-149.5	18.7
15	-4.8	-167.8	-147.0	20.8
20	-4.5	-167.4	-144.5	22.9
25	-4.1	-166.9	-142.0	24.9

Beam: GBLTV				
Elevation angle (°)	Max. EIRP density (dBW/4 kHz)	Max. PFD (dBW/m^2-4 kHz)	Permissible PFD (dBW/m^2-4 kHz)	Margin (dB)
5	-7.0	-170.3	-152.0	18.3
10	-7.0	-170.2	-149.5	20.7
15	-7.0	-170.0	-147.0	23.0
20	-7.0	-169.9	-144.5	25.4
25	-7.0	-169.8	-142.0	27.8

No PFD limits for the 11700 – 12200 MHz band are specified in **§**25.208 or in No. 21.16 of the ITU Radio Regulations with respect to the operation of geostationary satellites.

4.0 Satellite Antenna Gain Contours (§25.114(d)(3))

Annex A shows the typical antenna gain contours for the AMC-1 space station beams. The peak EIRP and G/T values of the beams are shown in Table 3.

Table 3: Maximum EIRP and G/T

Beam ID	Band	Pol	Link Direction	GXT filename	Max. EIRP (dBW)	Max. G/T (dB/K)
KRV	Ku	V	Receive	AMC-1 (47.5W) GIMS.mdb		7.2
KRH	Ku	H	Receive	AMC-1 (47.5W) GIMS.mdb		6.6
CRV	C	V	Receive	AMC-1 (47.5W) GIMS.mdb		5.5
KTV	Ku	V	Transmit	AMC-1 (47.5W) GIMS.mdb	50.4	
KTH	Ku	H	Transmit	AMC-1 (47.5W) GIMS.mdb	49.8	
CTV	C	V	Transmit	AMC-1 (47.5W) GIMS.mdb	15	
CTH	C	H	Transmit	AMC-1 (47.5W) GIMS.mdb	15	

The gain characteristics for the global horn antenna ("GBLRH") and ("GBLTV") are not provided as a GXT file because the GXT data is not available from the spacecraft manufacturer. Instead, gain vs. off-set angle information is provided as Figure A-8 in Annex A. SES requests a waiver to permit this substitution. As discussed in the narrative section of this modification application, grant of the requested waiver is consistent with Commission precedent.

5.0 Emission Designators and Link Budgets (§25.114(d)(4))

Annex B shows typical link budgets, including emission designators. Further carrier details and the link budgets are included in the Schedule S, Section S13. C-band link budgets, except for TT&C, are not provided as the C-band communications payload is not planned to be operated.

6.0 Maximum Theoretical Operation Levels

AMC-1 will be operated consistent with coordination agreements with adjacent satellites. In any case, in the 11.7-12.2 GHz band, the downlink EIRP density of the AMC-1 digital carriers will not exceed -19 dBW/Hz; and in the 14-14.5 GHz band, the input power density of the uplink digital carriers of earth stations operating with AMC-1 will not exceed -45 dBW/Hz.

7.0 Two Degree Spacing Analysis (§25.114(d)(7) and §25.140(b)(2))

Annex C provides analyses demonstrating the compatibility of AMC-1 at 47.5° W.L. with neighboring spacecraft.

8.0 Mitigation of Orbital Debris (§25.114(d)(14))

The information required under §25.114(d)(14) of the Commission's Rules is already on file with the Commission and is incorporated by reference herein.[3] The only change to that information is that SES proposes to move AMC-1 to 47.5° W.L. and co-locate it within the same 47.5° W.L. ±0.15° east/west stationkeeping control box with the NSS-806 satellite operated by New Skies Satellites B.V. using the proven Inclination-Eccentricity (I-E) separation method to ensure safe stationkeeping. SES has used this strategy successfully in the past to ensure proper operation and safety of multiple satellites within the same orbital box (most recently, in the case of AMC-2 and AMC-5 at 80.85° W.L. ±0.15°). At 47.5° W.L., AMC-1 will be in inclined orbit, but NSS-806 will remain stationkept in the North/South direction.

Other than the NSS-806 spacecraft operated by SES, SES Americom is not aware of any other FCC- or non-FCC licensed spacecraft that are operational or planned to be deployed at 47.5° W.L. or to nearby orbital locations such that there would be an overlap with the requested stationkeeping volume of AMC-1.

[3] *See* File No. SAT-MOD-20110718-00130, Technical Appendix, Section 3.

ANNEX A

Space Station Antenna Beam Diagrams

Figure A-1
Receive Beam: KRV
Ku-band, V-pol, Peak Gain: 34.1 dBi, Peak G/T = 7.2 dB/K

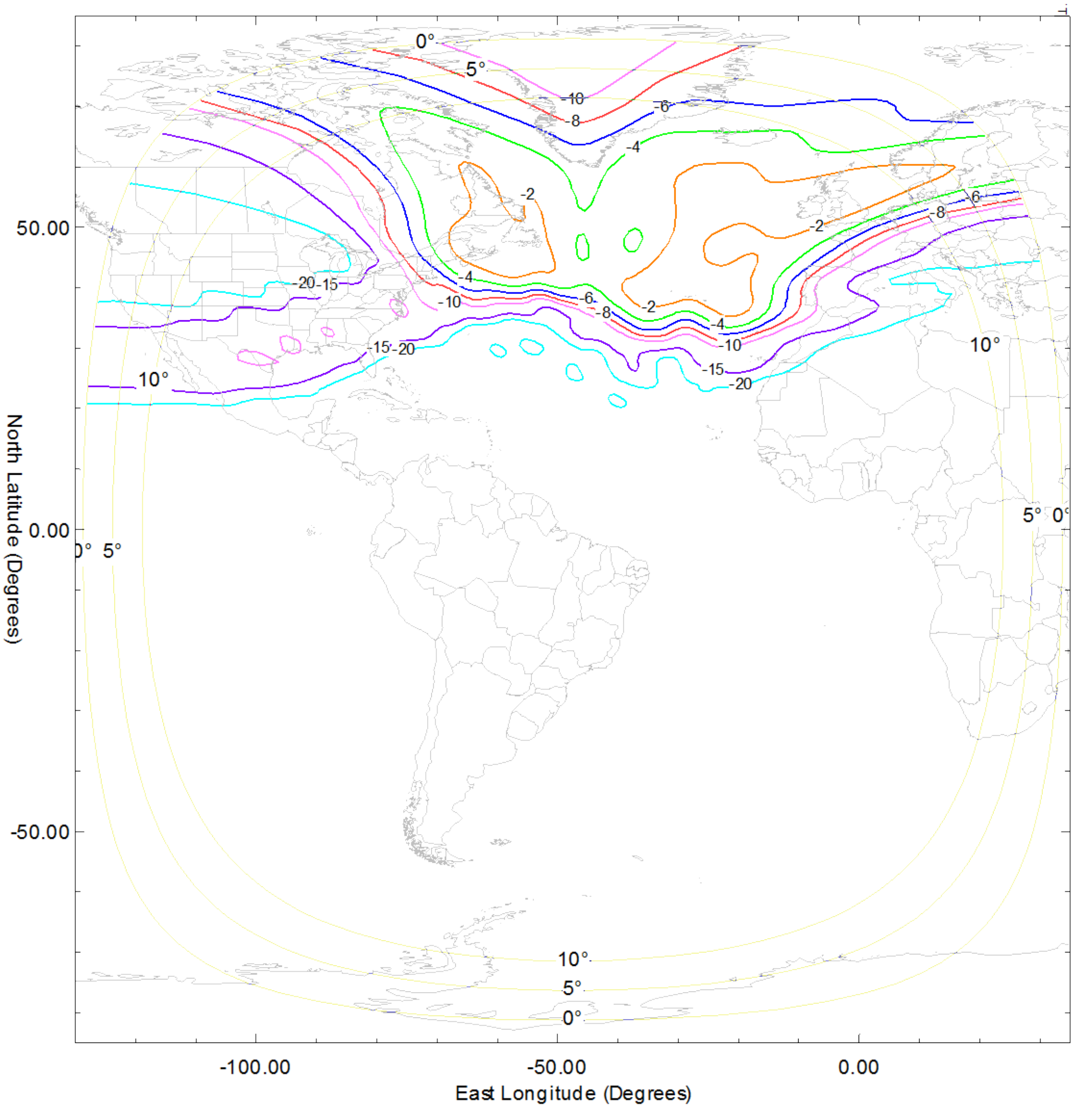

Figure A-2
Receive Beam: KRH
Ku-band, H-pol, Peak Gain: 34.2 dBi, Peak G/T = 6.6 dB/K

