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

In the Matter of	)	
	)	
SES Americom, Inc.	)	File No. SES-LIC-___________
	)	
Application for Blanket License for	)	
Operation of Ku-Band Transmit/Receive	)	
Earth Stations Aboard Aircraft	)	

APPLICATION FOR ESAA BLANKET LICENSE

SES Americom, Inc. ("SES") hereby respectfully requests that the Commission grant a blanket license authorizing SES to operate 1000 of each of two types of Ku-band transmit/receive earth stations aboard aircraft ("ESAA") terminals on domestic and international flights pursuant to Section 25.227 of the Commission's rules.[1] Grant of the requested authority is consistent with Commission precedent and will serve the public interest by allowing SES to provide in-flight broadband service, enhancing competition in this important market.

A completed FCC Form 312 and Schedule B are attached. SES seeks action on this application in order to commence ESAA operations beginning in October 2019.

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[1] 47 C.F.R. § 25.227. For the Commission's convenience, SES is attaching as Annex 1 hereto a table listing the requirements of Section 25.227 and providing a cross-reference to the necessary information. Annex 1 identifies the requirements set forth in the Commission's current rules, as the changes to the regulatory regime for ESAAs and other earth stations in motion ("ESIMs") that the Commission adopted last September have not yet taken effect. *See Amendment of Parts 2 and 25 of the Commission's Rules to Facilitate the Use of Earth Stations in Motion Communicating with Geostationary Orbit Space Stations in Frequency Bands Allocated to the Fixed-Satellite Service*, Report and Order and Further Notice of Proposed Rulemaking, FCC 18-138 (rel. Sept. 27, 2018) (the "ESIMs Order"). In the ESIMs Order, the Commission has decided to eliminate certain substantive requirements currently contained in Section 25.227, and SES herein seeks any necessary waiver of Section 25.227 to permit it to design its system without incorporating these elements.

I. INTRODUCTION

SES is a leading provider of satellite communications services in the United States and around the world. In response to customer demand, SES is seeking authority to commence ESAA operations using Ku-band Fixed-Satellite Service ("FSS") capacity.[2] SES will employ Commission-approved ESAA antennas in its network: the HR6400 and HR129 antenna models manufactured by Astronics AeroSat ("Astronics"). Complete technical information regarding the antennas is already on file with the Commission and is incorporated by reference herein.[3]

Astronics has been licensed by the Commission for ESAA operations using both the HR6400 and the HR129 antennas for communications with satellites on the Commission's Permitted Space Station List ("Permitted List") in conformance with the off-axis Equivalent Isotropically Radiated Power ("EIRP") spectral density masks set forth in Section 25.227(a)(1), as well as for operations with individual satellites pursuant to coordination with adjacent satellites as described in Section 25.227(a)(2).[4] SES seeks comparable authority here, to allow the two ESAA terminals to communicate with any Permitted List spacecraft for operations that comply with the mask and use portions of the conventional and extended Ku-band spectrum that

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[2] Specifically, SES will perform uplinks in the 14.0-14.5 GHz conventional Ku-band spectrum throughout its network. Downlinks will use spectrum in the 10.7-12.75 GHz range. Additional detail regarding the planned spectrum use is provided below, along with requests for necessary waivers associated with the intended operations.

[3] *See Astronics AeroSat Corp.,* Call Sign E140087, File No. SES-LIC-20140902-00688, Technical Annex at 3, 8-14, and Annex B (describing the HR6400 terminal's technical characteristics and providing antenna performance data); File No. SES-MFS-20161003-00823, Technical Appendix at 1-3 and Section III (describing the HR129 terminal's technical characteristics and providing antenna performance data).

[4] *Astronics AeroSat Corp.,* Call Sign E140087, File No. SES-MFS-20170319-00302, granted June 19, 2017 ("Astronics ESAA License"), Section D (identifying individual satellites and the Permitted List as authorized points of communication for both the HR6400 and HR129 terminals).

are included in Permitted List authority and to authorize operations in other frequencies and/or at higher power levels on a satellite-specific basis as coordinated with adjacent satellites.

The details regarding the proposed ESAA network components are supplied in the attached Technical Description, and the space stations, teleports, and specific frequency assignments to be used with the network are identified below and in Annex 2. A letter confirming that the proposed ESAA operations will conform to coordination agreements with the operators of adjacent satellites is attached as Annex 3. These materials demonstrate that the ESAA network will comply with all substantive requirements for ESAA operations that will remain applicable once the ESIMs Order takes effect. SES is not submitting a showing with respect to current provisions of Section 25.227 that the Commission has decided to delete in the ESIMs Order: the antenna pointing accuracy specification and associated shutdown requirements and the data logging requirement. SES seeks any necessary waiver of these rule sections below.

II. SATELLITES TO BE USED WITH THE SES ESAA NETWORK

SES will use transponder capacity on commercial Ku-band FSS satellites. As discussed above, SES seeks Permitted List authority and also requests that the Commission authorize communications with ten in-orbit satellites operated by SES entities:

- ASTRA 4A at 4.8° E.L., licensed by Sweden
- NSS-6 at 169.5° W.L., licensed by the Netherlands
- NSS-12 at 57° E.L., licensed by the Netherlands
- SES-4 at 22° W.L., licensed by the Netherlands
- SES-6 at 40.5° W.L., licensed by the Netherlands
- SES-9 at 108.3° E.L., licensed by the United Kingdom (Gibraltar)
- SES-10 at 66.9° W.L., licensed by Colombia
- SES-12 at 95° E.L., licensed by the Netherlands
- SES-14 at 47.5° W.L., licensed by Brazil

- SES-15 at 129.15° W.L., licensed by the United Kingdom (Gibraltar)

Each of these satellites is eligible for authority to communicate with the planned SES ESAA network, as discussed below. Five of the satellites (SES-4, SES-6, SES-10, SES-14, and SES-15) are already on the Permitted List. The Commission has authorized U.S. ESAA networks to communicate with ASTRA-4A and with NSS-6 at a previous orbital location, and a petition to add NSS-6 to the Permitted List for operations at 169.5° W.L. is pending. The remaining satellites, NSS-12, SES-9, and SES-12, have not previously been authorized for communications with U.S.-licensed earth stations but qualify for U.S. market access under Commission policies.

ASTRA 4A: ASTRA 4A is licensed by Sweden and is positioned at 4.8° E.L. ASTRA 4A is not on the Permitted List, but the spacecraft has been approved for operations with U.S.-licensed ESAA terminals.[5] As a result, technical data relating to the satellite, including orbital debris mitigation materials, are already on file with the Commission.

SES seeks authority to use ASTRA 4A capacity for ESAA operations on a primary basis in the 14-14.25 GHz uplink spectrum and the 11.7-12.2 GHz downlink spectrum, consistent with the Commission's orders in the ESAA proceeding.[6] SES also seeks authority to use ASTRA 4A capacity for ESAA operations on a nonconforming basis in the 12.2-12.75 GHz downlink spectrum. ASTRA 4A will provide coverage of Europe and Africa.

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[5] *AC BidCo LLC*, Call Sign E120106, File Nos. SES-STA-20160729-00699, granted Aug. 24, 2016 & SES-MFS-20160824-00738, granted Dec. 13, 2016.

[6] *Revisions to Parts 2 and 25 of the Commission's Rules to Govern the Use of Earth Stations Aboard Aircraft Communicating with Fixed-Satellite Service Geostationary-Orbit Space Stations Operating in the 10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz and 14-14.5 GHz Frequency Bands*, Notice of Proposed Rulemaking and Report and Order, IB Docket Nos. 12-376 & 05-20, 27 FCC Rcd 16510 (2012) ("ESAA Order"); Second Report and Order and Order on Reconsideration, IB Docket No. 12-376, 29 FCC Rcd 4226 (2014) ("ESAA Second Order," and with the ESAA Order, the "ESAA Decisions").

NSS-6: NSS-6 is licensed by the Netherlands and will be relocated later this year to 169.5° W.L. NSS-6 is not yet on the Permitted List, but the spacecraft has been approved for operations with U.S.-licensed ESAA terminals from its prior orbital location of 95° E.L.,[7] and a petition for U.S. market access for the satellite following its relocation to 169.5° W.L. is pending.[8] As a result, full technical information regarding the spacecraft is already on file with the Commission.

SES seeks authority to use NSS-6 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and on an unprotected basis in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink spectrum, consistent with the NSS-6 Petition and the ESAA Decisions. SES also seeks authority to use NSS-6 capacity for ESAA operations on a nonconforming basis in the 12.5-12.75 GHz downlink spectrum. NSS-6 will provide coverage of Alaska, Hawaii, the Northwestern United States, the Pacific Ocean, East Asia, and Australia.

NSS-12: NSS-12 is licensed by the Netherlands and is positioned at 57° E.L. NSS-12 is not on the Permitted List, but its licensing administration, the Netherlands, is a member of the World Trade Organization ("WTO"). Accordingly, under the Commission's *DISCO II* market access framework, there is a presumption that allowing the satellite to communicate with U.S.-

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7 *See Panasonic Avionics Corp.*, Call Sign E100089, File No. SES-MFS-20150609-00349, granted June 30, 2016.

