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

In the Matter of	)	
	)	
SES Americom, Inc.	)	File No. SAT-PPL-_____
	)	
Request to Add NSS-11 to the Permitted Space Station List for Ku-band Operations	)	

PETITION

SES Americom, Inc. ("SES") hereby respectfully requests that the Commission authorize the Gibraltar-licensed NSS-11 Ku-band spacecraft to serve the U.S. market from 176° E.L.[1] Specifically, SES requests that the Commission add NSS-11 to the Commission's Permitted Space Station List ("Permitted List") for fixed-satellite service ("FSS") and telemetry, tracking and control ("TT&C") operations in the 14-14.5 GHz band for Earth-to-space operations and the 12.25-12.75 GHz band for space-to-Earth operations. Grant of the requested authority is consistent with Commission precedent and will serve the public interest by allowing SES to meet demand for new Ku-band services to the U.S. market from 176° E.L.

A completed FCC Form 312 is attached, along with technical materials on Schedule S and in narrative form pursuant to Section 25.114 of the Commission's rules. SES seeks action on this petition to permit use of the in-orbit NSS-11 spacecraft to initiate service to U.S. customers beginning on January 1, 2019.

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[1] The NSS-11 satellite network operates pursuant to the following filing of the Luxembourg Administration: LUX-G9-30.

I. BACKGROUND

NSS-11 is a Ku-band spacecraft that was launched in October of 2000 and operates under an authorization issued by the Gibraltar Regulatory Authority ("GRA") at the 176° E.L. orbital location, where it currently provides service to Asia. In response to customer demand, SES is seeking authority to use NSS-11 to commence service to Alaska, Hawaii, Guam, the Pacific Ocean, the Aleutian Islands, and the Northwestern United States.

II. AUTHORIZING NSS-11 TO PROVIDE FSS IN THE U.S. IS CONSISTENT WITH FCC POLICIES AND THE PUBLIC INTEREST

SES is a leading provider of satellite communications services in the United States and around the world. Granting U.S. market access for NSS-11 will enable SES to introduce Ku-band service at the 176° E.L. orbital location for the benefit of U.S. satellite service customers. Furthermore, grant of market access for NSS-11 is consistent with the Commission's *DISCO II* policies.[2]

In the *DISCO II* proceeding, the Commission adopted policies for determining whether to permit foreign-licensed satellites to serve the U.S. market, and these standards are codified in Section 25.137 of the Commission's Rules.[3] The Commission's policies are intended to ensure that entry by a foreign-licensed satellite will not distort competition in the U.S.[4] The Commission also considers whether there are spectrum availability issues or concerns relating to national security, law enforcement, foreign policy or trade that would present an obstacle to U.S.

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2 *See Amendment of the Commission's Policies to Allow Non-U.S. Licensed Space Stations providing Domestic and International Service in the United States*, Report & Order, 12 FCC Rcd 24094 (1997) ("*DISCO II*").

3 47 C.F.R. § 25.137.

4 *DISCO II* at ¶ 7.

market access.[5] SES's request to add NSS-11 to the Permitted List in the Ku-band fully complies with the Commission's requirements.

In *DISCO II*, the Commission adopted a presumption that, with respect to services covered by the WTO agreement, entry into the U.S. market by entities licensed by WTO member countries will promote competition in the U.S. market.[6] FSS operations except for DTH are covered by the WTO agreement.[7]

SES seeks authority to use NSS-11 to provide FSS services to U.S. customers. Gibraltar, the licensing administration for NSS-11, is a British Overseas Territory. The United Kingdom is responsible for the external relations of its territories, while each territory is responsible for its domestic law.[8] Through the United Kingdom, Gibraltar is a WTO-member country. Accordingly, the SES proposal to provide WTO-covered services is subject to the presumption in favor of entry described above.

Allowing SES to use NSS-11 to offer FSS to, from, and within the U.S. will promote competition and is otherwise consistent with the *DISCO II* framework. Therefore, the Commission should add NSS-11 to the Permitted List for services in the Ku-band.

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5 *See id.* at ¶ 178.

6 *Id.* at ¶ 39.

7 *Id.* at ¶¶ 25 & 30.

8 Under the Colonial Laws Validity Act 1865 of the United Kingdom, the local legislative body of a British Overseas Territory is empowered to make laws for the "peace, order and good government" for that territory only, subject to a presumption that such laws cannot have extraterritorial effect.