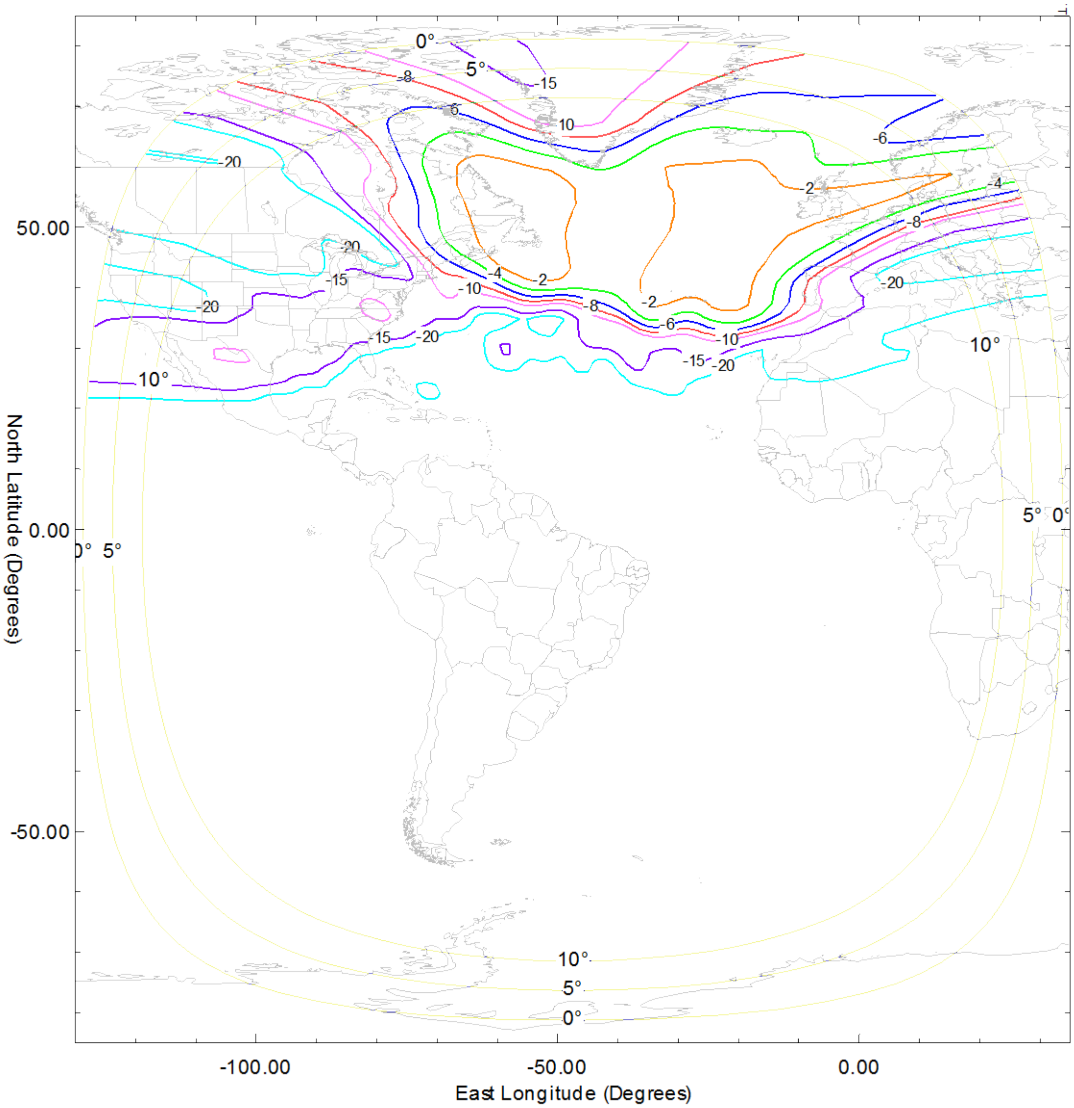

Figure A-3
Transmit Beam: KTV
Ku-band, V-pol, Peak Gain: 33.9 dBi, Peak EIRP = 50.4 dBW

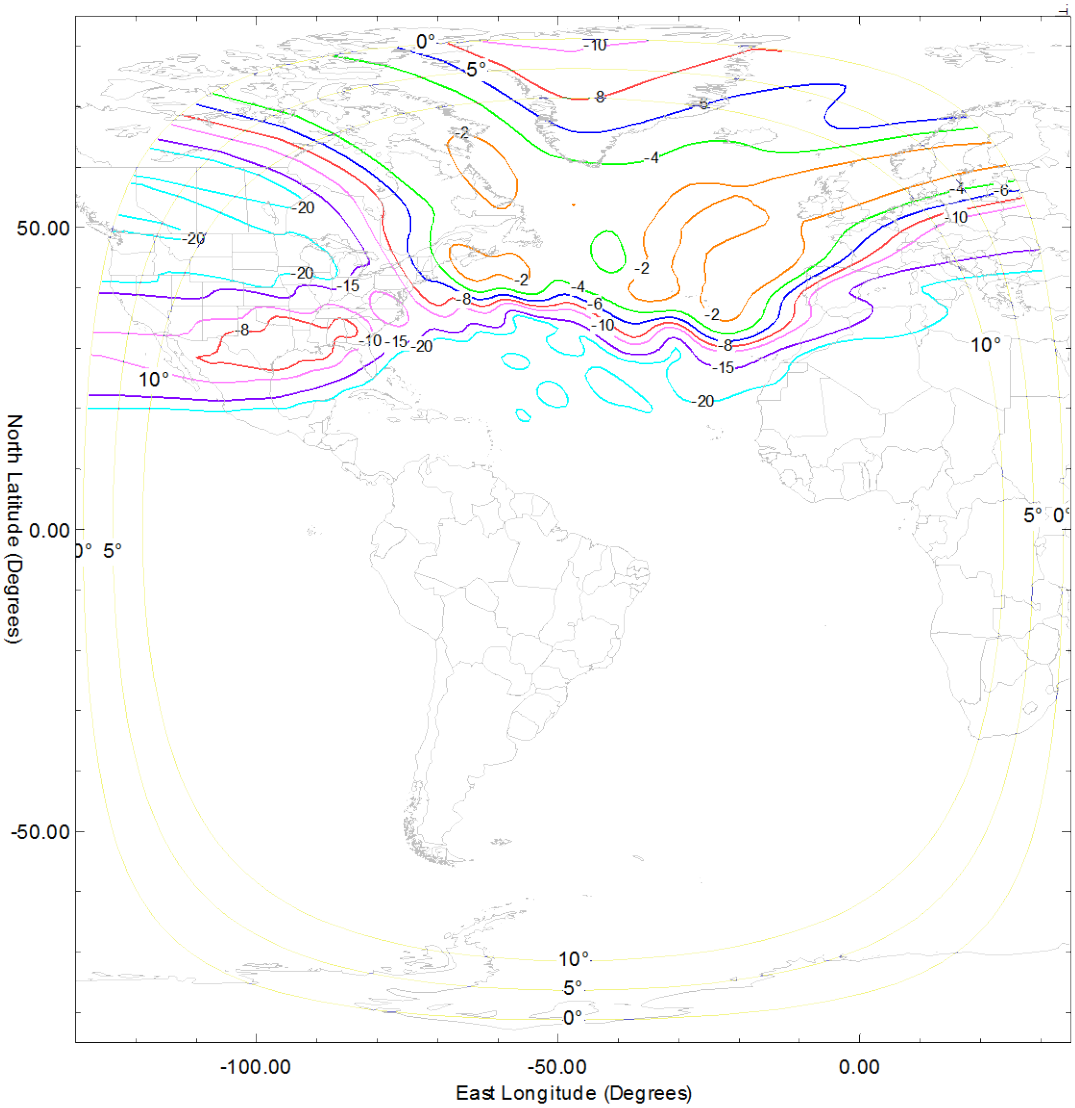

Figure A-4
Transmit Beam: KTH
Ku-band, H-pol, Peak Gain: 33.1 dBi, Peak EIRP = 49.8 dBW