8 *New Skies Satellites B.V.*, Call Sign S3048, File No. SAT-PPL-20190403-00022 (the "NSS-6 Petition"), accepted for filing, Report No. SAT-01386 (May 3, 2019). The NSS-6 Petition notes that the Netherlands license for the satellite specifies operations at 169.5° W.L. with an east-west stationkeeping tolerance of +/- 0.1 degrees and requests a waiver of Section 25.210(j) to accommodate this larger stationkeeping allowance. *See id.*, Legal Narrative at 7. In addition, the NSS-6 Petition requests waivers of the Commission's orbital debris mitigations provisions in Section 25.114(d)(14)(ii) and 25.283(c) because the oxidizer tanks on the satellite cannot be vented at end of life. *See id.* at 8-9. To the extent necessary, SES similarly seeks a waiver of these rules to permit ESAA terminals to communicate with NSS-6.

licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.[9]

SES seeks authority to use NSS-12 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum and on an unprotected basis in the 10.95-11.7 GHz downlink spectrum, consistent with the Commission's ESAA Decisions. SES also seeks authority to use NSS-12 capacity for ESAA operations on a nonconforming basis in the 12.2-12.75 GHz downlink spectrum. NSS-12 will provide coverage of Europe, the Middle East, Central and Southern Asia, and East Africa. Annex 5 contains technical materials regarding the proposed SES operations with NSS-12, including a coverage map, link budgets, and an orbital debris mitigation statement.[10]

SES-4: SES-4 is a Netherlands-licensed satellite positioned at the 22° W.L. orbital location that has been approved for U.S. market access,[11] and complete technical information regarding the satellite is therefore already on file with the Commission. SES seeks authority to use SES-4 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum and on an unprotected basis in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink spectrum, consistent with the SES-4 Authorization and the ESAA Decisions. SES also seeks authority to use SES-4 capacity for ESAA operations on a

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9 *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, 24112, ¶ 39 (1997) ("*DISCO II*").

10 NSS-12 is built on the Space Systems Loral SSL1300 bus, and the Commission has previously licensed or granted U.S. market access to numerous other satellites using this bus, including the SES-4 spacecraft discussed below.

11 *New Skies Satellites B.V.*, Call Sign S2828, File Nos. SAT-PPL-20110620-00112 ("SES-4 Petition"), granted Mar. 15, 2012, & SAT-MPL-20120406-00065, granted Sept. 5, 2012 ("SES-4 Authorization").

nonconforming basis in the 12.5-12.75 GHz downlink spectrum.[12] SES-4 will provide coverage of North and South America, Europe, the Middle East, and West Africa.

SES-6: SES-6 is a Netherlands-licensed satellite positioned at the 40.5° W.L. orbital location that has been approved for U.S. market access,[13] and complete technical information regarding the satellite is therefore already on file with the Commission. SES seeks authority to use SES-6 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and on an unprotected basis in the 10.95-11.45 GHz downlink spectrum, consistent with the SES-6 Authorization and the ESAA Decisions. SES-6 will provide coverage of the East Coast of North America, Europe, and the North Atlantic.

SES-9: SES-9 is a Gibraltar-licensed satellite positioned at 108.3° E.L. SES-9 is not on the Permitted List, but its licensing administration, Gibraltar, is a British Overseas Territory that, through the United Kingdom, is a WTO-member country. Accordingly, under the Commission's *DISCO II* market access framework referenced above, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.

SES seeks authority to use SES-9 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum, consistent with the Commission's ESAA Decisions. SES also seeks authority to use SES-9 capacity for ESAA

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[12] Because SES-4 uses the 12.5-12.75 GHz band segment only outside the U.S. in ITU Region 1, the SES Petition did not request U.S. market access for these frequencies (*see* SES-4 Petition, Narrative at 4), and the SES-4 Authorization does not include this band segment. Technical information regarding operations of SES-4 in the 12.5-12.75 GHz band was, however, included in the SES Petition for completeness, and is therefore on file with the Commission. *See* SES-4 Petition, Schedule S.

[13] *New Skies Satellites, B.V.*, Call Sign S2870, File No. SAT-PPL-20120717-00117, grant-stamped in part July 12, 2013 and in part August 1, 2013, corrected Aug. 8, 2013 ("SES-6 Authorization").

operations on a nonconforming basis in the 12.2-12.75 GHz downlink spectrum. SES-9 will provide coverage of Asia, the Indian Ocean Region, Australia, the Middle East, and parts of Africa. Annex 5 contains technical materials regarding the proposed SES operations with SES-9, including coverage maps, link budgets, and an orbital debris mitigation statement.[14]

SES-10: SES-10 is a Colombian-licensed satellite positioned at the 66.9° W.L. orbital location that has been approved for U.S. market access,[15] and complete technical information regarding the satellite is therefore already on file with the Commission. SES seeks authority to use SES-10 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum and on an unprotected basis in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink spectrum, consistent with the SES-10 Authorization and the ESAA Decisions. SES-10 will provide coverage of Central America and South America, including Brazil.

SES-12: SES-12 is licensed by the Netherlands and is positioned at 95° E.L. SES-12 is not on the Permitted List, but its licensing administration, the Netherlands, is a WTO member. Accordingly, under the Commission's *DISCO II* market access framework referenced above, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.

SES seeks authority to use SES-12 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum and on an

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[14] SES-9 is built on the Boeing BSS-702HP bus, and the Commission has previously licensed or granted U.S. market access to many other satellites using this bus, including VIASAT 2 (Call Sign S2902).

[15] *New Skies Satellites, B.V.*, Call Sign S2950, File No. SAT-MPL-20170108-00002, reissued Mar. 22, 2017 ("SES-10 Authorization").

unprotected basis in the 10.7-11.7 GHz downlink spectrum, consistent with the Commission's ESAA Decisions. SES also seeks authority to use SES-12 capacity for ESAA operations on a nonconforming basis in the 12.2-12.75 GHz downlink spectrum. SES-12 will provide coverage of Australia, Asia, Africa, and the Middle East. Annex 5 contains technical materials regarding the proposed SES operations with SES-12, including a coverage map, link budgets, and an orbital debris mitigation statement.[16]

SES-14: SES-14 is a Brazilian-licensed satellite positioned at the 47.5° W.L. orbital location that has been approved for U.S. market access,[17] and complete technical information regarding the satellite is therefore already on file with the Commission. SES seeks authority to use SES-14 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum and on an unprotected basis in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink spectrum, consistent with the SES-14 Authorization and the ESAA Decisions. SES also seeks authority to use SES-14 capacity for ESAA operations on a nonconforming basis in the 12.2-12.45 GHz downlink spectrum. SES-14 will provide coverage of South America, including Brazil, North America, the Atlantic, and portions of Europe and West Africa.

SES-15: SES-15 is a Gibraltar-licensed satellite positioned at the 129.15° W.L. orbital location that has been approved for U.S. market access,[18] and complete technical information

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16 SES-12 is built on the Airbus E3000 bus, and the Commission has previously granted U.S. market access to other satellites using this bus, including the SES-14 spacecraft discussed below.

17 *SES DTH do Brasil Ltda*, Call Sign S2974, File No. SAT-MPL-20170606-00083, granted Sept. 7, 2017 ("SES-14 Authorization").

18 *SES Satellites (Gibraltar) Limited*, Call Sign S2951, File Nos. SAT-PPL-20160126-00007, granted July 12, 2016; SAT-MPL-20160718-00063, granted Dec. 14, 2016; & SAT-MPL-20170914-00130, granted Nov. 22, 2017 ("SES-15 Authorization").

regarding the satellite is therefore already on file with the Commission. SES seeks authority to use SES-15 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum and on an unprotected basis in the 10.7-11.7 GHz downlink spectrum, consistent with the SES-15 Authorization and the ESAA Decisions. SES-15 will provide coverage of North America.

III. COORDINATION AND SPECTRUM SHARING

The SES ESAA network will use Ku-band capacity to provide continuous connectivity and entertainment services on domestic and international flights. The letter provided in Annex 3 confirms that SES's proposed ESAA operations are consistent with the coordination agreements between operators of the satellites discussed above and operators of adjacent spacecraft. In addition, the SES operations will conform to Commission policies with respect to sharing with other services.

Space Research Service: Section 25.227(c)[19] governs use of the 14.0-14.2 GHz band, in which the National Aeronautics and Space Administration ("NASA") operates earth stations as part of the Tracking and Data Relay Satellite System ("TDRSS"). SES is in the process of negotiating a coordination agreement with NASA for protection of existing and future TDRSS sites. Pending completion of coordination with NASA, SES will not operate ESAA antennas in the 14.0-14.2 GHz band within radio line-of-sight of NASA TDRSS facilities. SES will notify the Commission when coordination is complete.

Radio Astronomy: Section 25.227(d)[20] governs use of the 14.47-14.5 GHz band used by radio astronomy service ("RAS") observatories. SES will seek a coordination agreement with

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[19] 47 C.F.R. § 25.227(c).

[20] 47 C.F.R. § 25.227(d).

the National Science Foundation ("NSF") for protection of existing and future RAS observatories. Pending completion of coordination with NSF, SES will not operate ESAA antennas in the 14.47-14.5 GHz band within radio line-of-sight of RAS observatories. SES will notify the Commission when coordination is complete.