III. RULE WAIVERS ARE WARRANTED FOR NSS-11

SES seeks limited waivers of the Commission's rules in connection with the petition for NSS-11 U.S. market access authority. Grant of these 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.[9]

NSS-11 substantially complies with the Commission's rules, but certain waivers are necessary in light of the frequencies used and the technical characteristics of the spacecraft. The Commission has granted similar waivers in other cases. As shown below, NSS-11 will allow SES to initiate new Ku-band services at the 176° E.L. orbital location, and grant of the waivers will therefore serve the public interest.

Section 2.106: SES seeks a waiver of the U.S. Table of Frequency Allocations to permit NSS-11 to use the 12.25-12.75 GHz frequency band for FSS downlinks on an unprotected, non-interference basis in International Telecommunication Union ("ITU") Region 2, including in the United States. Grant of the requested waiver is consistent with Commission precedent and with the public interest.

Waivers of the Table of Allocations are generally granted "when there is little potential for interference into any service authorized under the Table of Frequency allocations and when

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[9] *PanAmSat Licensee Corp.*, 17 FCC Rcd 10483, 10492 (Sat. Div. 2002) (footnotes omitted).

the nonconforming operator accepts any interference from authorized services."[10] A waiver for NSS-11 is in the public interest because SES's use of these frequencies in ITU Region 2 will not cause harmful interference to any terrestrial fixed service ("FS") stations or broadcasting-satellite service ("BSS") operations.

Terrestrial FS networks operating within the United States will not be subject to harmful interference because NSS-11's transmissions in the 12.25-12.75 GHz frequency band in ITU Region 2 will comply with the power flux density ("pfd") limits for this band specified in Article 21.16. The technical materials being submitted in support of this application demonstrate that the pfd levels for the NSS-11 transmit beams do not exceed those in Article 21.16.

Similarly, there is no potential for harmful interference from NSS-11 into U.S. BSS networks. The Commission has authorized a number of satellites to use the 12.2-12.7 GHz frequencies for FSS downlinks within the U.S. and ITU Region 2. For example, in an order regarding EUTELSAT 172B at 172° E.L., the Commission noted that waiving the Table of Allocations to allow FSS downlinks in the 12.2-12.7 GHz frequencies "was justified because FSS operations in these bands are consistent with No. 5.492 of the ITU Radio Regulations and there are no U.S. BSS satellites transmitting from orbital locations within 50° of the 172° E.L. orbital location."[11]

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[10] *The Boeing Company,* 16 FCC Rcd 22645 (IB & OET 2001) at 22651 & n.48 (citing cases).

[11] *ES 172 LLC*, Call Sign S3021, File No. SAT-RPL-20170927-00136, grant-stamped Apr. 25 2018, Attachment to Grant at 2, ¶ 3. No. 5.492 states that "Assignments to stations of the broadcasting-satellite service which are in conformity with the appropriate regional Plan or included in the Regions 1 and 3 List in Appendix 30 may also be used for transmissions in the fixed-satellite service (space-to-Earth), provided that such transmissions do not cause more interference, or require more protection from interference, than the broadcasting-satellite service transmissions operating in conformity with the Plan or the List, as appropriate." 47 C.F.R. § 2.106, No. 5.492.

The same rationale justifies grant of a waiver for NSS-11. According to the ITU Region 2 BSS Plan, no BSS assignment can be located further west than 175.2° W.L., which is 8.8 degrees away from NSS-11 at 176° E.L. With this orbital separation, there would be no risk of harmful interference to Region 2 BSS networks from the operation of NSS-11 in the 12.25-12.7 GHz frequency band. Moreover, no BSS satellites currently operate at 175.2° W.L. Instead, the nearest operational BSS satellite to NSS-11 that serves any portion of ITU Region 2 in the 12.25-12.7 GHz band is located fifty-five degrees away from NSS-11 at 129° W.L. Accordingly, no operational BSS satellite providing service to ITU Region 2 would be subjected to harmful interference from the NSS-11 transmissions.

NSS-11 operations in ITU Region 2 will also be compatible with any future non-geostationary orbit ("NGSO") FSS operations, which have an allocation in the 12.2-12.7 GHz band in ITU Region 2.[12] The Commission has required NGSO systems authorized to serve the United States to comply with ITU limits on the equivalent power flux density ("EPFD") of NGSO operations,[13] and those limits are designed to facilitate co-frequency sharing between NGSO systems and geostationary orbit systems.

Finally, NSS-11 transmissions in the 12.7-12.75 GHz frequency band to earth stations in ITU Region 2 will not cause harmful interference to, nor claim protection from, any FSS Earth-to-space links operating in that band in ITU Region 2. SES will ensure that its receiving earth stations are sufficiently separated from any transmitting FSS earth station operating in the 12.7-12.75 GHz frequency band in ITU Region 2. If sufficient distance separation cannot be achieved, SES will not claim protection from interference that may be due to the transmitting FSS earth

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12 47 C.F.R. § 2.106, No. 5.487A.