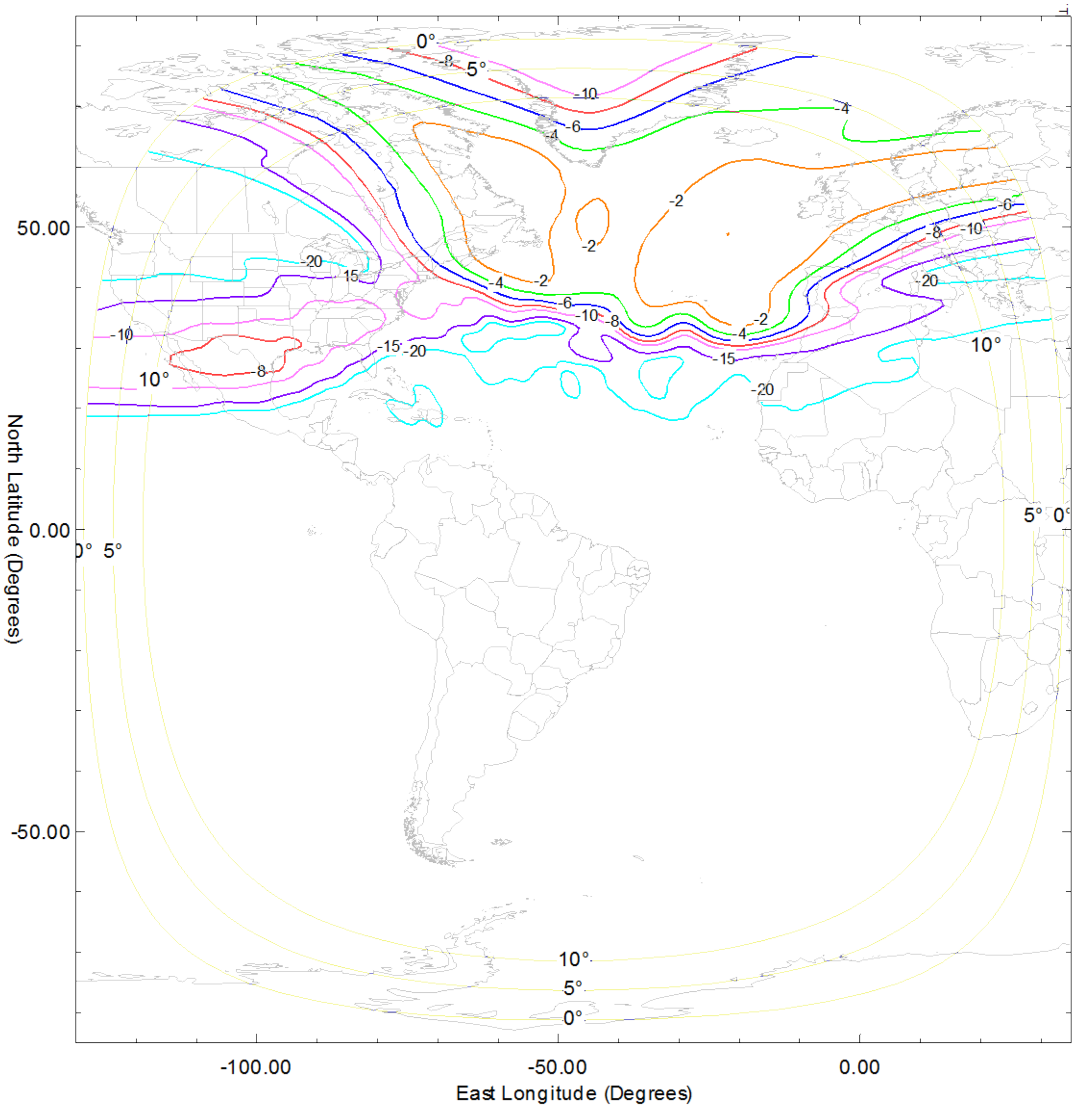

Figure A-5
Receive Beam: CRV
C-band, V-pol, Peak Gain: 33.3 dBi, Peak G/T = 5.5 dB/K

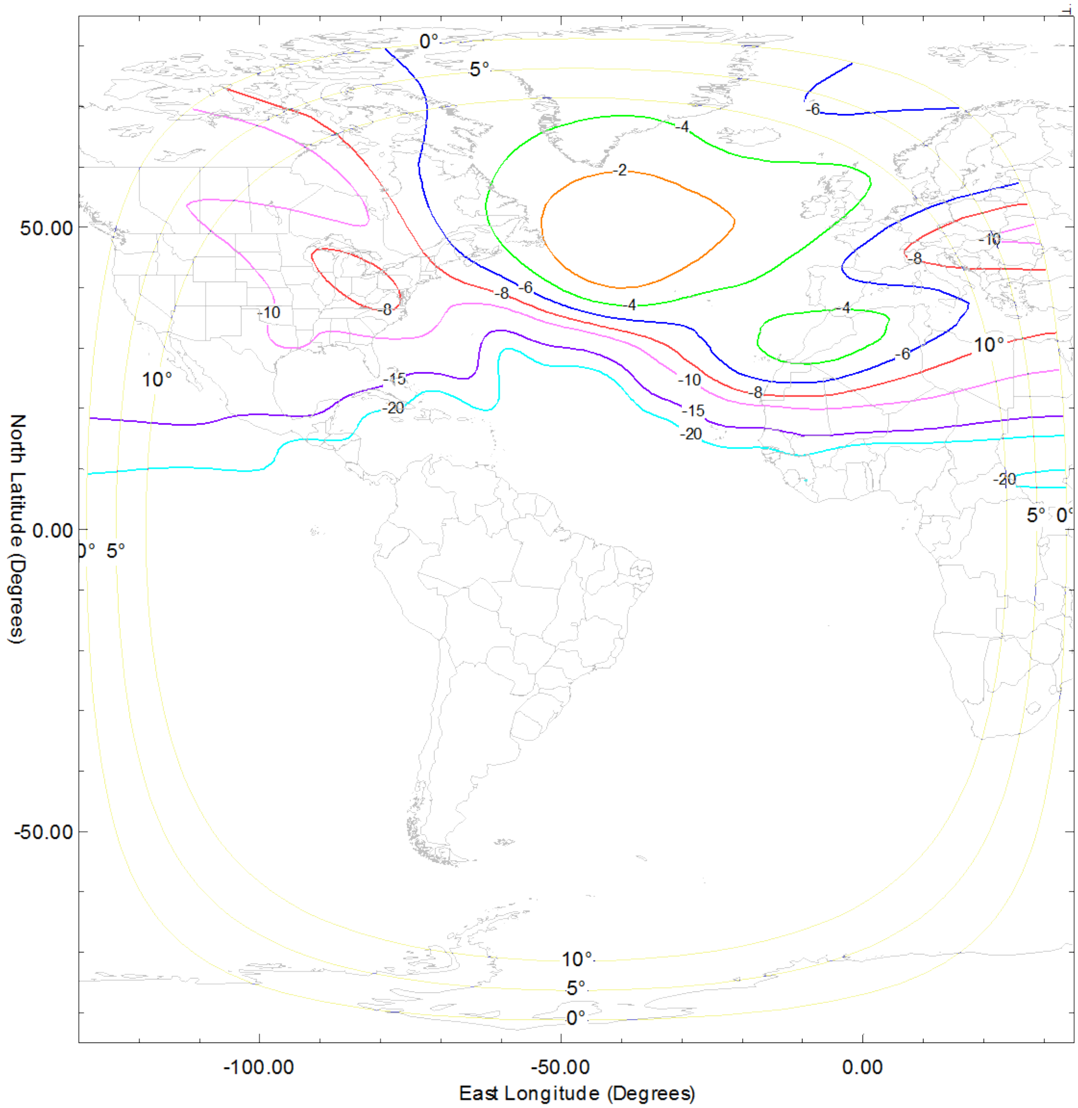

Figure A-6
Transmit Beam: CTV
C-band, V-pol, Peak Gain: 30.4 dBi, Peak EIRP = 41.3 dBW

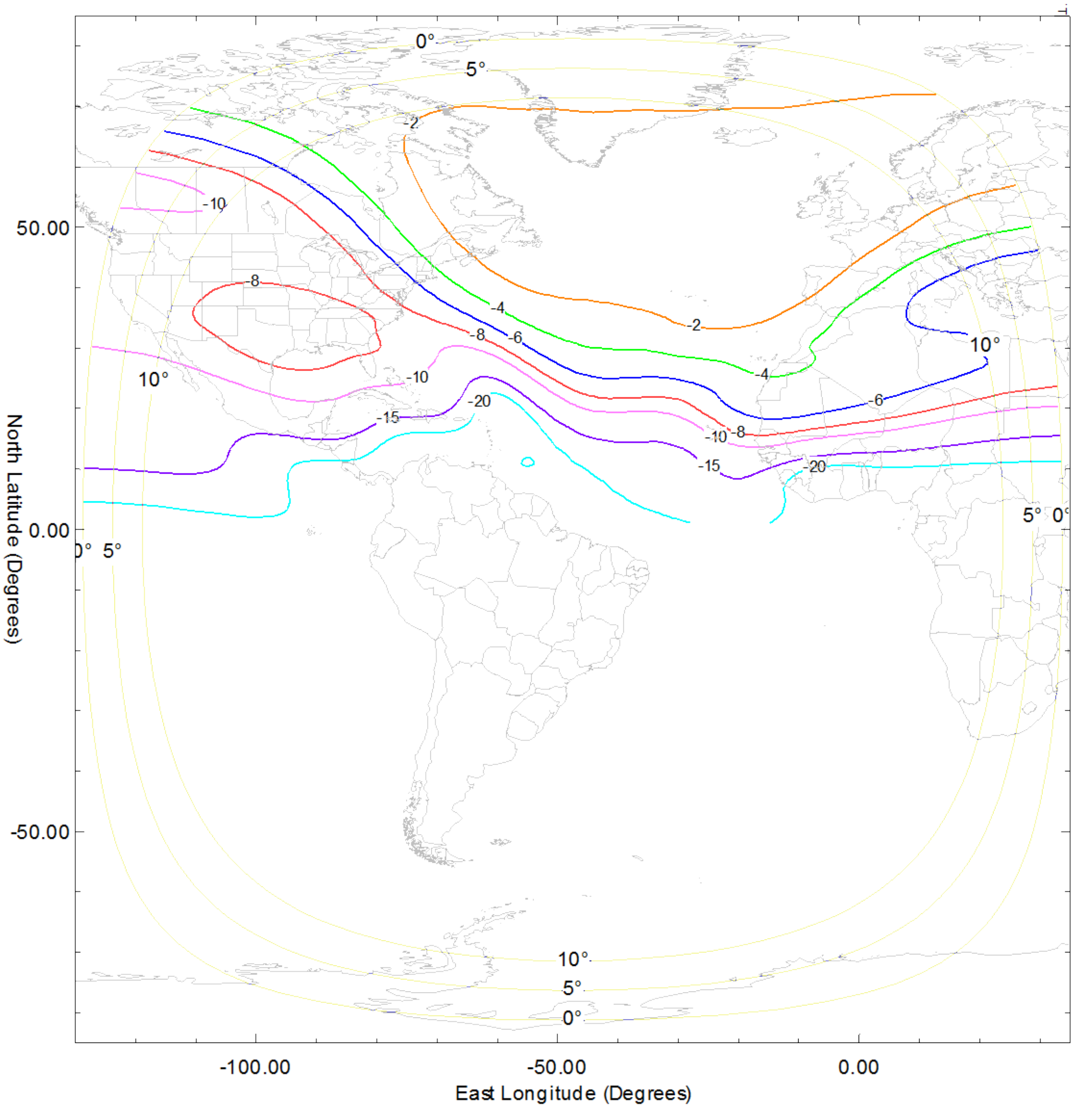

Figure A-7
Transmit Beam: CTH
C-band, H-pol, Peak Gain: 30.4 dBi, Peak EIRP = 40.8 dBW