IV. WAIVER REQUESTS

SES requests limited waivers of the Commission's rules in connection with this ESAA blanket license application. Specifically, SES requests waivers of the U.S. Table of Allocations in Section 2.106 and footnote NG52 to permit ESAA operations in the 10.7-10.95 GHz, 11.2-11.45 GHz, and 12.2-12.75 GHz spectrum, and waivers of provisions in Section 25.227 that have been deleted by the ESIMs Order. 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.[21]

A. The U.S. Table of Allocations and Footnote NG52

SES requests a waiver of the Table of Allocations in Section 2.106 of the Commission's rules to permit use of downlink spectrum in the 12.2-12.75 GHz band range for ESAA operations. The Commission has expressly recognized that "terminals on U.S.-registered aircraft may need to access foreign satellites while traveling outside of the United States (*e.g.*, over international waters), and therefore may need to downlink in the extended Ku-band in certain

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

circumstances."[22] To allow ESAA providers to meet this need, the Commission has granted authority for terminals to receive signals in the 12.2-12.75 GHz band, including in U.S. airspace.[23]

The same rationale supports grant of a waiver to permit SES to receive transmissions from the ASTRA-4A, NSS-6, NSS-12, SES-4, SES-9, SES-12, and SES-14 satellites using spectrum in the 12.2-12.75 GHz range. With the exception of the proposed use of NSS-6 and SES-14 in the 12.2-12.75 GHz frequencies, all operations in the 12.2-12.75 GHz frequency range will occur outside of U.S. airspace. In each case, the proposed operations are consistent with coordination agreements with operators of adjacent satellites within six degrees. Authorizing SES to receive signals from these satellites will not alter the technical characteristics of the satellite's operations in any way, and therefore will not create harmful interference to other authorized users of the spectrum. Furthermore, SES will not claim interference protection from such authorized users. Under these circumstances, grant of a Section 2.106 waiver is justified to permit use of frequencies in the 12.2-12.75 GHz band for downlinks from ASTRA-4A, NSS-6, NSS-12, SES-4, SES-9, SES-12, and SES-14 as part of the SES ESAA network.

SES also requests a waiver of footnote NG52 to the Table of Allocations to permit ESAA operations in the 10.7-10.95 GHz and 11.2-11.45 GHz bands on an unprotected, non-interference

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[22] *Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service*, IB Docket No. 05-20, Notice of Proposed Rulemaking, 20 FCC Rcd 2906 (2005) at ¶ 18 (footnote omitted).

[23] *See, e.g.*, AC BidCo LLC, Call Sign E120106, File No. SES-MFS-20180813-02152, granted Nov. 8, 2018, Section B and condition 900387 (authorizing reception of transmissions in the 12 GHz band on a non-interference, non-protected basis including transmissions from Intelsat 19 in U.S. airspace using 12.25-12.75 GHz); Astronics ESAA License, Section B and condition 90387; Intelsat License LLC, Call Sign E170121, File No. SES-LIC-20170626-00682, granted Oct. 4, 2017, Section B and condition 900414.

basis for ESAA operations, including for terminals in U.S. airspace. Grant of this waiver is consistent with Commission precedent.

The ESAA Decisions adopted footnote NG52, the successor to former footnote NG104, which specified that use of the 10.7-11.7 GHz band by the fixed-satellite service is limited to international operations. In the ESAA Order, the Commission made clear that ESAA operations in the 10.95-11.2 GHz and 11.45-11.7 GHz band were permitted on an unprotected basis and did not require a waiver of new footnote NG52, but that express carve-out does not extend to the 10.7-10.95 GHz and 11.2-11.45 GHz band segments.[24] The Commission has, however, authorized ESAA operations in both these portions of the extended Ku-band.[25]

Consistent with these past rulings, SES requests a waiver of the Table of Allocations and footnote NG52 to permit its terminals to receive transmissions, including for U.S. domestic services, from SES-6 and NSS-12 in the 11.2-11.45 GHz band segment and from SES-12 and SES-15 in the 10.7-10.95 GHz and 11.2-11.45 GHz band segments. As noted above, SES is attaching a letter confirming that operation of its ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of these spacecraft.

Authorizing SES to receive signals from in the 10.7-10.95 GHz and 11.2-11.45 GHz band segments will not alter the technical characteristics of the satellites' operations in any way, and therefore will not create harmful interference to other authorized users of the spectrum. Furthermore, SES will not claim interference protection from such authorized users. Under these circumstances, waiving footnote NG52 is justified to permit use of SES-6, NSS-12, SES-12, and

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24 *See ESAA Order* at ¶ 21.

25 *See, e.g.*, Astronics ESAA License, Section B (authorizing use of the 10.7-12.75 GHz band).

SES-15 capacity in the 10.7-10.95 GHz and 11.2-11.45 GHz band segments for ESAA operations, including in U.S. airspace.

B. Antenna Pointing and Data Logging Requirements

In the ESIMs Order, the Commission determined that provisions in Section 25.227, the current ESAA rule, relating to antenna pointing accuracy, terminal shutoff when antenna mispointing is detected, and data logging are unnecessary, and therefore deleted these specifications from the new rules governing ESIMs operations.[26] These rule changes have not yet taken effect, however, as the ESIMs Order has not been published in the Federal Register.

SES has designed its ESAA operations to conform to the revised operating requirements set forth in the ESIMs Order and therefore has not implemented measures to comply with the antenna pointing accuracy and data logging requirements deleted in the ESIMs Order. Similarly, rather than designing the ESAA system to trigger terminal shutoff based on antenna pointing accuracy, the system will comply with the requirements of the new ESIMs rule provisions in Section 25.228(b) and (c) to terminate transmissions in the event the system detects that the terminal has exceeded or is about to exceed the relevant off-axis EIRP density limits.[27] SES seeks waiver of the obsolete provisions in Section 25.227 addressing these matters: the pointing accuracy and related shutoff requirements in subsections 25.227(a)(1) and 25.227(b)(1) and the data logging requirements in Section 25.227(a)(6).[28] Because the Commission has determined

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[26] *See ESIMs Order* at ¶¶ 17-18 (eliminating antenna pointing accuracy requirements for ESAAs and other ESIMs); ¶ 21 (replacing shutoff requirements based on antenna mispointing with requirements linked to detection that an ESIM terminal has exceeded or is about to exceed relevant off-axis EIRP density limits); ¶ 24 (deleting requirements to log and maintain data regarding the specifics of ESIM terminal operations).

[27] *See id.* at ¶ 21 and new Sections 25.228(b) and (c).

[28] SES also seeks any necessary waiver of the requirement in Section 25.227(b)(7) that SES certify it will comply with data logging requirements in Section 25.227(a)(6).

that these requirements are unnecessary, the requested waiver is consistent with Commission policy.

V. PUBLIC INTEREST SHOWING

Grant of the SES ESAA blanket license application will promote competition in the market for in-flight broadband services, to the benefit of air travelers in the U.S. and abroad. ESAA networks enhance the security of air travel and allow passengers to access services that provide entertainment and enable increased productivity. With its long industry history and technological expertise as a satellite and earth station operator, SES is well-positioned to bring high-quality, reliable in-flight communications to passengers and crew on flights in U.S. airspace and around the globe.

The Commission has previously licensed both of the ESAA terminals SES proposes to use, and most of the satellites to be used are either on the Permitted List or have been authorized for operations with U.S.-licensed ESAA networks. The remaining satellites, NSS-12, SES-9, and SES-12, are licensed by WTO-member countries and meet the requirements of the *DISCO II* U.S. market access policy.

Accordingly, grant of the application is consistent with Commission policies and precedent and will serve the public interest.

VI. CONCLUSION

For the foregoing reasons, SES respectfully requests that the Commission grant SES a blanket license to operate Ku-band transmit/receive ESAA terminals on domestic and international flights, consistent with the technical parameters specified herein.

Respectfully submitted,

SES Americom, Inc.

By: *<u>/s/ Petra A. Vorwig</u>*

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Dated: June 3, 2019

ANNEX 1: Table of Information Required by Section 25.227

Section 25.227 Requirement	Citation to Information Provided
25.227(a)(1)(iii), 25.227(a)(2)(ii)	SES demonstrates in the Technical Description attached as Annex 5 that its ESAA terminals are self-monitoring and capable of automatically ceasing or reducing emissions within 100 milliseconds if the ESIM transmitter exceeds the relevant off-axis EIRP density limits.
25.227(a)(4) & 25.227(b)(5)	N/A: no use of a contention protocol is proposed.
25.227(a)(5) & 25.227(b)(6)	The 24/7 point of contact information for the SES ESAA network is the SES Network Operations Center in Manassas, Virginia. The phone number is +1 703 366 1500, and the email address is noc-sesnetworks@ses.com. The street address is: 12811 Randolph Ridge Lane Manassas, VA 20109, as specified in Form 312 Schedule B, Items E2-E9.
25.227(a)(15)	SES certifications are in Annex 7 attached.
25.227(b)(1) 25.227(b)(2)(i)	Off-axis EIRP density information regarding the Astronics Aerosat HR6400 and HR129 antenna models was previously provided to the Commission in support of the existing Astronics ESAA License, Call Sign E140087.
25.227(b)(2)(ii)	The target satellite operator certification is in Annex 3 attached.
25.227(b)(2)(iii) & (iv)	SES demonstrates in the Technical Description attached as Annex 5 that its system will comply with coordination agreements and requirements to cease emissions.
25.227(b)(4)	The ESAA network will operate in U.S. airspace, foreign airspace, and in the airspace over international waters. Coverage areas for the specific satellites to be used in the ESAA network are described in the table found in Annex 2 attached, and a composite coverage map for the overall network is included in Annex 5.
25.227(b)(7)	SES certifications are in Annex 7 attached.
25.227(b)(8)	The Radiation Hazard analyses for the ESAA terminals is in Annex 6 attached.
25.227(c)	SES is pursuing a coordination agreement with NASA and will file the agreement with the Commission when it is concluded.
25.227(d)	SES will seek a coordination agreement with NSF and will file the agreement with the Commission when it is concluded.