13 *See WorldVu Satellites Limited LLC*, Order and Declaratory Ruling, 32 FCC Rcd 5366 (2017) at ¶ 24(d).

station. The NSS-11 downlink transmissions in the 12.7-12.75 GHz frequency band will not cause interference to receiving space stations. SES is not aware of any nearby geostationary space station in ITU Region 2 receiving in the 12.7-12.75 GHz frequency band.

Sections 25.114(d)(14)(ii) and 25.283(c): These rules address requirements relating to venting stored energy sources at the spacecraft's end of life.[14] NSS-11 is a Lockheed Martin A2100 series spacecraft. As described in more detail in the Technical Appendix, the oxidizer tanks on the spacecraft were sealed following completion of the launch phase and will therefore retain residual pressure when the spacecraft is retired. Given the spacecraft design, it is physically impossible for SES to vent the oxidizer tanks.

Under Commission precedent, grant of a waiver is warranted. In a number of cases involving various spacecraft models with similar limitations, the Commission has waived Section 25.283(c) to permit launch and operation of spacecraft that do not allow for full venting of pressure vessels at end of life, based on a finding that modifying the space station design at a late stage of construction would pose an undue hardship.[15] SES would have faced the same hardship if it had been required to alter the design of NSS-11 to conform to Section 25.283(c) prior to launch of the spacecraft.

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[14] Section 25.283(c) contains the substantive venting requirement, and Section 25.114(d)(14)(ii) requires applicants to submit information that addresses "whether stored energy will be removed at the spacecraft's end of life." 47 C.F.R. § 25.114(d)(14)(ii).

[15] *See, e.g., EchoStar Satellite Operating Corp.*, File No. SAT-LOA-20071221-00183, Call Sign S2746, grant-stamped Mar. 12, 2008, Attachment at ¶ 4 (granting a partial waiver of Section 25.283(c) for AMC-14, a Lockheed Martin A2100 model spacecraft, on grounds that requiring modification of satellite would present an undue hardship); *DIRECTV Enterprises LLC*, File No. SAT-LOA-20090807-00086, Call Sign S2797, grant-stamped Dec. 15, 2009, Attachment at ¶ 4 (same for DIRECTV 12, a Boeing 702 model spacecraft); *PanAmSat Licensee Corp.*, File Nos. SAT-MOD-20070207-00027, SAT-AMD-20070716-00102, Call Sign S2237, grant-stamped Oct. 4, 2007, Attachment at ¶ 7 (same for Intelsat 11, an Orbital Sciences Star model spacecraft).

With NSS-11 already in orbit and operational, there is no question of bringing the satellite into compliance with the rule. The Commission has expressly recognized this, finding a waiver of Section 25.283(c) to be justified for in-orbit spacecraft that cannot satisfy the rule's requirements. For example, in a decision involving the AMC-2 satellite, the Commission waived the rule on its own motion, observing that venting the spacecraft's sealed oxidizer tanks "would require direct retrieval of the satellite, which is not currently possible."[16]

The same practical obstacle is present here. Because NSS-11 is already in orbit, SES can do nothing to enable full venting of residual pressure in the oxidizer tanks. Given this reality, a waiver is clearly warranted.

IV. CONCLUSION

For the foregoing reasons, SES respectfully requests that the Commission add NSS-11 to the Permitted List for FSS operations and TT&C in the Ku-band.

Respectfully submitted,

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[16] File No. SAT-MOD-20101215-00261, Call Sign S2134, grant-stamped Mar. 8, 2011, Attachment at ¶ 4. *See also XM Radio Inc.*, File No. SAT-MOD-20100722-00165, Call Sign S2616, grant-stamped Oct. 14, 2010, Attachment at ¶ 2 (waiving Section 25.283(c) for XM-4, a Boeing 702 model spacecraft, because "modification of the spacecraft would present an undue hardship, since XM-4 is an in-orbit space station and venting XM-4's helium and xenon tanks would require direct retrieval of the satellite, which is not currently possible").

TECHNICAL APPENDIX

NSS-11 AT 176° E.L.