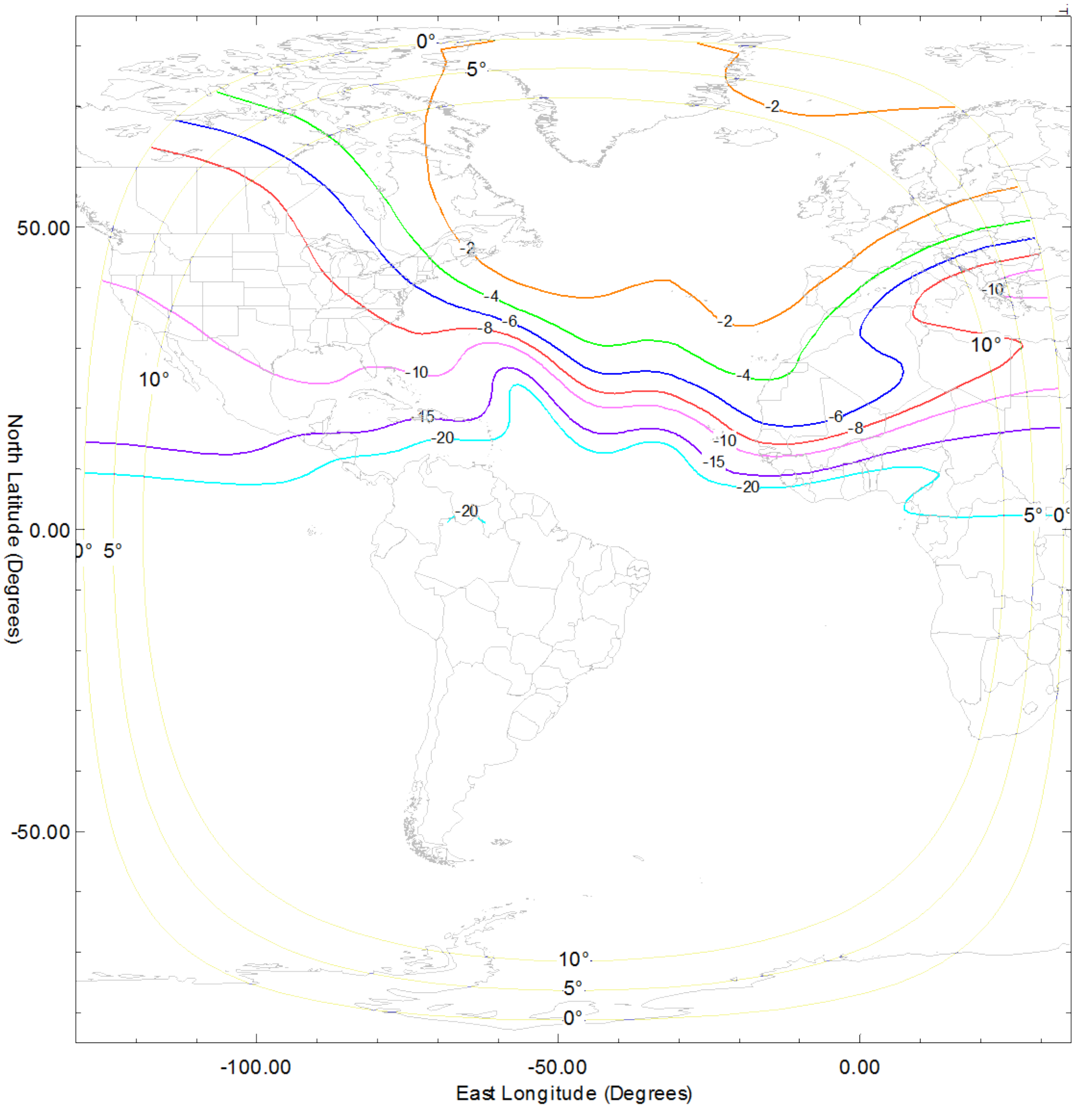

Figure A-8
Global Horn Characteristics

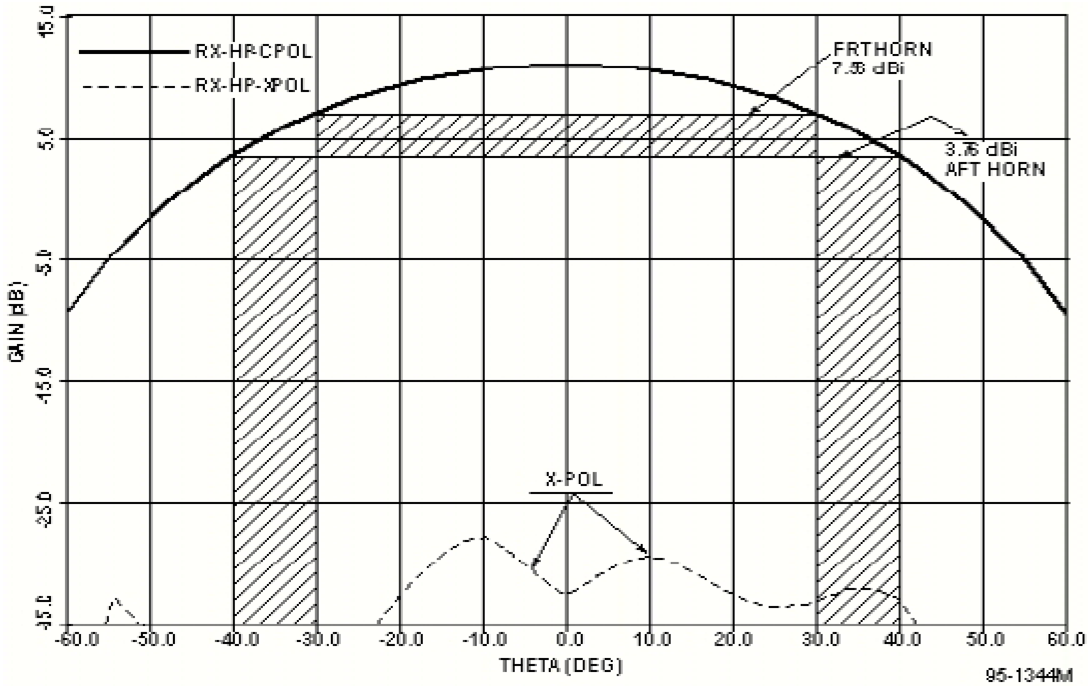

Figure 2.3-4. Measured Performance of Command Horn

ANNEX B

Link Budgets

Table B-1
Ku-Band Link Budgets

Link Parameters	Units	Ku-band					
		7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
Uplink Frequency	GHz	14.240	14.240	14.240	14.240	14.240	14.240
Downlink Frequency	GHz	11.940	11.940	11.940	11.940	11.940	11.940
Carrier Allocated Bandwidth	kHz	7200.0	3600.0	5040.0	55.0	1400.0	36000.0
Energy Dispersal	MHz	n/a	n/a	n/a	n/a	n/a	n/a
Uplink:							
Nominal E/S e.i.r.p. per carrier	dBW	38.0	61.4	60.2	40.1	54.7	74.8
Earth Station Diameter	m	0.3	8.1	2.4	2.4	3.8	6.1
Earth Station Gain	dBi	31.1	59.8	49.2	49.2	53.2	57.3
Uplink Input Power per Carrier	dBW	6.9	1.6	11.0	-9.1	1.5	17.5
Free Space Loss	dB	206.9	206.9	206.9	206.9	206.9	206.9
G/T Satellite	dB/K	5.7	2.7	0.8	0.8	0.8	3.0
C/N Thermal Uplink	dB	-2.4	21.0	16.4	13.3	16.5	24.7
C/I XPOL, ACI, IM, ASI	dB	-3.7	22.7	20.0	16.9	20.1	26.1
C/(N+I) uplink	dB	-6.1	18.7	14.9	11.7	14.9	22.3
Downlink:							
Satellite e.i.r.p. per carrier	dBW	16.4	35.3	34.2	14.0	28.7	48.5
Maximum e.i.r.p. density	dBW/4kHz	-15.4	6.5	6.9	3.8	6.9	9.7
Free Space Loss	dB	205.5	205.5	205.5	205.5	205.5	205.5
Earth Station Diameter	m	8.1	0.3	2.4	2.4	3.8	1.2
Earth Station Gain	dBi	58.2	29.6	47.7	47.7	51.7	41.7
Noise Temperature	K	195.0	80.0	130.0	130.0	140.0	120.0
Earth Station G/T	dB/K	35.3	10.6	26.5	26.5	30.2	20.9
C/N Thermal Downlink	dB	7.1	4.3	17.6	14.5	21.4	17.7
C/I XPOL, ACI, IM, ASI	dB	8.9	2.2	17.7	14.6	21.7	17.4
C/(N+I) downlink	dB	4.9	0.1	14.6	11.5	18.5	14.6
Adjacent Satellite Interference:							
Uplink Inp. Pwr. Dens. @ 2 degrees	dBW/Hz	-50	-50	-50	-50	-50	-50
Downlink e.i.r.p. Dens @ 2 degrees	dBW/Hz	-26	-26	-26	-26	-26	-26
C/I up (single satellite)	dB	-0.7	25.7	23.0	19.9	23.1	29.1
C/I dn (single satellite)	dB	11.9	5.2	20.7	17.6	24.7	20.4
Aggregate C/I up	dB	-3.7	22.7	20.0	16.9	20.1	26.1
Aggregate C/I down	dB	8.9	2.2	17.7	14.6	21.7	17.4
Overall:							
C/(N+I) overall	dB	-6.5	0.0	11.7	8.6	13.4	13.9
C/(N+I) required	dB	-6.5	0.0	6.9	6.9	9.3	6.9
System Margin	dB	0.0	0.0	4.8	1.7	4.1	7.0

Table B-2
TT&C Link Budgets

Link Parameters	Units	TT&C			
		800KF9D	300KF9D	300KF9D	300KF9D
Uplink Frequency	GHz	6.4235			
Downlink Frequency	GHz		3.7005	4.1995	12.198
Carrier Allocated Bandwidth	kHz	800.0	300.0	300.0	300.0
Energy Dispersal	MHz	n/a	n/a	n/a	n/a
Uplink:					
Nominal E/S e.i.r.p. per carrier	dBW	70.9			
Earth Station Diameter	m	7.3			
Earth Station Gain	dBi	51.9			
Uplink Input Power per Carrier	dBW	19.0			
Free Space Loss	dB	199.7			
G/T Satellite towards E/S	dB/K	-2.5			
C/N Thermal Uplink	dB	38.3			
C/I XPOL, ACI, IM, ASI	dB	34.9			
C/(N+I) uplink	dB	33.3			
Downlink:					
Satellite e.i.r.p. per carrier	dBW		15.0	15.0	12.4
Maximum e.i.r.p. density	dBW/4kHz		-3.8	-3.8	-6.4
Free Space Loss	dB		195.9	195.9	205.5
Earth Station Diameter	m		7.3	7.3	9.0
Earth Station Gain	dBi		47.2	48.3	59.3
Noise Temperature	K		100.0	100.0	120.0
Earth Station G/T	dB/K		27.2	28.3	38.5
C/N Thermal Downlink	dB		20.1	21.2	19.3
C/I XPOL, ACI, IM, ASI	dB		20.4	21.5	19.0
C/(N+I) downlink	dB		17.2	18.3	16.2
Adjacent Satellite Interference:					
Uplink Inp. Pwr. Dens. @ 2 degrees	dBW/Hz	-47	-47	-47	-50
Downlink e.i.r.p. Dens @ 2 degrees	dBW/Hz		-37	-37	-26
C/I up (single satellite)	dB	37.9			
C/I dn (single satellite)	dB		23.4	24.5	22.0
Aggregate C/I up	dB	34.9			
Aggregate C/I down	dB		20.4	21.5	19.0
Overall:					
C/(N+I) overall	dB	33.3	17.2	18.3	16.2
C/(N+I) required	dB	10.0	9.0	9.0	9.0
System Margin	dB	23.3	8.2	9.3	7.2

ANNEX C

Interference Analysis

Interference Analysis

The interference analysis is divided into two sections. The first estimates interference levels using a generic approach, *i.e.*, the two adjacent systems are assumed to be identical and spaced at two degrees. The second section investigates the specific case of interference between AMC-1 and adjacent systems, INTELSAT-1R, INTELSAT 29e, INTELSAT-14 and DIRECTV-KU-45W, using published emission characteristics.

<u>Generic Two Degree Spacing Analysis</u>