ANNEX 2:

Spacecraft and Teleport Tables

Satellite	Location	Beam Coverage Area	Tx (GHz)	RX (GHz)	Use in U.S. Airspace?
ASTRA 4A	4.8° E.L.	Europe, Africa	14-14.25	11.7-12.2; 12.2-12.75	No
NSS-6	169.5° W.L.	Alaska, Hawaii, the Northwestern U.S., the Pacific Ocean, East Asia, and Australia	14-14.5	10.95-11.2; 11.45-11.7; 12.5-12.75	Yes
NSS-12	57° E.L.	Europe, the Middle East, Central and Southern Asia, and East Africa	14-14.5	10.95-11.7; 11.7-12.2; 12.5-12.75	No
SES-4	22° W.L.	North and South America, Europe, the Middle East, and West Africa	14-14.5	10.95-11.2; 11.45-11.7; 11.7-12.2	Yes
				12.5-12.75	No
SES-6	40.5° W.L.	East Coast of North America, Europe, and the North Atlantic	14-14.5	10.95-11.45	Yes
SES-9	108.3° E.L.	Asia, the Indian Ocean Region, Australia, the Middle East, and parts of Africa	14-14.5	11.7-12.2; 12.2-12.75	No
SES-10	66.9° W.L.	Central America and South America, including Brazil	14-14.5	10.95-11.2; 11.45-11.7; 11.7-12.2	Yes
SES-12	95° E.L.	Australia, Asia, Africa, and the Middle East	14-14.5	10.7-11.7; 11.7-12.2; 12.2-12.75	No
SES-14	47.5° W.L.	South America, including Brazil, North America, the Atlantic, parts of Europe and West Africa	14-14.5	10.95-11.2; 11.45-11.7; 11.7-12.2; 12.2-12.45	Yes
SES-15	129.15° W.L.	North America	14-14.5	10.7-11.7; 11.7-12.2	Yes

Satellite	Teleport Location	FCC Call Sign
ASTRA 4A	Betzdorf, Luxembourg	N/A
NSS-6	Brewster, WA	E160015
NSS-12	Moscow, Russia	N/A
SES-4	Manassas, VA	E020071
SES-6	Betzdorf, Luxembourg	N/A
SES-9	Adelaide, Australia	N/A
SES-10	Somis, CA	E170090
SES-12	Adelaide, Australia	N/A
	Perth, Australia	N/A
	Jakarta, Indonesia	N/A
	Dubai, UAE	N/A
SES-14	Betzdorf, Luxembourg	N/A
	Bogota, Colombia	N/A
	Mt. Airy, MD	E170197
SES-15	Somis, CA	E160022
	Brewster, WA	E160015
	Mt. Airy, Md	E160021

ANNEX 3: Satellite Company Letter

SES
beyond frontiers

Philippe Secher
Senior Manager,
Spectrum Management & Development Americas

May 14, 2019

Federal Communications Commission
International Bureau
445 12th Street, NW
Washington, DC 20554

Subject: **Statement of SES in Support of ESAA Application**

To Whom It May Concern,

This letter supports the application of SES Americom, Inc. ("SES Americom") for a blanket earth station aboard aircraft ("ESAA") license from the Federal Communications Commission ("FCC") to operate two types of aircraft-mounted satellite earth station terminals, the HR6400 and the HR129, pursuant to ITU RR 5.504A and Section 25.227 of the Commission's rules. The ESAA terminals are planned to be operated with a total of 10 satellites under the requested blanket license, as specified in the table below. SES is filing this application pursuant to the FCC's rules governing ESAA operations, including Section 25.227.

Satellite	Orbital Location
ASTRA-4A	4.8° E.L.
NSS-6	169.5° W.L.
NSS-12	57° E.L.
SES-4	22.0° W.L.
SES-6	40.5° W.L.
SES-9	108.2° E.L.
SES-10	69.9° W.L.
SES-12	95.0° E.L.
SES-14	47.5° W.L.
SES-15	129.15° W.L.

SES certifies that it has completed coordination as required under the FCC's rules and that the power density levels of the proposed SES Americom operations are consistent with any existing satellite coordination agreements to which SES is a party with adjacent satellite operations within +/- 6 degrees of the above-listed satellites' orbital locations.

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Company Register No. B 81 267
Identification No. LU18953352

SES
beyond frontiers

If the FCC authorizes the operations as proposed, SES will include the power density levels in all future satellite network coordination agreements with operators of satellites that are adjacent (within +/- 6 degrees) to the satellites addressed by this statement.

Yours Sincerely,

Philippe Secher

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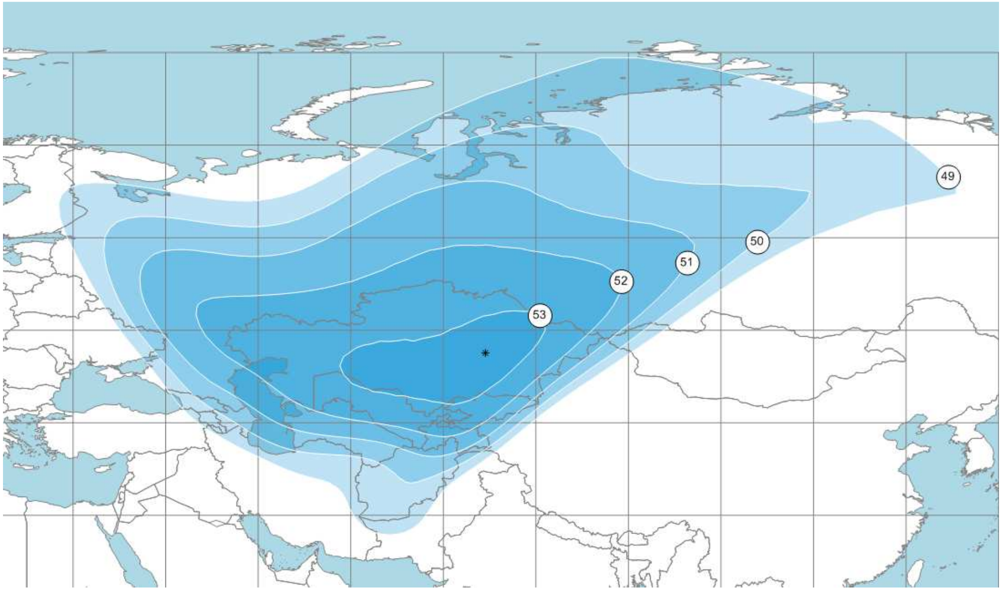
Company Register No. B 81 267
Identification No. LU18953352