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

This technical appendix is submitted in support of an application of SES Americom, Inc. ("SES") seeking authority to serve the U.S. market with the in-orbit NSS-11 spacecraft operating at 176° E.L. NSS-11 is equipped with twenty-eight 36 MHz Ku-band transponders with uplink frequencies in the 14-14.5 GHz band and downlink frequencies in the 12.25-12.75 GHz band using both horizontal and vertical polarizations. These Ku-band transponders will provide coverage of Alaska, Hawaii, Guam, the Pacific Ocean, the Aleutian Islands, the Northwestern United States, and East Asia. The Telemetry, Tracking and Command ("TT&C") capabilities in the Ku-band will be used as described below. The interconnectivity of the NSS-11 uplink and downlink transponders and the satellite's detailed frequency plan are described below.

2.0 Schedule S (§25.114(c))

The Schedule S online information is submitted as part of this filing. Pursuant to Section 25.114(c)(4)(vi)(A), the gxt diagrams for the global telecommand receive beam ("GBLR") and telemetry transmit beam ("GBLH") and the bicone antennas ("BCAR") and ("BCAT") are not included because for each of these beams the contour at 8 dB below peak falls entirely beyond the edge of the visible Earth.

3.0 TT&C frequencies and beams

The TT&C subsystem consists of redundant receivers and transmitters which are able to operate through either an omnidirectional antenna system or through the communications antennas. There are two global horn antennas on NSS-11. NSS-11 will use the global horn antenna ("GBLH") for transmitting telemetry carriers in Ku-band in the horizontal polarization, and the global horn antenna ("GBLR") for receiving the Ku-band telecommand carrier with a vertical polarization while on-station. For large attitude excursions, a bicone antenna is utilized allowing command ("BCAR") and telemetry ("BCAT") use at body angles where both horn antennas are

pointed off the Earth. This antenna has the same polarization scheme as the horn antennas. The communications antennas ("BTX1" and "BTX2") will be used when using the low-power beacon outputs which route to the communications reflectors for transmitting telemetry carriers in Ku-band in the vertical polarization. The polarizations for the telemetry beams "BTX1" and "BTX2" are switchable for the frequencies below. All of these carriers are described in the Schedule S and below.

Table 1: TT&C Carrier Frequencies

	Frequency, MHz	Nominal polarization
Global horn (GBLR) and bicone antenna (BCAR) command carriers (bandwidth: 800 KHz)		
Ku-band	14498.0	V
Global horn (GBLH) and bicone antenna (BCAT) telemetry (bandwidth: 400 KHz)		
Ku-band	12250.5	H
	12251.5	H
	12749.5	H
Low powered beacon (BTX1 and BTX2) telemetry (bandwidth: 400 KHz)		
Ku-band	12250.5	V
	12251.5	V
	12749.5	V

4.0 PFD Compliance for Sharing in the 12.25 GHz to 12.75 GHz band

The Commission's rules do not specify a power flux density ("pfd") limit in the 12.25-12.75 GHz band, but Article 21.16 the ITU Radio Regulations includes pfd limits for this band. The pfd levels for the NSS-11 transmit beams have been provided in the Schedule S and in Annex A and show that the levels do not exceed those in Article 21.16.

5.0 Adjacent Satellite Compatibility (§25.140(a))

SES certifies that the uplink EIRP density levels from earth stations communicating with NSS-11 in the conventional Ku-band will not exceed the applicable envelopes in §25.218, §25.221(a)(1), §25.222(a)(1), §25.226(a)(1), or §25.227(a)(1) unless coordinated with operators of authorized co-frequency space stations at assigned locations within six degrees of 176° E.L. and except as provided in §25.140(d).

Attached as Annex B hereto is an interference analysis pursuant to §25.140(a)(3)(v) demonstrating the compatibility of NSS-11 with adjacent spacecraft operating in the 12.25-12.75 GHz frequency band. The only satellite within two degrees of 176° E.L. is Eutelsat 174A at 174° E.L., and the analysis in Annex B uses the C/N characteristics supplied in the Eutelsat 174A application[1] for the ADH4/ADV4 beam and a TV Carrier, since these are the beams whose frequencies overlap with those of NSS-11. The analysis also considers a hypothetical co-frequency space station located at 178° E.L. with the same receiving and transmitting characteristics as NSS-11. The results of the interference analysis demonstrate that NSS-11 is compatible with adjacent satellite networks and can successfully operate in a two-degree spacing environment.

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

6.1 Spacecraft Hardware Design (§ 25.114(d)(14)(i)):

SES, which was responsible for the design, manufacture and operation of the NSS-11 satellite, has assessed and limited the amount of debris released in a planned manner during normal operations of NSS-11 at 176.0° E.L. No debris is generated during normal on-station operations, and the spacecraft is in a stable configuration.