This portion of the analysis intends to provide a rough estimate of the interference between two networks with an orbital longitude separation of two degrees. Several simplifying assumptions are made:

- The power densities of the wanted and interfering networks are assumed to be the same.
- Any difference in propagation loss between the wanted and interfering networks is ignored.
- Stationkeeping tolerance and earth station pointing errors are ignored.

Uplink

The uplink C/I ratio is calculated from the following equations:

$$C/N_{UP} = PD_{ES,W} + G_{ES,W}(\theta_W) - PL + G/T_{SS,W} - k$$

$$I/N_{UP} = PD_{ES,I} + G_{ES,I}(\theta_I) - PL + G/T_{SS,I} - k$$

$$C/I_{UP} = C/N_{UP} - I/N_{UP}$$

where:

C/N_{UP} = uplink wanted carrier-to-noise ratio, dB

$PD_{ES,W}$ = power density of wanted earth station emission, dBW/Hz

$G_{ES,W}(\theta_W)$ = gain of wanted earth station in direction of wanted space station, dBi

PL = propagation loss, dB

$G/T_{SS,W}$ = wanted space station G/T in direction of wanted earth station, dB/K

k = Boltzmann constant, dBJ/K

I/N_{UP} = uplink interference-to-noise ratio, dB

$PD_{ES,I}$ = power density of interfering earth station emission, dBW/Hz

$G_{ES,I}(\theta_I)$ = gain of interfering earth station in direction of wanted space station, dBi

$G/T_{SS,I}$ = wanted space station G/T in direction of interfering earth station, dB/K

C/I_{UP} = uplink carrier-to-interference ratio, dB

Assuming that the power densities of the wanted and interfering emissions are the same, and ignoring any difference in propagation loss between the wanted space station and the wanted and interfering earth stations, C and I can be combined to give:

$$C / I_{UP} = G_{ES,W}(\theta_W) - G_{ES,I}(\theta_I) + \Delta G / T$$

with:

$$\Delta G / T = G / T_{SS,W} - G / T_{SS,I}$$

Thus, the uplink C/I can be estimated using the gains of the earth stations and an assumption defining the locations of the wanted and interfering earth stations relative to the wanted space station beam boresight (*i.e.*, on which G/T contour the earth stations are located).

Ignoring pointing errors ($\theta_W = 0$), the wanted earth station gain is just the peak value. For a longitude separation of 2.0 degrees, the topocentric angle is approximately 2.2 degrees.

Assuming an antenna gain reference pattern of 29 – 25 * log(φ),[4] the gain of the interfering earth station toward the wanted space station is 29 – 25 * log(2.2) = 20.4 dBi.

Using these values in the expression for C/I_{UP} gives:

$$C/I_{UP} = G_{ES,W}(0) - 20.4 + \Delta G/T$$

This relationship can be used to estimate the uplink C/I for typical earth station antenna gain values with varying levels of G/T contour mismatch between the two satellites:

[4] According to Section 29.209(c)(1), receiving earth stations are afforded protection to the extent that they meet the 25.209(a) and (b) masks at 1.5 degrees off-axis.

Table C-1: Uplink C/I at Two Degree Spacing

Uplink			
Parameter		Value	Value
Orbital separation (°)		2.0	2.0
Topocentric angle (°)		2.2	2.2
Off-axis gain (dB)		20.4	20.4
Ku-band			
ΔG/T (dB)		-2.0	0.0
Earth station			
Diameter (m)	Gain (dBi)	C/I (dB)	C/I (dB)
1.2	43.2	20.8	22.8
1.8	46.7	24.3	26.3
2.4	49.2	26.8	28.8
4.5	54.7	32.2	34.2
6.0	57.2	34.7	36.7
C-band			
ΔG/T (dB)		-1.0	0.0
Earth station			
Diameter (m)	Gain (dBi)	C/I (dB)	C/I (dB)
3.8	46.0	24.6	25.6
4.5	47.5	26.1	27.1
6.0	50.0	28.6	29.6
7.5	51.9	30.5	31.5
9.0	53.5	32.1	33.1
Worst-case			
C/I (dB)		20.8	22.8
Assumed C/N (dB)		8.0	8.0
I/N (dB)		-12.8	-14.8
ΔT/T (%)		5.3	3.3
Increase in noise temperature (dB)		0.22	0.14

Assuming that the minimum (*i.e.*, threshold) C/N for a digital service is 8 dB, the effect of the worst-case Ku-band C/I (20.8 dB) from the 1.2 m diameter earth station in Table C-1 above would only degrade the C/N by 0.22 dB, equivalent to an increase of 5.3% in the wanted system noise temperature.

For C-band, the worst-case C/I (24.6 dB) into the 3.8 m diameter earth station in Table C-1 above would degrade the C/N by 0.09 dB, equivalent to an increase of 2.2% in the wanted system noise temperature.