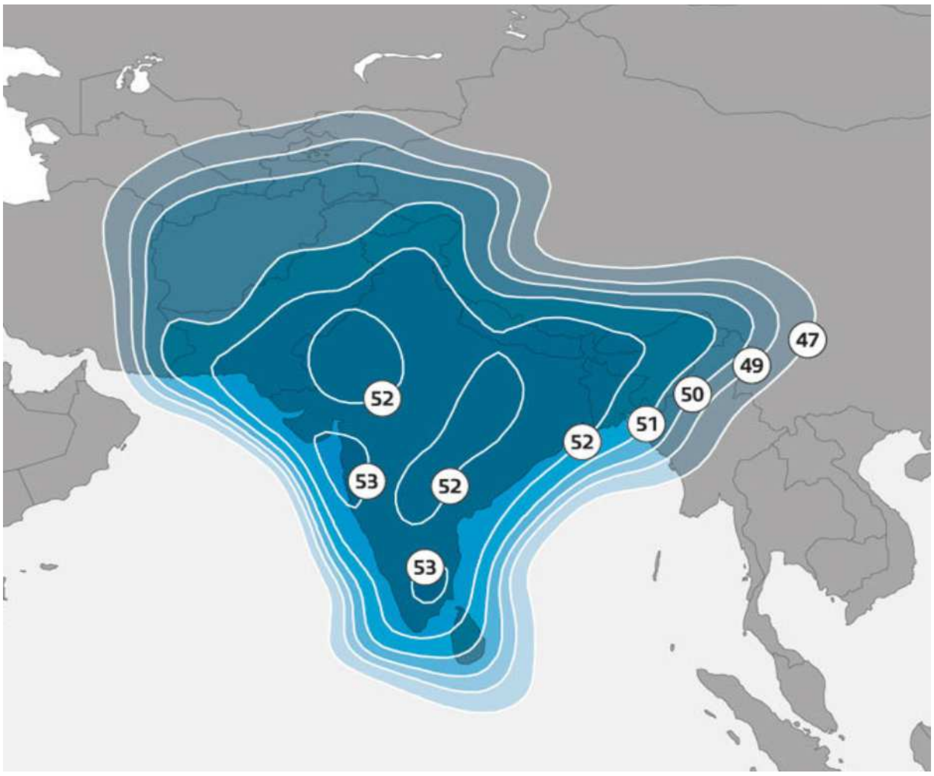
ANNEX 4: Satellite Specific Information

NSS-12

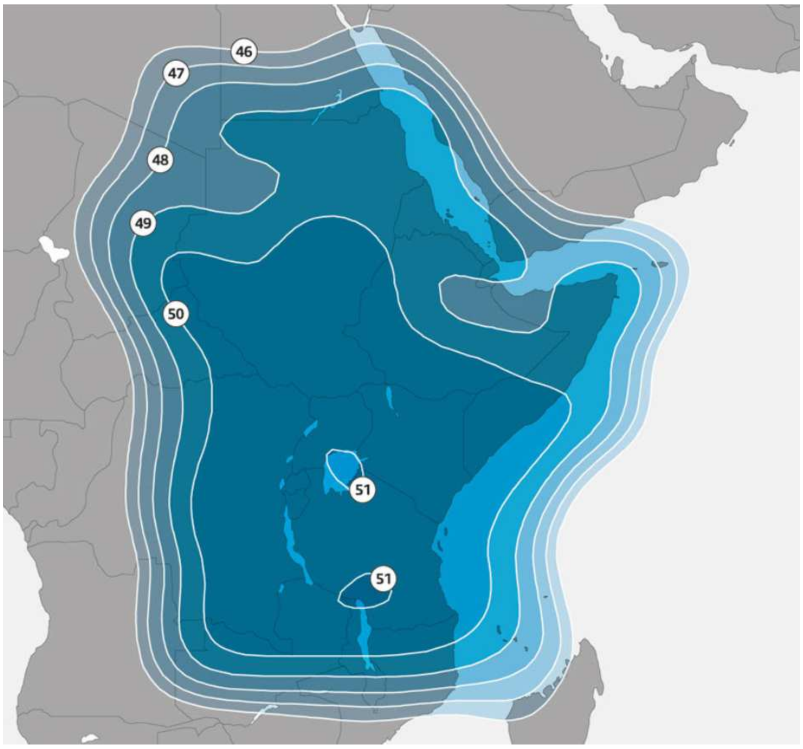
1. **Coverage Maps**



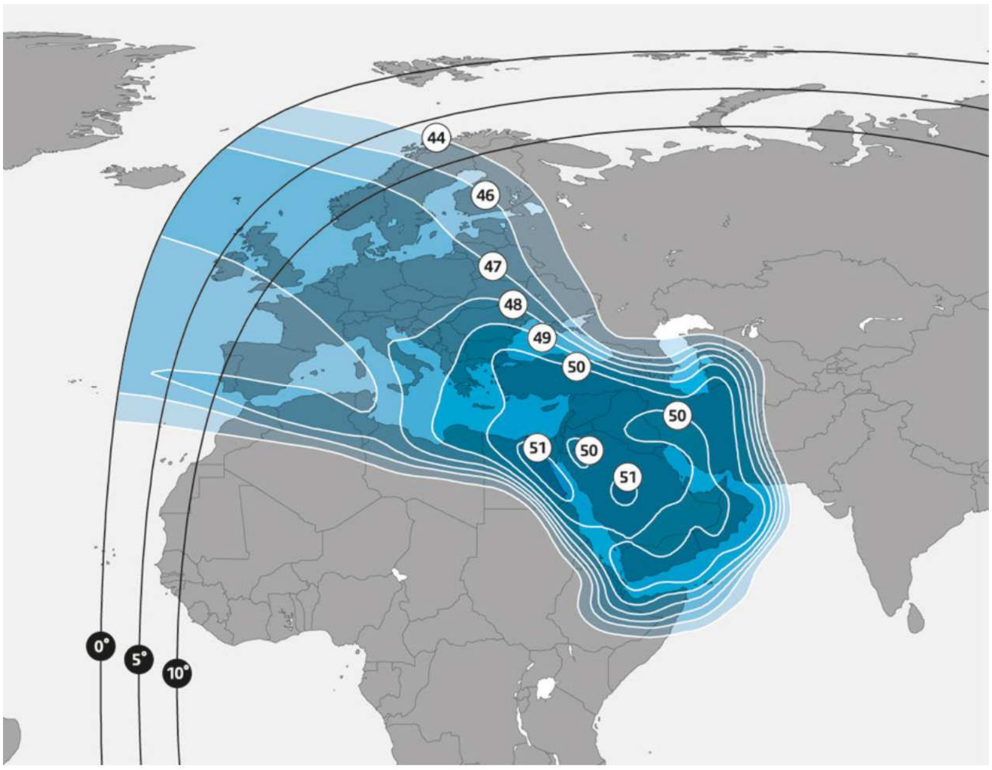
NSS-12 Central Asia Beam EIRP



NSS-12 South Asia Beam EIRP



NSS-12 East Africa Beam EIRP



NSS-12 Middle East and Europe Beam EIRP

2. Link Budgets

HR6400 Forward Link			
CAV03/CAH03+SC	10-May-19		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	NSS-12	2a. Data Rate (including "Overhead") [kbps]	70279.54
1b. Satellite Longitude [deg]	57	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	QPSK
1c. Uplink/Downlink Beam	CAV/CAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	LDPC+BCH
1d. Transponder Id	CAV03/CAH03+SC	2d. Inner Code Rate (FEC Rate/Code Rate)	0.83
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	0.94
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	3.56
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	1.00E-10
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-83.00		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	Moscow / Russian Federation	4a. Location Name	
3b. Terminal Id (Name/Number)	RUS-MSC-054 14125.0/1107	4b. Terminal Id (Name/Number)	Ku_AeroSat_HR6400_0m
3c. Uplink Frequency [GHz]	14.16	4c. Downlink Frequency [GHz]	11.11
3d. Latitude [deg]	55.80	4d. Latitude [deg]	56.80
3e. Longitude [deg]	37.65	4e. Longitude [deg]	39.80
3f. Elevation Angle [deg]	24.31	4f. Elevation Angle [deg]	23.77
3g. Tx Dish Size [m]	9.00	4g. Rx Dish Size [m]	0.83
3h. Uplink Tx EIRP@ Tx [dBW]	77.18	4h. G/T of Rx [dB/K]	11.02
3i. Satellite Footprint G/T @ Tx [dB/K]	2.86	4i. Satellite Footprint EIRP @ Rx [dBW]	50.74
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-7.19	6a. Carrier Output Backoff at Transmitting Transponder [dB]	0.00
5b. Up Link Free Space Loss [dB]	207.32	6b. Down Link Free Space Loss [dB]	205.22
5c. C/No Uplink Total [dBHz]	99.30	6c. C/No Downlink Total [dBHz]	82.95
5d. C/(IMo Intermod + Io + X-Po)	96.77	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	93.72
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	82.43	7c.Total Link Availability (end-to-end) [%]	99.6168
7b. System Link Margin (including Rain Model) [dB]	1.50	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	5.16
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	100.00%	9a. Required Power Equivalent BW (PEB) [%]	100.00%
8b. Required Bandwidth [MHz]	54.0	9b. Required Power Equivalent BW (PEB) [MHz]	54.0

HR6400 Return Link			
CAV05/CAH05	**10-May-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	NSS-12	2a. Data Rate (including "Overhead") [kbps]	666.67
1b. Satellite Longitude [deg]	57	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	BPSK
1c. Uplink/Downlink Beam	CAV/CAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	2D16S
1d. Transponder Id	CAV05/CAH05	2d. Inner Code Rate (FEC Rate/Code Rate)	0.67
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	3.27
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	N/A
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-80.94		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name		4a. Location Name	Moscow / Russian Federa
3b. Terminal Id (Name/Number)	Ku_AeroSat_HR6400_0m83_\	4b. Terminal Id (Name/Number)	RUS-MSC-054 14125.0/1
3c. Uplink Frequency [GHz]	14.28	4c. Downlink Frequency [GHz]	11.48
3d. Latitude [deg]	56.80	4d. Latitude [deg]	55.80
3e. Longitude [deg]	39.80	4e. Longitude [deg]	37.65
3f. Elevation Angle [deg]	23.77	4f. Elevation Angle [deg]	24.31
3g. Tx Dish Size [m]	0.83	4g. Rx Dish Size [m]	9.00
3h. Uplink Tx EIRP@ Tx [dBW]	43.69	4h. G/T of Rx [dB/K]	36.83
3i. Satellite Footprint G/T @ Tx [dB/K]	3.91	4i. Satellite Footprint EIRP @ Rx [dBW]	50.36
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	3.38	6a. Carrier Output Backoff at Transmitting Transponder [dB]	-31.39
5b. Up Link Free Space Loss [dB]	207.40	6b. Down Link Free Space Loss [dB]	205.50
5c. C/No Uplink Total [dBHz]	68.01	6c. C/No Downlink Total [dBHz]	70.10
5d. C/(IMo Intermod + Io + X-Po)	66.11	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	69.18
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	62.51	7c.Total Link Availability (end-to-end) [%]	99.0040
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	4.27
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	4.44%	9a. Required Power Equivalent BW (PEB) [%]	0.14%
8b. Required Bandwidth [MHz]	2.4	9b. Required Power Equivalent BW (PEB) [MHz]	0.1

HR129 Forward Link			
CAV03/CAH03+SC	10-May-19		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	NSS-12	2a. Data Rate (including "Overhead") [kbps]	50924.73
1b. Satellite Longitude [deg]	57	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	QPSK
1c. Uplink/Downlink Beam	CAV/CAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	LDPC+BCH
1d. Transponder Id	CAV03/CAH03+SC	2d. Inner Code Rate (FEC Rate/Code Rate)	0.60
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	0.94
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	1.96
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	1.00E-10
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-83.00		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	Moscow / Russian Federation	4a. Location Name	
3b. Terminal Id (Name/Number)	RUS-MSC-054 14125.0/1107	4b. Terminal Id (Name/Number)	HR129_NSS-12_CA
3c. Uplink Frequency [GHz]	14.16	4c. Downlink Frequency [GHz]	11.11
3d. Latitude [deg]	55.80	4d. Latitude [deg]	56.80
3e. Longitude [deg]	37.65	4e. Longitude [deg]	39.80
3f. Elevation Angle [deg]	24.31	4f. Elevation Angle [deg]	23.77
3g. Tx Dish Size [m]	9.00	4g. Rx Dish Size [m]	0.29
3h. Uplink Tx EIRP@ Tx [dBW]	77.18	4h. G/T of Rx [dB/K]	10.95
3i. Satellite Footprint G/T @ Tx [dB/K]	2.86	4i. Satellite Footprint EIRP @ Rx [dBW]	50.74
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-7.19	6a. Carrier Output Backoff at Transmitting Transponder [dB]	0.00
5b. Up Link Free Space Loss [dB]	207.32	6b. Down Link Free Space Loss [dB]	205.22
5c. C/No Uplink Total [dBHz]	99.47	6c. C/No Downlink Total [dBHz]	81.54
5d. C/(IMo Intermod + Io + X-Po)	96.93	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	83.05
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	79.14	7c.Total Link Availability (end-to-end) [%]	99.5302
7b. System Link Margin (including Rain Model) [dB]	1.50	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	3.56
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	100.00%	9a. Required Power Equivalent BW (PEB) [%]	100.00%
8b. Required Bandwidth [MHz]	54.0	9b. Required Power Equivalent BW (PEB) [MHz]	54.0
			Template v2 20160311