[1] *ES 172 LLC*, Call Sign S2610, File Nos. SAT-MOD-20171122-00159 & SAT-AMD-20171205-00165, granted Feb. 14, 2018.

SES has also assessed and limited the probability of the space station becoming a source of orbital debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. The design of the NSS-11 satellite locates all sources of stored energy within the body of the structure, which provides protection from small orbital debris. SES requires that spacecraft manufacturers assess the probability of micrometeorite damage that can cause any loss of functionality. This probability is then factored into the ultimate spacecraft probability of success. Any significant probability of damage would need to be mitigated in order for the spacecraft design to meet SES's required probability of success of the mission. SES has taken steps to limit the effects of any collisions through shielding, the placement of components, and the use of redundant systems.

6.2 Minimizing Accidental Explosions (§ 25.114(d)(14)(ii)):

The NSS-11 satellite was designed and manufactured by Lockheed Martin and was launched in 2000.

SES has assessed and limited the probability of accidental explosions during and after completion of mission operations. As part of the Safety Data Package submission for the spacecraft, an extensive analysis is completed by the spacecraft manufacturer, reviewing each potential hazard relating to accidental explosions. A matrix is generated indicating the worst-case effect, the hazard cause, and the hazard controls available to minimize the severity and the probability of occurrence. Each subsystem is analyzed for potential hazards, and the Safety Design Package is provided for each phase of the program running from design phase, qualification, manufacturing and operational phase of the spacecraft. Also, the spacecraft manufacturer generates a Failure Mode Effects and Criticality Analysis for the spacecraft to identify all potential mission failures. The risk of accidental explosion is included as part of this

analysis. This analysis indicates failure modes, possible causes, methods of detection, and compensating features of the spacecraft design.

The design of the NSS-11 spacecraft is such that the risk of explosion is minimized both during and after mission operations. In designing and building the spacecraft, the manufacturer took steps to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. All propulsion subsystem pressure vessels, which have high margins of safety at launch, have even higher margins in orbit, since use of propellants and pressurants during launch decreases the propulsion system pressure. Burst tests are performed on all pressure vessels during qualification testing to demonstrate a margin of safety against burst. Bipropellant mixing is prevented by the use of valves that prevent backwards flow in propellant and pressurization lines. All pressures, including those of the batteries, are monitored by telemetry.

At the end of operational life, after the satellite has reached its final disposal orbit, onboard sources of stored energy will be depleted or secured, and the batteries will be discharged. However, at the end of NSS-11's operational life, there will be oxidizer remaining in the tanks that cannot be vented. Following insertion of the spacecraft into orbit, the spacecraft manufacturer permanently sealed the oxidizer tanks by firing pyrotechnic valves. This is a design feature of the Lockheed A2100 series spacecraft that cannot now be changed or remedied. Information regarding the residual oxidizer in the tanks is as follows:

Tank	Volume [l]	Pressure [bar]	Temp. [deg C]	Oxidizer mass [kg]
Ox 1	328.4	17.0	9.4	12.05
Ox 2	328.4	17.0	9.4	12.05

The oxidizer tanks are well shielded, and the residual pressure in the tanks will be well below their maximum rating.

In the narrative portion of this application, SES requests any necessary waiver of Sections 25.114(d)(14)(ii) and 25.283(c) in connection with the residual oxidizer that will remain in these tanks at the end of the satellite's life.

6.3 Safe Flight Profiles (§ 25.114(d)(14)(iii)):

SES has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Specifically, SES has assessed the possibility of collision with satellites located at, or reasonably expected to be located at, the requested orbital location or assigned in the vicinity of that location.

Regarding avoidance of collisions with controlled objects, in general, if a geosynchronous satellite is controlled within its specified longitude and latitude station-keeping limits, collision with another controlled object (excluding where the satellite is collocated with another object) is the direct result of that object entering the allocated space.

SES is not aware of any other FCC- or non-FCC licensed spacecraft that are operational or planned to be deployed at 176° E.L. or to nearby orbital locations such that there would be an overlap with the stationkeeping volume of NSS-11.

On-station operations require station-keeping within +/- 0.1 degrees for N-S station-keeping and +/- 0.05 degrees for E-W station-keeping, thereby ensuring adequate collision avoidance distance from other satellites in geosynchronous orbit. In the event that collocation with another satellite is required, SES will use the proven Inclination-Eccentricity technique to ensure adequate separation between satellites. This strategy is presently in use by SES at several orbital locations to ensure proper operation and safety of multiple satellites within one orbital box.