These values are less than the ITU coordination trigger criteria; *i.e.*, internationally, if a 6% increase in noise temperature is not exceeded, then coordination is not needed between the concerned networks.

Downlink

For the downlink, the C/I ratio is estimated based on the wanted and interfering receive power densities:

$$C_{DN} = ED_{SS,W} + GC_{SS,W} - PL + G_{ES,W}(\theta_W)$$

$$I_{DN} = ED_{SS,I} + GC_{SS,I} - PL + G_{ES,W}(\theta_I)$$

$$C/I_{DN} = C_{DN} - I_{DN}$$

where:

C_{DN} = downlink wanted receive power density, dBW/Hz

$ED_{SS,W}$ = peak EIRP density of wanted space station emission, dBW/Hz

$GC_{SS,W}$ = gain contour of wanted space station in direction of wanted earth station (non-positive number), dB

I_{DN} = downlink interfering receive power density, dBW/Hz

$ED_{SS,I}$ = peak EIRP density of interfering space station emission, dBW/Hz

$GC_{SS,I}$ = gain contour of interfering space station in direction of wanted earth station (non-positive number), dB

$G_{ES,W}(\theta_I)$ = gain of wanted earth station in direction of interfering space station, dBi

C/I_{DN} = downlink carrier-to-interference ratio, dB

Again, assuming equal signal power densities and propagation losses between the competing networks, the downlink C/I can be expressed as:

$$C/I_{DN} = G_{ES,W}(\theta_W) - G_{ES,W}(\theta_I) + \Delta GC$$

with:

$$\Delta GC = GC_{SS,W} - GC_{SS,I}$$

Thus, the downlink C/I can be estimated using the gain of the wanted earth station and an assumption defining the location of the wanted earth station relative to the wanted and interfering space station beam boresights (*i.e.*, on which EIRP contours the earth station is located).

Ignoring the earth station pointing error and using a gain reference pattern of 29 – 25 * log(φ)), the downlink C/I can be reduced to:

$$C/I_{DN} = G_{ES,W}(0) - 20.4 + \Delta GC$$

This relationship can be used to estimate the downlink C/I for typical earth station antenna gain values with varying levels of EIRP (ΔGC) degradation:

Table C-2: Downlink C/I at Two Degree Spacing

Downlink			
Parameter		Value	Value
Orbital separation (◦)		2.0	2.0
Topocentric angle (◦)		2.2	2.2
Off-axis gain (dB)		20.4	20.4
Ku-band			
ΔGC (dB)		-2.0	0.0
Earth station			
Diameter (m)	Gain (dBi)	C/I (dB)	C/I (dB)
1.2	41.7	19.2	21.2
1.8	45.2	22.7	24.7
2.4	47.7	25.2	27.2
4.5	53.1	30.7	32.7
6.0	55.6	33.2	35.2
C-band			
ΔGC (dB)		-1.0	0.0
Earth station			
Diameter (m)	Gain (dBi)	C/I (dB)	C/I (dB)
3.8	42.1	21.6	21.6
4.5	43.5	23.1	23.1
6.1	46.2	25.7	25.7
7.5	48.0	27.5	27.5
Worst-case			
C/I (dB)		19.2	21.2
Assumed C/N (dB)		8.0	8.0
I/N (dB)		-11.2	-13.2
ΔT/T (%)		7.5	4.8
Increase in noise temperature (dB)		0.32	0.20

Assuming that the minimum (*i.e.*, threshold) C/N for a digital service is 8 dB, the effect of the worst-case Ku-band C/I (19.2 dB) into the 1.2 m diameter earth station in Table C-2 above would degrade the C/N by 0.32 dB, equivalent to an increase of 7.5% in the wanted system noise temperature. Although this is above the typical criteria of 6%, the wanted system link degradation is still less than 0.5 dB, which is likely to be significantly less than the link margin.

For C-band, the worst-case C/I (21.6 dB) into the 3.8 m diameter earth station in Table C-2 above would degrade the C/N by 0.18 dB, equivalent to an increase of 4.3% in the wanted system noise temperature, which is below the 6% coordination threshold.

Specific C/I Analysis

For this portion of the analysis, the carrier-to-interference ratio between two adjacent systems is estimated for a set of competing emissions. The analysis methodology consists of defining the emission characteristics for each network and computing the interference levels resulting from co-channel operation. C/I levels are calculated for each combination of overlapping emissions (*i.e.*, the same frequency band and link direction). Results are presented in tables providing the interference levels for combinations of emissions pairs.

The worst-case geometry for the earth and space stations is assumed. That is, the space stations are positioned closer to each other by their respective stationkeeping tolerances and the earth station is mispointed toward the interfering space station by an assumed pointing error.

The equations and parameter definitions presented above can be used to express the uplink and downlink C/I as follows:

$$C/I_{UP} = (PD_{ES,W} - PD_{ES,I}) + (G_{ES,W}(\theta_W) - G_{ES,I}(\theta_I)) + \Delta G/T$$

$$C/I_{DN} = (ED_{SS,W} - ED_{SS,I}) + (G_{ES,W}(\theta_W) - G_{ES,W}(\theta_I)) + \Delta GC$$

Here the uplink C/I is estimated using the emission power densities and gains of the earth stations, and an assumption defining the locations of the wanted and interfering earth stations relative to the wanted space station beam boresight. The downlink C/I is estimated using the wanted and interfering space station emission EIRP densities, the gain of the wanted earth station, and an assumption defining the location of the wanted earth station relative to the wanted and interfering space station beam boresights.

The off-axis performance of the earth station antenna is modeled using Part 25 Section 25.209. According to Section 29.209(c)(1), receiving earth stations are afforded protection to the extent that they meet the 25.209(a) and (b) masks at 1.5 degrees off-axis. Therefore, all receiving earth stations are assumed to meet this mask in the interference analysis contained herein. Note that this antenna pattern does not define gain values for angles less than 1.5 degrees. In order to account for earth station pointing errors, a parabolic main beam model is used for gain values at small off-axis angles ($G_{MAX} – 0.0025 * (D/\lambda * \varphi) ^ 2$).

Earth station topocentric off-axis angles are approximated by adding 10% to the geocentric angular separation, taking into account the satellite stationkeeping tolerance and earth station pointing error.

System characteristics used in the analysis are shown in the following tables. Five space stations are considered: AMC-1 and four adjacent stations: INTELSAT-1R, INTELSAT-29e, INTELSAT-14 and DIRECTV-KU-45W.

Table C-3 provides the space station name and orbital information, and assumed earth station parameters of the networks.

Table C-3: Station Parameters

Parameter	System 1A	System 1B	System 2	System 3A	System 3B
Space station name	INTELSAT-1R	INTELSAT-29e	AMC-1	INTELSAT-14	DIRECTV-KU-45W
Nominal orbit location (+E, -W)	-50.00	-50.00	-47.50	-45.00	-45.20
Stationkeeping tolerance (◦)	0.05	0.05	0.15	0.05	0.05
Earth station pointing error (◦)	0.10	0.10	0.10	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65	0.65	0.65	0.65

This analysis considers the digital emissions signals of both networks. Analog TV/FM signals are coordinated on a case-by-case basis with nearby spacecraft, and are therefore not addressed in this analysis. Digital signals are more robust and operate typically down to much lower C/N ratios than analog signals, and therefore are more tolerant of interference.

Tables C-4a, C-4b, C-4c and C-4d show the INTELSAT-1R, INTELSAT-29e, INTELSAT-14 and DIRECTV-KU-45W emission characteristics considered here (derived from the respective Schedule S files).

Table C-4a: INTELSAT-1R Typical Emissions

Ku-band							
Uplink				Downlink			
Emission	Frequency (MHz)	ES power density (dBW/Hz)	ES gain (dBi)	Emission	Frequency (MHz)	SS EIRP density (dBW/Hz)	ES gain (dBi)
36M0G7W	14020.0	-51.4	56.8	36M0G7W	11720.0	-26.0	44.4
10M3G7W	14020.0	-61.4	56.8	10M3G7W	11720.0	-27.2	47.1
100KG7W	14020.0	-62.1	56.8	100KG7W	11720.0	-27.9	47.1
1M45G7W	14020.0	-62.2	56.8	1M45G7W	11720.0	-28.0	47.1
400KG7W	14020.0	-57.3	48.9	400KG7W	11720.0	-30.9	55.1

Table C-4b: INTELSAT-29e Typical Emissions

Ku-band							
Uplink				Downlink			
Emission	Frequency (MHz)	ES power density (dBW/Hz)	ES gain (dBi)	Emission	Frequency (MHz)	SS EIRP density (dBW/Hz)	ES gain (dBi)
62M5G7W	14020.0	-66.7	56.8	62M5G7W	11720.0	-26.0	50.8
36M0G7W	14020.0	-55.9	56.7	36M0G7W	11720.0	-26.0	44.8
10M3G7W	14020.0	-64.9	56.8	10M3G7W	11720.0	-26.0	47.2
100KG7W	14020.0	-65.6	56.8	100KG7W	11720.0	-26.7	47.2
1M45G7W	14020.0	-65.8	56.8	1M45G7W	11720.0	-26.8	47.2

Table C-4c: INTELSAT-14 Typical Emissions

Ku-band							
Uplink				Downlink			
Emission	Frequency (MHz)	ES power density (dBW/Hz)	ES gain (dBi)	Emission	Frequency (MHz)	SS EIRP density (dBW/Hz)	ES gain (dBi)
36M0G7W	14020.0	-51.2	57.1	36M0G7W	11720.0	-26.0	43.0
10M3G7W	14020.0	-51.2	57.1	10M3G7W	11720.0	-26.0	43.5
100KG7W	14020.0	-51.2	57.1	100KG7W	11720.0	-26.0	42.6
1M45G7W	14020.0	-51.4	57.1	1M45G7W	11720.0	-26.2	42.7
400KG7W	14020.0	-50.8	44.5	400KG7W	11720.0	-38.3	55.3

Table C-4d: DIRECTV-KU-45W Typical Emissions

Ku-band							
Uplink				Downlink			
Emission	Frequency (MHz)	ES power density (dBW/Hz)	ES gain (dBi)	Emission	Frequency (MHz)	SS EIRP density (dBW/Hz)	ES gain (dBi)
36M0G7W	14020.0	-70.2	60.7	36M0G7W	11720.0	-22.5	36.3

Table C-5 shows the AMC-1 emission characteristics considered here (derived from the Schedule S file).