HR129 Return Link				
CAV05/CAH05	10-May-19			
Satellite & Carrier Characteristics				
1. Satellite Characteristics		**2. Carrier Parameters**		
1a. Satellite Name	NSS-12		2a. Data Rate (including "Overhead") [kbps]	666.67
1b. Satellite Longitude [deg]	57		2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	BPSK
1c. Uplink/Downlink Beam	CAV/CAH		2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	2D16S
1d. Transponder Id	CAV05/CAH05		2d. Inner Code Rate (FEC Rate/Code Rate)	0.67
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku		2e. Outer Code Rate (e.g. Reed/Solomon)	
1f. Xpdr Total Bandwidth [MHz]	54.00		2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP		2g. Required Eb/No Threshold [dB]	3.27
1h. DL Beam Polarization (V,H,L,R)	HLP		2h. Bit Error Rate (BER)	N/A
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-80.94			
Terminal Characteristics				
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**		
3a. Location Name			4a. Location Name	Moscow / Russian Federa
3b. Terminal Id (Name/Number)	HR129_NSS-12_CA		4b. Terminal Id (Name/Number)	RUS-MSC-054 14125.0/1
3c. Uplink Frequency [GHz]	14.28		4c. Downlink Frequency [GHz]	11.48
3d. Latitude [deg]	56.80		4d. Latitude [deg]	55.80
3e. Longitude [deg]	39.80		4e. Longitude [deg]	37.65
3f. Elevation Angle [deg]	23.77		4f. Elevation Angle [deg]	24.31
3g. Tx Dish Size [m]	0.29		4g. Rx Dish Size [m]	9.00
3h. Uplink Tx EIRP@ Tx [dBW]	43.69		4h. G/T of Rx [dB/K]	36.82
3i. Satellite Footprint G/T @ Tx [dB/K]	3.91		4i. Satellite Footprint EIRP @ Rx [dBW]	50.36
Link Budgets (including Rain statistics)				
5. Uplink & Intermod		**6. Downlink & Intermod**		
5.a. Carrier Output Backoff at Tx Earth Station [dB]	0.09		6a. Carrier Output Backoff at Transmitting Transponder [dB]	-31.39
5b. Up Link Free Space Loss [dB]	207.40		6b. Down Link Free Space Loss [dB]	205.50
5c. C/No Uplink Total [dBHz]	68.01		6c. C/No Downlink Total [dBHz]	70.10
5d. C/(IMo Intermod + Io + X-Po)	66.11		6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	69.18
7. Total (Uplink + Downlink + Intermod + Other Interference)				
7a. C/No Overall [dBHz]	62.51		7c.Total Link Availability (end-to-end) [%]	99.0022
7b. System Link Margin (including Rain Model) [dB]	1.00		7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	4.27
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**		
8a. Required Bandwidth [%]	4.44%		9a. Required Power Equivalent BW (PEB) [%]	0.14%
8b. Required Bandwidth [MHz]	2.4		9b. Required Power Equivalent BW (PEB) [MHz]	0.1
				Template v2 20160311

3. Orbital Debris Mitigation Statement for NSS-12 (SSL1300 Bus)

Spacecraft Hardware Design

New Skies Satellites B.V. ("SES") has assessed and limited the amount of debris released in a planned manner during normal operations of NSS-12. No debris is generated during normal on-station operations, and the spacecraft will be in a stable configuration.

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 SES's spacecraft 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 the following steps to limit the effects of such collisions: (1) critical spacecraft components are located inside the protective body of the spacecraft and properly shielded; and (2) all spacecraft subsystems have redundant components to ensure no single-point failures. The spacecraft will not use any subsystems for end-of-life disposal that are not used for normal operations.

Minimizing Accidental Explosions

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 SES 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-12 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. 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, all on-board sources of stored energy will be depleted or secured, excess propellant remaining in the chemical propulsion tanks will be vented, excess pressurant remaining in the helium tanks will be vented, and the batteries will be discharged.

Safe Flight Profiles

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.

In considering current and planned satellites that may have a station-keeping volume that overlaps that of the NSS-12 satellite, SES has reviewed the FCC databases for FCC licensed satellite networks and those that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been published by the ITU near 57° E.L. have also been reviewed. Only those networks that either operate, or are planned to operate, and have an overlapping station-keeping volume with the NSS-12 satellite, have been taken into account in the analysis.

One other satellite is operating at the nominal 57° E.L. orbital location – ASTRA 1G operating at 57.2° E.L. ASTRA 1G is operated by SES, and SES has developed a colocation strategy to ensure the satellites can operate safely. The company is not aware of any other system with an overlapping station-keeping volume with NSS-12 that is the subject of an ITU filing and that is either in orbit or progressing towards launch. SES therefore concludes that physical coordination of NSS-12 with another operator is not required at the present time.

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 de-orbit of a spacecraft is required, the initial phase is treated as a satellite move, and the same precautions are used to ensure collision avoidance.

Post-Mission Disposal

Post-mission disposal of the satellite from operational orbit will be accomplished by carrying out maneuvers to a higher orbit. The fuel budget for elevating the satellite to a disposal orbit is included in the satellite design. SES plans to maneuver NSS-12 to a disposal orbit with a minimum perigee of 283.5 km above the normal GSO operational orbit. This proposed disposal orbit altitude results from application of the IADC formula based on the following calculation:

Total Solar Pressure Area “A” = 100.0 m2
“M” = Dry Mass of Satellite = 2476 kg
“CR” = Solar Pressure Radiation Coefficient = 1.2

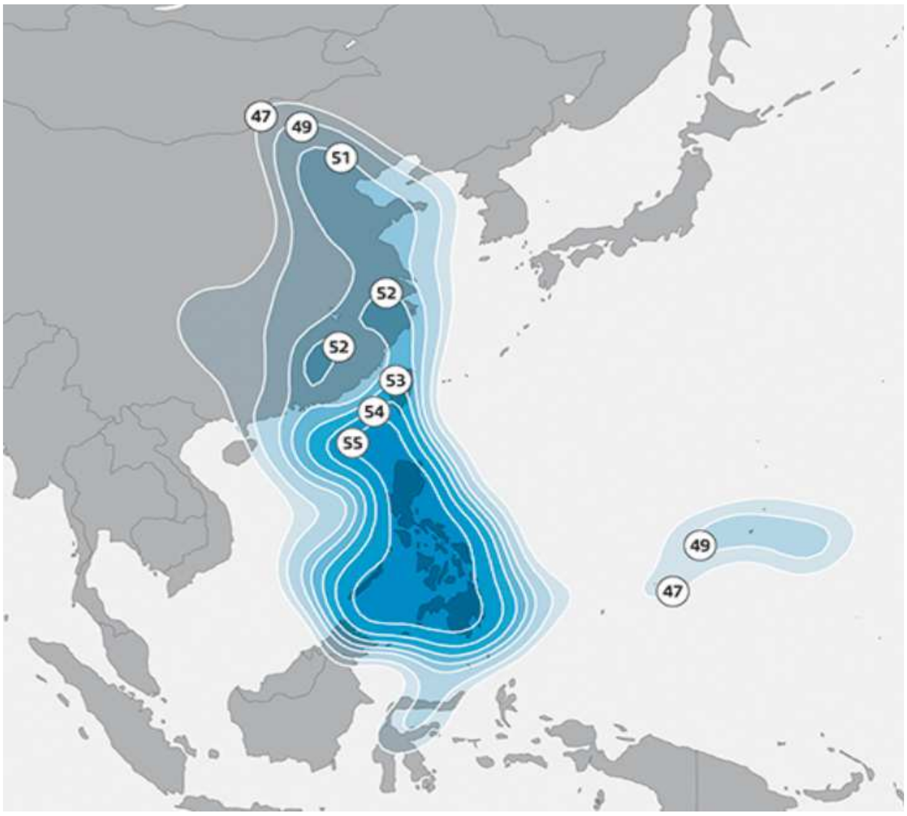
Therefore the Minimum Disposal Orbit Perigee Altitude:

= 36,021 km + 1000 x CR x A/m
= 36,021 km + 1000 x 1.2 x 100.0/2476
= 36,069.5 km
= 283.5 km above GSO (35,786 km)

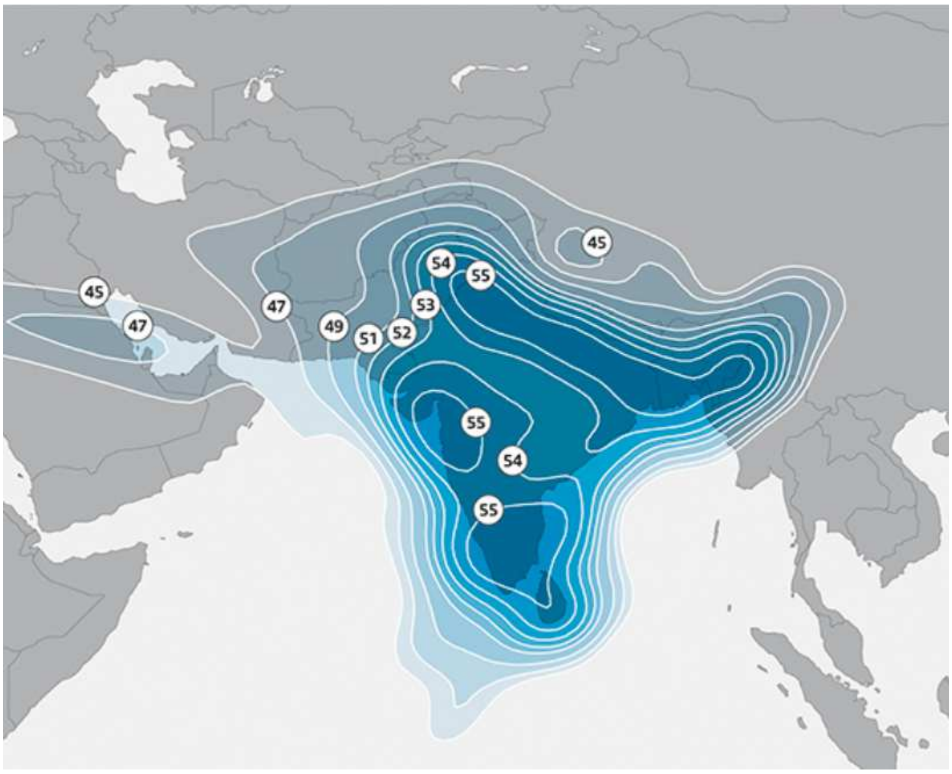
SES intends to reserve 10.84 kg of propellant in order to account for post-mission disposal of NSS-12. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