SES uses the Space Data Center ("SDC") system from the Space Data Association to monitor the risk of close approach of its satellites with other objects. Any close encounters (separation of less than 10 km) are flagged and investigated in more detail. If required, avoidance maneuvers are performed to eliminate the possibility of collisions.

During any relocation, the moving spacecraft is maneuvered such that it is at least 30 km away from the synchronous radius at all times. In most cases, much larger deviation from the synchronous radius is used. In addition, the SDC system is used to ensure no close encounter occurs during the move. When deorbit of a spacecraft is required, the initial phase is treated as a satellite move, and the same precautions are used to ensure collision avoidance.

6.4 Post Mission Disposal Plan (§ 25.114(d)(14)(iv)):

Post-mission disposal of the satellite from operational orbit will be accomplished by carrying out maneuvers to raise the satellite to a higher orbit. The upper stage engine remains part of the satellite, and there is no re-entry phase for either component. The fuel budget for elevating the satellite to a disposal orbit is included in the satellite design.

NSS-11 is not subject to the minimum perigee requirement of Section 25.283(a) of the Commission's Rules because the satellite was launched prior to March 18, 2002. SES plans to maneuver NSS-11 to a disposal orbit with a minimum perigee at least 150 km above its operational geostationary orbit. SES intends to reserve 4.5 kg of fuel in order to account for post-mission disposal of NSS-11. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

Annex A: PFD tables by beam

CHT						
Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	54.2	54.2	54.2	54.2	54.2	54.2
Gain roll-off at elevation angle, dBi	-6.1	-5.5	-4.5	-3.41	-2.3	0.0
EIRP at elevation angle, dBW	48.1	48.7	49.7	50.8	51.9	54.2
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	8.5	9.2	10.1	11.2	12.3	14.6
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
pfd, dBW/m2/4KHz	-154.7	-154.0	-152.9	-151.7	-150.5	-147.4
No 21.16 PFD Limit (dBW/m2/4kHz)	-148.0	-145.5	-143.0	-140.5	-138.0	-138.0
Margin from No. 21.16 (dBW/m2/4kHz)	6.7	8.5	9.9	11.2	12.5	9.4
Annex 4 of Appendix 30 (8.6 degrees of orbital separation) (dBW/m2/4kHz)	-144.1	-144.1	-144.1	-144.1	-144.1	-144.1
Margin from Annex 4 of Appendix 30	10.6	9.9	8.8	7.6	6.4	3.3

SAT						
Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	54.2	54.2	54.2	54.2	54.2	54.2
Gain roll-off at elevation angle, dBi	-4.93	-4.81	-3.63	-3.18	-2.47	0
EIRP at elevation angle, dBW	49.2	49.3	50.5	51.0	51.7	54.2
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	9.7	9.8	11.0	11.4	12.1	14.6
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
pfd, dBW/m2/4KHz	-153.6	-153.4	-152.1	-151.5	-150.7	-147.5
No 21.16 PFD Limit (dBW/m2/4kHz)	-148.0	-145.5	-143.0	-140.5	-138.0	-138.0
Margin from No. 21.16 (dBW/m2/4kHz)	5.6	7.9	9.1	11.0	12.7	9.5
Annex 4 of Appendix 30 (8.6 degrees of orbital separation) (dBW/m2/4kHz)	-144.1	-144.1	-144.1	-144.1	-144.1	-144.1
Margin from Annex 4 of Appendix 30	9.5	9.2	7.9	7.4	6.6	3.3

NET						
Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	54.4	54.4	54.4	54.4	54.4	54.4
Gain roll-off at elevation angle, dBi	-4.0	-4.0	-4	-4	-4.0	0.0
EIRP at elevation angle, dBW	50.4	50.4	50.4	50.4	50.4	54.4
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	10.9	10.9	10.9	10.9	10.9	14.9
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
pfd, dBW/m2/4KHz	-152.4	-152.3	-152.2	-152.1	-152.0	-147.2
No 21.16 PFD Limit (dBW/m2/4kHz)	-148.0	-145.5	-143.0	-140.5	-138.0	-138.0
Margin from No. 21.16 (dBW/m2/4kHz)	4.4	6.8	9.2	11.6	14.0	9.2
Annex 4 of Appendix 30 (8.6 degrees of orbital separation) (dBW/m2/4kHz)	-144.1	-144.1	-144.1	-144.1	-144.1	-144.1
Margin from Annex 4 of Appendix 30	8.3	8.2	8.1	7.9	7.8	3.1