Table C-5: AMC-1 Typical Emissions

Ku-band							
Uplink				Downlink			
Emission	Frequency (MHz)	ES power density (dBW/Hz)	ES gain (dBi)	Emission	Frequency (MHz)	SS EIRP density (dBW/Hz)	ES gain (dBi)
7M20G1W	14020.0	-60.9	31.1	7M20G1W	11720.0	-51.4	58.2
3M60G1W	14020.0	-63.1	59.8	3M60G1W	11720.0	-29.5	29.6
5M04G1W	14020.0	-55.2	49.2	5M04G1W	11720.0	-29.1	47.7
100KG1W	14020.0	-58.3	49.2	100KG1W	11720.0	-32.3	47.7
1M40G7W	14020.0	-59.2	53.2	1M40G7W	11720.0	-29.1	51.7
36M0G7W	14020.0	-57.3	57.3	36M0G7W	12198.0	-26.3	41.7

Applying the methodology present above to the emission characteristics shown in Tables C-4 and C-5 results in the C/I levels shown in Appendix 1 to this Annex. A separate table is provided for each frequency band/link direction pair that shows the C/I level for each emission pair.

The worst-case C/I levels extracted from the tables in Appendix 1 for each band and link direction are summarized in Table C-6. This table also shows the resulting impact to the wanted links assuming a threshold C/N of 8 dB.

Table C-6: Worst-Case C/I and Impact to Wanted Links

Worst-case interference AMC-1 into INTELSAT-1R					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	37.2	8.0	-29.2	0.1	0.01
Ku-band downlink	35.2	8.0	-27.2	0.2	0.01

Worst-case interference INTELSAT-1R into AMC-1					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	12.3	8.0	-4.3	37.6	1.38
Ku-band downlink	7.9	8.0	0.1	101.4	3.04

Worst-case interference AMC-1 into INTELSAT-29e					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	24.1	8.0	-16.1	2.4	0.11
Ku-band downlink	25.6	8.0	-17.6	1.7	0.07

Worst-case interference INTELSAT-29e into AMC-1					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	6.8	8.0	1.2	133.2	3.68
Ku-band downlink	-2.1	8.0	10.1	1013.8	10.47

Worst-case interference AMC-1 into INTELSAT-14					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	37.2	8.0	-29.2	0.1	0.01
Ku-band downlink	35.2	8.0	-27.2	0.2	0.01

Worst-case interference INTELSAT-14 into AMC-1					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	12.3	8.0	-4.3	37.6	1.38
Ku-band downlink	7.9	8.0	0.1	101.4	3.04

Worst-case interference AMC-1 into DirecTV-45W					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	40.8	8.0	-32.8	0.1	0.00
Ku-band downlink	39.7	8.0	-31.7	0.1	0.00

Worst-case interference DirecTV-45W into AMC-1					
Link	Worst-case C/I (dB)	C/N (dB)	I/N (dB)	ΔT/T (%)	Inc. in Noise (dB)
Ku-band uplink	40.0	8.0	-32.0	0.1	0.00
Ku-band downlink	14.4	8.0	-6.4	22.7	0.89

As can be seen from these results, the interference between the networks is well below the 6% coordination threshold for most cases. This is primarily due to the 2.5 degree geocentric separation of the space stations and the fact that the adjacent satellites serve geographically different areas. The SES worst case C/I is low with respect to INTELSAT-29e because the aeronautical link uses a small antenna with a low EIRP and there is co-coverage between these two satellites. SES will use spread spectrum techniques to achieve the required link availability.

APPENDIX 1

C/I CALCULATIONS

Table A1-1: INTELSAT-1R/AMC-1 Ku-Band Uplink C/I

Ku-band Uplink C/I	System 1	System 2
Space station name	INTELSAT-1R	AMC-1
Nominal orbit location (+E, -W)	-50.00	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-49.95	-47.65
Longitude separation (◦)	2.30	2.30
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward wanted space station(◦)	2.43	2.43
Difference in wanted space station G/T toward wanted and interfering earth stations (dB)	10.0	10.0

AMC-1 into INTELSAT-1R									
Wanted INTELSAT-1R Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
36M0G7W	14020.0	-51.4	56.8	55.1	57.3	49.4	52.5	53.3	51.4
10M3G7W	14020.0	-61.4	56.8	45.1	47.3	39.4	42.5	43.3	41.4
100KG7W	14020.0	-62.1	56.8	44.4	46.6	38.7	41.8	42.6	40.7
1M45G7W	14020.0	-62.2	56.8	44.3	46.5	38.6	41.7	42.5	40.6
400KG7W	14020.0	-57.3	48.9	42.9	45.1	37.2	40.3	41.1	39.2

INTELSAT-1R into AMC-1									
Interfering INTELSAT-1R Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
36M0G7W	14020.0	-51.4	56.8	12.3	35.0	35.7	32.6	35.3	40.0
10M3G7W	14020.0	-61.4	56.8	22.3	45.0	45.7	42.6	45.3	50.0
100KG7W	14020.0	-62.1	56.8	23.0	45.7	46.4	43.3	46.0	50.7
1M45G7W	14020.0	-62.2	56.8	23.1	45.8	46.5	43.4	46.1	50.8
400KG7W	14020.0	-57.3	48.9	18.2	40.9	41.6	38.5	41.2	45.9

Table A1-2: INTELSAT-1R/AMC-1 Ku-Band Downlink C/I

Ku-band Downlink C/I	System 1	System 2
Space station name	INTELSAT-1R	AMC-1
Nominal orbit location (+E, -W)	-50.00	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-49.95	-47.65
Longitude separation (◦)	2.30	2.30
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward interfering space station (◦)	2.43	2.43
Difference in wanted and interfering space station gain toward wanted earth station (dB)	10.0	10.0

AMC-1 into INTELSAT-1R									
Wanted INTELSAT-1R Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
36M0G7W	11720.0	-26.0	44.4	60.3	38.4	38.1	41.2	38.0	35.2
10M3G7W	11720.0	-27.2	47.1	61.7	39.8	39.5	42.6	39.4	36.6
100KG7W	11720.0	-27.9	47.1	61.0	39.1	38.8	41.9	38.7	35.9
1M45G7W	11720.0	-28.0	47.1	60.9	39.0	38.7	41.8	38.6	35.8
400KG7W	11720.0	-30.9	55.1	65.0	43.1	42.7	45.8	42.7	39.9

INTELSAT-1R into AMC-1									
Interfering INTELSAT-1R Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
36M0G7W	11720.0	-26.0	44.4	20.9	7.9	34.9	31.8	38.6	32.0
10M3G7W	11720.0	-27.2	47.1	22.1	9.1	36.1	33.0	39.8	33.2
100KG7W	11720.0	-27.9	47.1	22.8	9.8	36.8	33.7	40.5	33.9
1M45G7W	11720.0	-28.0	47.1	22.9	9.9	36.9	33.8	40.6	34.0
400KG7W	11720.0	-30.9	55.1	25.8	12.8	39.8	36.7	43.5	36.9

Table A1-3: INTELSAT-29e/AMC-1 Ku-Band Uplink C/I

Ku-band Uplink C/I	System 1	System 2
Space station name	INTELSAT-29e	AMC-1
Nominal orbit location (+E, -W)	-50.00	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-49.95	-47.65
Longitude separation (◦)	2.30	2.30
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward wanted space station(◦)	2.43	2.43
Difference in wanted space station G/T toward wanted and interfering earth stations (dB)	0.0	0.0

AMC-1 into INTELSAT-29e									
Wanted INTELSAT-29e Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
62M5G7W	14020.0	-66.7	56.8	29.8	32.0	24.1	27.2	28.0	26.1
36M0G7W	14020.0	-55.9	56.7	40.5	42.8	34.9	38.0	38.8	36.9
10M3G7W	14020.0	-64.9	56.8	31.6	33.8	25.9	29.0	29.8	27.9
100KG7W	14020.0	-65.6	56.8	30.9	33.1	25.2	28.3	29.1	27.2
1M45G7W	14020.0	-65.8	56.8	30.7	32.9	25.0	28.1	28.9	27.0