SES-9

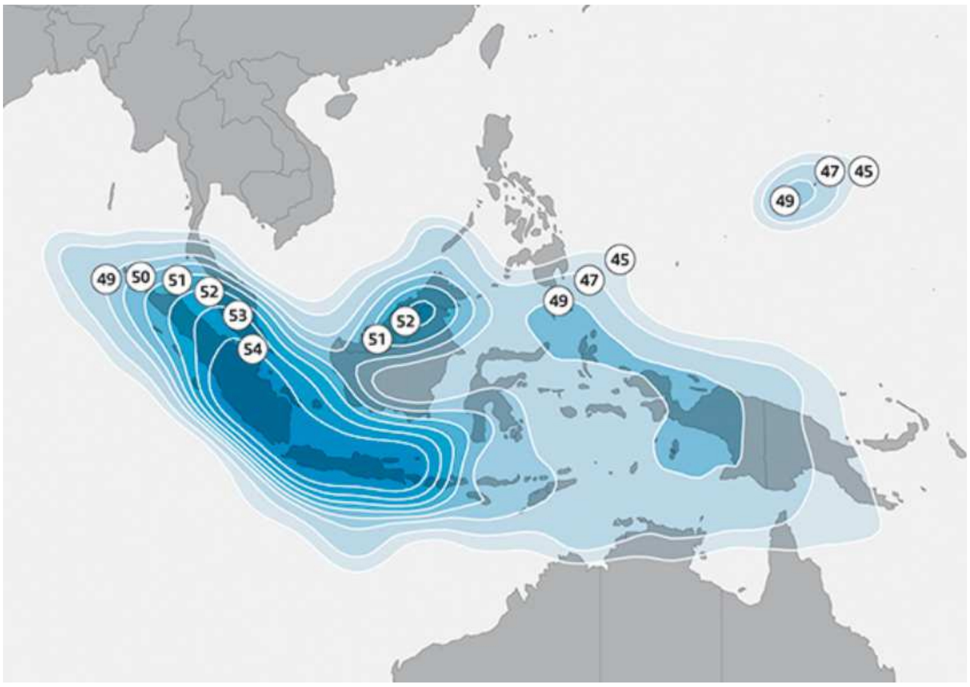
1. **Coverage Maps**



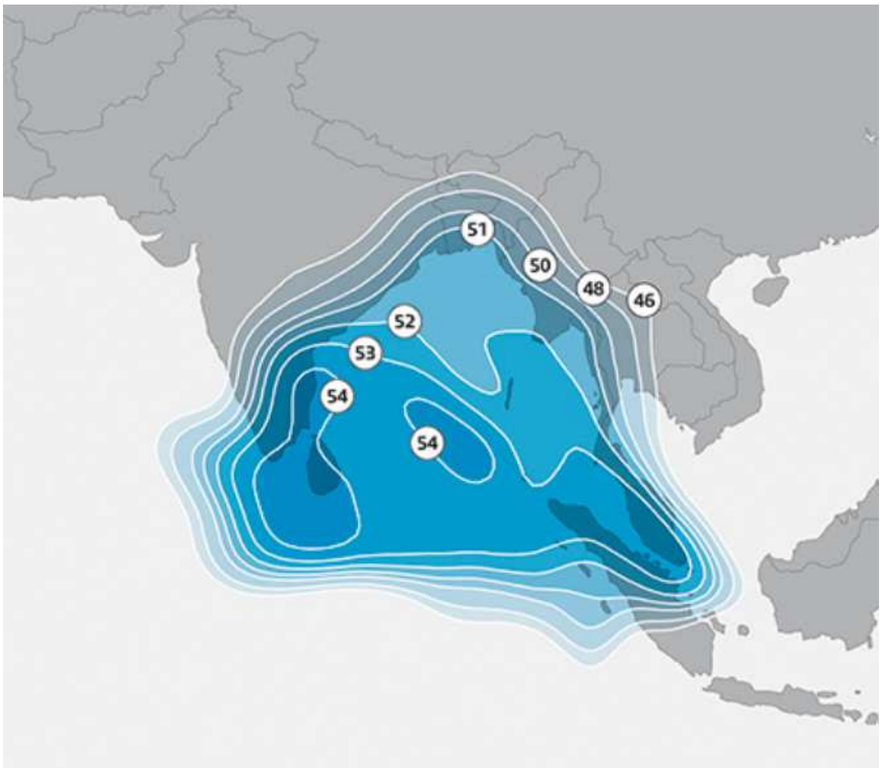
SES-9 North East Beam EIRP



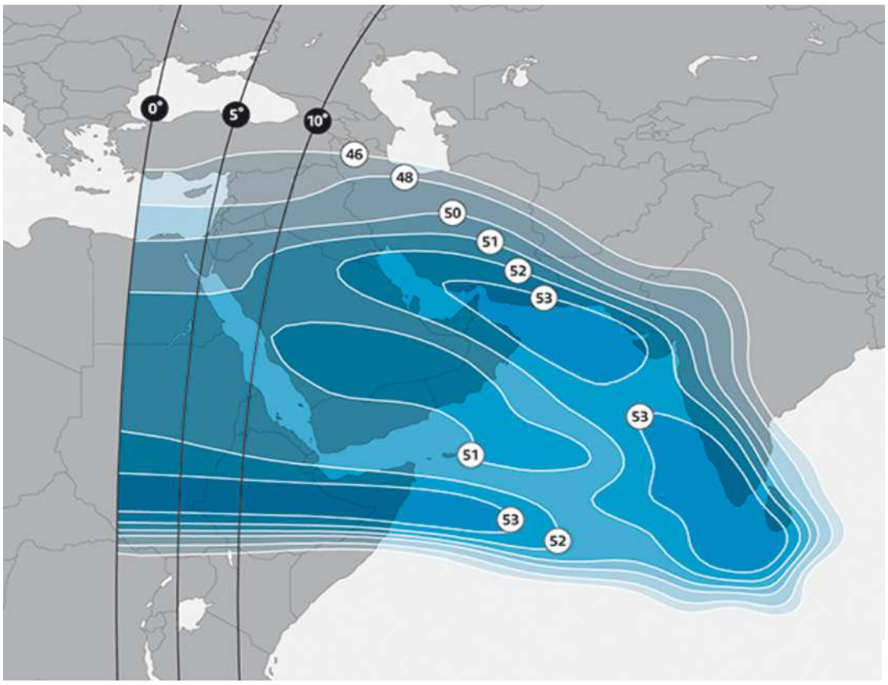
SES-9 South Asia Beam EIRP



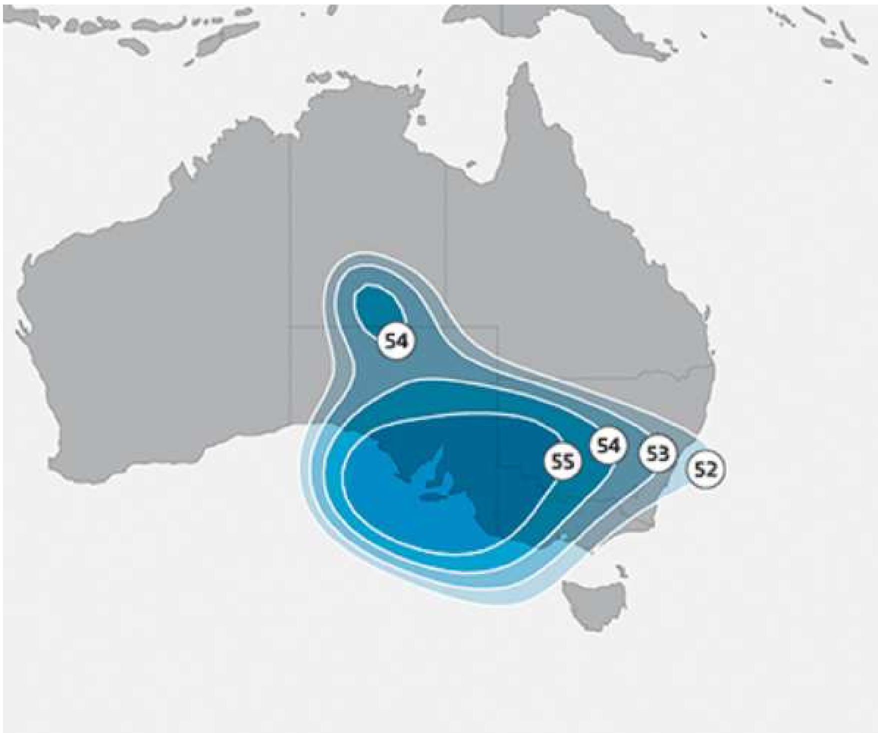
SES-9 South East Asia Beam EIRP



SES-9 East Indian Ocean Beam EIRP



SES-9 West Indian Ocean Beam EIRP



SES-9 Australia Beam EIRP

2. Link Budgets

HR6400 Forward Link			
SAV18/SAH18	**10-May-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-9	2a. Data Rate (including "Overhead") [kbps]	84823.19
1b. Satellite Longitude [deg]	108.3	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	8PSK
1c. Uplink/Downlink Beam	SAV/SAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	LDPC+BCH
1d. Transponder Id	SAV18/SAH18	2d. Inner Code Rate (FEC Rate/Code Rate)	0.67
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	0.94
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	4.65
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	1.00E-10
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-78.82		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	Gurgaon / India (Republic of)	4a. Location Name	
3b. Terminal Id (Name/Number)	IND-GUR-011 14125.0/11075	4b. Terminal Id (Name/Number)	Ku_AeroSat_HR6400_0m83_V_TxRx_SES-9-SA Test
3c. Uplink Frequency [GHz]	14.09	4c. Downlink Frequency [GHz]	12.34
3d. Latitude [deg]	28.38	4d. Latitude [deg]	22.97
3e. Longitude [deg]	76.90	4e. Longitude [deg]	74.55
3f. Elevation Angle [deg]	42.37	4f. Elevation Angle [deg]	43.76
3g. Tx Dish Size [m]	11.30	4g. Rx Dish Size [m]	0.83
3h. Uplink Tx EIRP@ Tx [dBW]	75.64	4h. G/T of Rx [dB/K]	13.09
3i. Satellite Footprint G/T @ Tx [dB/K]	8.18	4i. Satellite Footprint EIRP @ Rx [dBW]	54.60
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-16.36	6a. Carrier Output Backoff at Transmitting Transponder [dB]	0.00
5b. Up Link Free Space Loss [dB]	206.93	6b. Down Link Free Space Loss [dB]	205.76
5c. C/No Uplink Total [dBHz]	102.11	6c. C/No Downlink Total [dBHz]	84.17
5d. C/(IMo Intermod + Io + X-Po)	97.37	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	87.88
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	82.53	7c.Total Link Availability (end-to-end) [%]	99.0214
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	5.75
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	100.00%	9a. Required Power Equivalent BW (PEB) [%]	100.00%
8b. Required Bandwidth [MHz]	54.0	9b. Required Power Equivalent BW (PEB) [MHz]	54.0

HR6400 Return Llink			
SAV20/SAH20	**10-May-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-9	2a. Data Rate (including "Overhead") [kbps]	1000.00
1b. Satellite Longitude [deg]	108.3	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	BPSK
1c. Uplink/Downlink Beam	SAV/SAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	2D16S
1d. Transponder Id	SAV20/SAH20	2d. Inner Code Rate (FEC Rate/Code Rate)	0.50
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	1.91
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	N/A
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-78.22		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name		4a. Location Name	Gurgaon / India (Republic of)
3b. Terminal Id (Name/Number)	Ku_AeroSat_HR6400_0m83_H_TxRx_SES-9_SA	4b. Terminal Id (Name/Number)	IND-GUR-011 14125.0/11075.0
3c. Uplink Frequency [GHz]	14.21	4c. Downlink Frequency [GHz]	12.46
3d. Latitude [deg]	20.80	4d. Latitude [deg]	28.38
3e. Longitude [deg]	75.80	4e. Longitude [deg]	76.90
3f. Elevation Angle [deg]	46.09	4f. Elevation Angle [deg]	42.37
3g. Tx Dish Size [m]	0.83	4g. Rx Dish Size [m]	11.30
3h. Uplink Tx EIRP@ Tx [dBW]	42.03	4h. G/T of Rx [dB/K]	39.49
3i. Satellite Footprint G/T @ Tx [dB/K]	7.46	4i. Satellite Footprint EIRP @ Rx [dBW]	55.81
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	2.60	6a. Carrier Output Backoff at Transmitting Transponder [dB]	-33.17
5b. Up Link Free Space Loss [dB]	206.94	6b. Down Link Free Space Loss [dB]	205.86
5c. C/No Uplink Total [dBHz]	68.62	6c. C/No Downlink Total [dBHz]	66.59
5d. C/(IMo Intermod + Io + X-Po)	64.85	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	76.23
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	62.91	7c.Total Link Availability (end-to-end) [%]	99.0001
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	2.91
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	4.44%	9a. Required Power Equivalent BW (PEB) [%]	0.13%
8b. Required Bandwidth [MHz]	2.4	9b. Required Power Equivalent BW (PEB) [MHz]	0.1

HR129 Forward Link			
SAV18/SAH18	**10-May-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-9	2a. Data Rate (including "Overhead") [kbps]	27698.90
1b. Satellite Longitude [deg]	108.3	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	QPSK
1c. Uplink/Downlink Beam	SAV/SAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	LDPC+BCH
1d. Transponder Id	SAV18/SAH18	2d. Inner Code Rate (FEC Rate/Code Rate)	0.33
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	0.92