GBLT						
Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	6.0	6.0	6.0	6.0	6.0	6.0
Gain roll-off at elevation angle, dBi	0.0	0.0	0.0	0.0	0.0	0.0
EIRP at elevation angle, dBW	6.0	6.0	6.0	6.0	6.0	6.0
Carrier bandwidth, MHz	0.4	0.4	0.4	0.4	0.4	0.4
EIRP density at elevation angle dBW/4kHz	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
pfd, dBW/m2/4KHz	-177.3	-177.2	-177.1	-176.9	-176.8	-176.1
No 21.16 PFD Limit (dBW/m2/4kHz)	-148.0	-145.5	-143.0	-140.5	-138.0	-138.0
Margin from No. 21.16 (dBW/m2/4kHz)	29.3	31.7	34.1	36.4	38.8	38.1
Annex 4 of Appendix 30 (8.6 degrees of orbital separation) (dBW/m2/4kHz)	-144.1	-144.1	-144.1	-144.1	-144.1	-144.1
Margin from Annex 4 of Appendix 30	33.1	33.0	32.9	32.8	32.7	31.9

BTX1						
Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	14.6	14.6	14.6	14.6	14.6	14.6
Gain roll-off at elevation angle, dBi	-20.0	-20.0	-19.9	-19.4	-18.5	0.0
EIRP at elevation angle, dBW	-5.4	-5.4	-5.2	-4.8	-3.9	14.6
Carrier bandwidth, MHz	0.4	0.4	0.4	0.4	0.4	0.4
EIRP density at elevation angle dBW/4kHz	-25.4	-25.4	-25.2	-24.8	-23.9	-5.4
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
pfd, dBW/m2/4KHz	-188.7	-188.5	-188.3	-187.7	-186.7	-167.5
No 21.16 PFD Limit (dBW/m2/4kHz)	-148.0	-145.5	-143.0	-140.5	-138.0	-138.0
Margin from No. 21.16 (dBW/m2/4kHz)	40.7	43.0	45.3	47.2	48.7	29.5
Annex 4 of Appendix 30 (8.6 degrees of orbital separation) (dBW/m2/4kHz)	-144.1	-144.1	-144.1	-144.1	-144.1	-144.1
Margin from Annex 4 of Appendix 30	44.5	44.4	44.2	43.6	42.6	23.3

BTX2						
Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	19.7	19.7	19.7	19.7	19.7	19.7
Gain roll-off at elevation angle, dBi	-20.0	-20.0	-20.0	-20.0	-20.0	0.0
EIRP at elevation angle, dBW	-0.3	-0.3	-0.3	-0.3	-0.3	19.7
Carrier bandwidth, MHz	0.4	0.4	0.4	0.4	0.4	0.4
EIRP density at elevation angle dBW/4kHz	-20.3	-20.3	-20.3	-20.3	-20.3	-0.3
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
pfd, dBW/m2/4KHz	-183.5	-183.4	-183.3	-183.2	-183.1	-162.3
No 21.16 PFD Limit (dBW/m2/4kHz)	-148.0	-145.5	-143.0	-140.5	-138.0	-138.0
Margin from No. 21.16 (dBW/m2/4kHz)	35.5	37.9	40.3	42.7	45.1	24.3
Annex 4 of Appendix 30 (8.6 degrees of orbital separation) (dBW/m2/4kHz)	-144.1	-144.1	-144.1	-144.1	-144.1	-144.1
Margin from Annex 4 of Appendix 30	39.4	39.3	39.2	39.1	39.0	18.2

Annex B: Compatibility with Adjacent Satellites

At 174° E.L.

DOWNLINK

Ku-band	12700 MHz
topocentric sep.	2.2 deg
k	-228.6 dBK

SES beams	SATH	NETH/NETV	CHTV
Carrier EIRP density, dBW/Hz	-21.4	-21.2	-21.4
Satellite EIRP max, dBW	54.15	54.41	54.19
Rx ES ant. Dia., m	0.9	1.2	0.9
Rx ES ant. Gain, dBi	39.7	42.2	39.7
Sidelobe gain (at 2.2 deg), dBi	20.4	20.4	20.4
Noise Temp, K	110	110	110
C/N (thermal), dB	19.5	22.2	19.5

Adiacent Satellite beams	ADH4/ADV4 FWD Best	ADH4/ADV4 RTN Best	TV Carrier
Carrier EIRP density, dBW/Hz	-27.7	-28.1	-28.2
Satellite EIRP max, dBW	53.4	53.4	53.4
Rx ES ant. Dia., m	1.2	4.5	0.9
Rx ES ant. Gain, dBi	42.2	53.7	39.7
Sidelobe gain (at 2.2 deg), dBi	20.4	20.4	20.4
Noise Temp, K	110	110	110
C/N (thermal), dB	15.7	26.8	12.7