INTELSAT-29e into AMC-1									
Interfering INTELSAT-29e Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
62M5G7W	14020.0	-66.7	56.8	17.6	40.3	41.0	37.9	40.6	45.3
36M0G7W	14020.0	-55.9	56.7	6.8	29.5	30.2	27.1	29.8	34.5
10M3G7W	14020.0	-64.9	56.8	15.8	38.5	39.2	36.1	38.8	43.5
100KG7W	14020.0	-65.6	56.8	16.5	39.2	39.9	36.8	39.5	44.2
1M45G7W	14020.0	-65.8	56.8	16.7	39.4	40.1	37.0	39.7	44.4

Table A1-4: INTELSAT-29e/AMC-1 Ku-Band Downlink C/I

Ku-band Downlink C/I	System 1	System 2
Space station name	INTELSAT-29e	AMC-1
Nominal orbit location (+E, -W)	-50.00	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-49.95	-47.65
Longitude separation (◦)	2.30	2.30
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward interfering space station (◦)	2.43	2.43
Difference in wanted and interfering space station gain toward wanted earth station (dB)	0.0	0.0

AMC-1 into INTELSAT-29e									
Wanted INTELSAT-29e Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
62M5G7W	11720.0	-26.0	50.8	56.4	34.4	34.1	37.2	34.1	31.2
36M0G7W	11720.0	-26.0	44.8	50.7	28.8	28.5	31.6	28.4	25.6
10M3G7W	11720.0	-26.0	47.2	53.0	31.1	30.8	33.9	30.7	27.9
100KG7W	11720.0	-26.7	47.2	52.3	30.4	30.1	33.2	30.0	27.2
1M45G7W	11720.0	-26.8	47.2	52.2	30.3	30.0	33.1	29.9	27.1

INTELSAT-29e into AMC-1									
Interfering INTELSAT-29e Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
62M5G7W	11720.0	-26.0	50.8	10.9	-2.1	24.9	21.8	28.6	22.0
36M0G7W	11720.0	-26.0	44.8	10.9	-2.1	24.9	21.8	28.6	22.0
10M3G7W	11720.0	-26.0	47.2	10.9	-2.1	24.9	21.8	28.6	22.0
100KG7W	11720.0	-26.7	47.2	11.6	-1.4	25.6	22.5	29.3	22.7
1M45G7W	11720.0	-26.8	47.2	11.7	-1.3	25.7	22.6	29.4	22.8

Table A1-5: INTELSAT-14/AMC-1 Ku-Band Uplink C/I

Ku-band Uplink C/I	System 1	System 2
Space station name	INTELSAT-14	AMC-1
Nominal orbit location (+E, -W)	-45.00	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-45.05	-47.35
Longitude separation (◦)	2.30	2.30
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward wanted space station(◦)	2.43	2.43
Difference in wanted space station G/T toward wanted and interfering earth stations (dB)	10.0	10.0

AMC-1 into INTELSAT-14									
Wanted INTELSAT-14 Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
36M0G7W	14020.0	-51.4	56.8	55.1	57.3	49.4	52.5	53.3	51.4
10M3G7W	14020.0	-61.4	56.8	45.1	47.3	39.4	42.5	43.3	41.4
100KG7W	14020.0	-62.1	56.8	44.4	46.6	38.7	41.8	42.6	40.7
1M45G7W	14020.0	-62.2	56.8	44.3	46.5	38.6	41.7	42.5	40.6
400KG7W	14020.0	-57.3	48.9	42.9	45.1	37.2	40.3	41.1	39.2

INTELSAT-14 into AMC-1									
Interfering INTELSAT-14 Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
36M0G7W	14020.0	-51.4	56.8	12.3	35.0	35.7	32.6	35.3	40.0
10M3G7W	14020.0	-61.4	56.8	22.3	45.0	45.7	42.6	45.3	50.0
100KG7W	14020.0	-62.1	56.8	23.0	45.7	46.4	43.3	46.0	50.7
1M45G7W	14020.0	-62.2	56.8	23.1	45.8	46.5	43.4	46.1	50.8
400KG7W	14020.0	-57.3	48.9	18.2	40.9	41.6	38.5	41.2	45.9

Table A1-6: INTELSAT-14/AMC-1 Ku-Band Downlink C/I

Ku-band Downlink C/I	System 1	System 2
Space station name	INTELSAT-14	AMC-1
Nominal orbit location (+E, -W)	-45.00	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-45.05	-47.35
Longitude separation (◦)	2.30	2.30
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward interfering space station (◦)	2.43	2.43
Difference in wanted and interfering space station gain toward wanted earth station (dB)	10.0	10.0

AMC-1 into INTELSAT-14									
Wanted INTELSAT-14 Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
36M0G7W	11720.0	-26.0	44.4	60.3	38.4	38.1	41.2	38.0	35.2
10M3G7W	11720.0	-27.2	47.1	61.7	39.8	39.5	42.6	39.4	36.6
100KG7W	11720.0	-27.9	47.1	61.0	39.1	38.8	41.9	38.7	35.9
1M45G7W	11720.0	-28.0	47.1	60.9	39.0	38.7	41.8	38.6	35.8
400KG7W	11720.0	-30.9	55.1	65.0	43.1	42.7	45.8	42.7	39.9

INTELSAT-14 into AMC-1									
Interfering INTELSAT-14 Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
36M0G7W	11720.0	-26.0	44.4	20.9	7.9	34.9	31.8	38.6	32.0
10M3G7W	11720.0	-27.2	47.1	22.1	9.1	36.1	33.0	39.8	33.2
100KG7W	11720.0	-27.9	47.1	22.8	9.8	36.8	33.7	40.5	33.9
1M45G7W	11720.0	-28.0	47.1	22.9	9.9	36.9	33.8	40.6	34.0
400KG7W	11720.0	-30.9	55.1	25.8	12.8	39.8	36.7	43.5	36.9

Table A1-7: DIRECTV-KU-45W/AMC-1 Ku-Band Uplink C/I

Ku-band Uplink C/I	System 1	System 2
Space station name	DirecTV-45W	AMC-1
Nominal orbit location (+E, -W)	-45.20	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-45.25	-47.35
Longitude separation (◦)	2.10	2.10
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward wanted space station(◦)	2.21	2.21
Difference in wanted space station G/T toward wanted and interfering earth stations (dB)	20.0	20.0

AMC-1 into DirecTV-45W									
Wanted DirecTV-45W Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
36M0G7W	14020.0	-70.2	60.7	46.5	48.7	40.8	43.9	44.7	42.8

DirecTV-45W into AMC-1									
Interfering DirecTV-45W Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			14020.0	14020.0	14020.0	14020.0	14020.0	14020.0
		ES power density (dBW/Hz)		-60.9	-63.1	-55.2	-58.3	-59.2	-57.3
			ES gain (dBi)	31.1	59.8	49.2	49.2	53.2	57.3
36M0G7W	14020.0	-70.2	60.7	40.0	62.7	63.5	60.3	63.0	67.8

Table A1-8: DIRECTV-KU-45W/AMC-1 Ku-Band Downlink C/I

Ku-band Downlink C/I	System 1	System 2
Space station name	DirecTV-45W	AMC-1
Nominal orbit location (+E, -W)	-45.20	-47.50
Stationkeeping tolerance (◦)	0.05	0.15
Assumed orbit location (+E, -W)	-45.25	-47.35
Longitude separation (◦)	2.10	2.10
Earth station pointing error (◦)	0.10	0.10
Earth station antenna efficiency (fraction)	0.65	0.65
Earth station angle toward interfering space station (◦)	2.21	2.21
Difference in wanted and interfering space station gain toward wanted earth station (dB)	20.0	20.0

AMC-1 into DirecTV-45W									
Wanted DirecTV-45W Emisssions				Interfering AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
36M0G7W	11720.0	-22.5	36.3	64.8	42.9	42.5	45.7	42.5	39.7

DirecTV-45W into AMC-1									
Interfering DirecTV-45W Emisssions				Wanted AMC-1 Emisssions					
Emission				7M20G1W	3M60G1W	5M04G1W	100KG1W	1M40G7W	36M0G7W
	Frequency (MHz)			11720.0	11720.0	11720.0	11720.0	11720.0	12198.0
		SS EIRP density (dBW/Hz)		-51.4	-29.5	-29.1	-32.3	-29.1	-26.3
			ES gain (dBi)	58.2	29.6	47.7	47.7	51.7	41.7
36M0G7W	11720.0	-22.5	36.3	26.4	14.4	40.4	37.3	44.1	37.4

DECLARATION

I, Stefan Brak, hereby certify under penalty of perjury that I am the technically qualified person responsible for preparation of the technical information contained in the foregoing exhibit; that I am familiar with the technical requirements of Part 25; and that I either prepared or reviewed the technical information contained in the exhibit and that it is complete and accurate to the best of my knowledge, information and belief.

_/s/_____________________

Stefan Brak
Manager, Spectrum Management and Development
SES Americom, Inc.

Dated: July 30, 2014