Downlink C/I into SES carriers due to interference from adj. satellite

	SES carriers		
Adj. Sat beams	SATH	NETH/NETV	CHTV
ADH4/ADV4 FWD Best	25.5	28.3	25.6
ADH4/ADV4 RTN Best	25.9	28.7	26.0
TV Carrier	26.1	28.8	26.1

Downlink C/I into adjacent sat carriers due to interference from SES carriers

	SES carriers		
Adj. Sat beams	SATH	NETH/NETV	CHTV
ADH4/ADV4 FWD Best	15.5	15.2	15.4
ADH4/ADV4 RTN Best	26.5	26.3	26.5
TV Carrier	12.4	12.2	12.4

SES	off-axis	on-axis
SATH	-1.0	18.3
NETH/NETV	-0.7	21.0
CHTV	-0.9	18.3

ADJ.		
ADH4/ADV4 FWD Best	-7.3	14.5
ADH4/ADV4 RTN Best	-7.7	25.6
TV Carrier	-7.8	11.5

Summary	SATH	NETH/NETV	CHTV
SES C/N	19.5	22.2	19.5
C/I into SES	26.3	28.8	26.3
C/N+I	18.7	21.4	18.7
Minimum required C/N	13.0	13.0	13.0
Excess Margin	6.5	9.2	6.5

Summary ETL	ADH4/ADV4 FWD Best	ADH4/ADV4 RTN Best	TV Carrier
ETL C/N	15.68	26.76	12.66
C/I from SES	15.2	26.3	12.2
C/N+I	12.42	23.51	9.41
Minimum required C/N	8.20	13.00	7.10
Excess Margin	4.22	10.51	2.31

At 178° E.L.

DOWNLINK

Ku-band	12700 MHz
topocentric sep.	2.2 deg
k	-228.6 dBK

SES beams	SATH	NETH/NETV	CHTV
Bandwidth, MHz	54	36	36
Carrier EIRP density, dBW/Hz	-30.4	-21.2	-21.2
Satellite EIRP max, dBW	46.96	54.41	54.41
Rx ES ant. Dia., m	0.65	1.2	0.9
Rx ES ant. Gain, dBi	36.9	42.2	39.7
Sidelobe gain (at 2.2 deg), dBi	20.4	20.4	20.4
Noise Temp, K	148	162	162
C/N (thermal), dB	6.4	20.5	18.0

Adiacent Satellite beams	Beam A	Beam B	Beam C
Carrier EIRP density, dBW/Hz	-30.4	-21.2	-21.2
Satellite EIRP max, dBW	46.96	54.41	54.41
Rx ES ant. Dia., m	0.65	1.2	0.9
Rx ES ant. Gain, dBi	36.9	42.2	39.7
Sidelobe gain (at 2.2 deg), dBi	20.4	20.4	20.4
Noise Temp, K	148	162	162
C/N (thermal), dB	6.4	20.5	18.0

Downlink C/I into SES carriers due to interference from adj. satellite

	SES carriers		
Adj. Sat beams	SATH	NETH/NETV	CHTV
Beam A	16.4	31.0	28.5
Beam B	7.2	21.7	19.3
Beam C	7.2	21.7	19.3

Downlink C/I into adjacent sat carriers due to interference from SES carriers

	SES carriers		
Adj. Sat beams	SATH	NETH/NETV	CHTV
Beam A	16.4	7.2	7.2
Beam B	31.0	21.7	21.7
Beam C	28.5	19.3	19.3

SES	off-axis	on-axis
SATH	-9.9	6.5
NETH/NETV	-0.7	21.0
CHTV	-0.7	18.5

ADJ.		
Beam A	-9.9	6.5
Beam B	-0.7	21.0
Beam C	-0.7	18.5

Summary	SATH	NETH/NETV	CHTV
SES C/N	6.4	20.5	18.0
C/I into SES	16.4	31.0	28.5
C/N+I	5.99	20.13	17.63
Minimum required C/N	-2.4	13.0	13.0
Excess Margin	8.39	7.13	4.63

Summary Adj	Beam A	Beam B	Beam C
Adj C/N	6.4	20.5	18.0
C/I from SES	16.4	31.0	28.5
C/N+I	5.99	20.13	17.63
Minimum required C/N	-2.4	13.0	13.0
Excess Margin	8.39	7.13	4.63

DECLARATION

I, Donna Wang, hereby certify under penalty of perjury that I am the technically qualified person responsible for 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/ Donna Wang

Donna Wang
Engineer, Spectrum Management & Development Americas
SES

Dated: August 15, 2018