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	1.41
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	1.00E-10
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-78.82		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	Gurgaon / India (Republic of)	4a. Location Name	
3b. Terminal Id (Name/Number)	IND-GUR-011 14125.0/11075	4b. Terminal Id (Name/Number)	HR129_SES-9_SA
3c. Uplink Frequency [GHz]	14.09	4c. Downlink Frequency [GHz]	12.34
3d. Latitude [deg]	28.38	4d. Latitude [deg]	20.50
3e. Longitude [deg]	76.90	4e. Longitude [deg]	75.80
3f. Elevation Angle [deg]	42.37	4f. Elevation Angle [deg]	46.24
3g. Tx Dish Size [m]	11.30	4g. Rx Dish Size [m]	0.29
3h. Uplink Tx EIRP@ Tx [dBW]	75.64	4h. G/T of Rx [dB/K]	12.48
3i. Satellite Footprint G/T @ Tx [dB/K]	8.18	4i. Satellite Footprint EIRP @ Rx [dBW]	54.89
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-16.36	6a. Carrier Output Backoff at Transmitting Transponder [dB]	0.00
5b. Up Link Free Space Loss [dB]	206.93	6b. Down Link Free Space Loss [dB]	205.71
5c. C/No Uplink Total [dBHz]	103.96	6c. C/No Downlink Total [dBHz]	81.00
5d. C/(IMo Intermod + Io + X-Po)	99.08	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	77.59
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	75.94	7c.Total Link Availability (end-to-end) [%]	97.6529
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	2.51
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	100.00%	9a. Required Power Equivalent BW (PEB) [%]	100.00%
8b. Required Bandwidth [MHz]	54.0	9b. Required Power Equivalent BW (PEB) [MHz]	54.0

HR129 Return Link			
SAV20/SAH20	**10-May-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-9	2a. Data Rate (including "Overhead") [kbps]	1000.00
1b. Satellite Longitude [deg]	108.3	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	BPSK
1c. Uplink/Downlink Beam	SAV/SAH	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	2D16S
1d. Transponder Id	SAV20/SAH20	2d. Inner Code Rate (FEC Rate/Code Rate)	0.50
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	VLP	2g. Required Eb/No Threshold [dB]	1.91
1h. DL Beam Polarization (V,H,L,R)	HLP	2h. Bit Error Rate (BER)	N/A
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-78.22		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name		4a. Location Name	Gurgaon / India (Republic
3b. Terminal Id (Name/Number)	HR129_SES-9_SA	4b. Terminal Id (Name/Number)	IND-GUR-011 14125.0/11
3c. Uplink Frequency [GHz]	14.21	4c. Downlink Frequency [GHz]	12.46
3d. Latitude [deg]	20.50	4d. Latitude [deg]	28.38
3e. Longitude [deg]	75.80	4e. Longitude [deg]	76.90
3f. Elevation Angle [deg]	46.24	4f. Elevation Angle [deg]	42.37
3g. Tx Dish Size [m]	0.29	4g. Rx Dish Size [m]	11.30
3h. Uplink Tx EIRP@ Tx [dBW]	40.84	4h. G/T of Rx [dB/K]	39.49
3i. Satellite Footprint G/T @ Tx [dB/K]	7.58	4i. Satellite Footprint EIRP @ Rx [dBW]	55.81
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	0.13	6a. Carrier Output Backoff at Transmitting Transponder [dB]	-34.13
5b. Up Link Free Space Loss [dB]	206.94	6b. Down Link Free Space Loss [dB]	205.86
5c. C/No Uplink Total [dBHz]	68.61	6c. C/No Downlink Total [dBHz]	68.30
5d. C/(IMo Intermod + Io + X-Po)	64.85	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	75.38
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	62.91	7c.Total Link Availability (end-to-end) [%]	99.0000
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	2.91
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	4.44%	9a. Required Power Equivalent BW (PEB) [%]	0.10%
8b. Required Bandwidth [MHz]	2.4	9b. Required Power Equivalent BW (PEB) [MHz]	0.1

3. Orbital Debris Mitigation Statement for SES-9 (BSS-702HP Bus)

Spacecraft Hardware Design

SES Satellites (Gibraltar) Limited ("SES") has assessed and limited the amount of debris released in a planned manner during normal operations of SES-9. No debris is generated during normal on-station operations, and the spacecraft will be in a stable configuration.

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 SES's recent spacecraft 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 the following steps to limit the effects of such collisions: (1) critical spacecraft components are located inside the protective body of the spacecraft and properly shielded; and (2) all spacecraft subsystems have redundant components to ensure no single-point failures. The spacecraft will not use any subsystems for end-of-life disposal that are not used for normal operations.

Minimizing Accidental Explosions

SES has assessed and limited the probability of accidental explosions during and after completion of mission operations. As part of the Safety Package, an extensive analysis is completed by the spacecraft manufacturer, reviewing each potential hazard relating to accidental explosions and analyzing each subsystem for potential hazards. 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 SES-9 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. For stationkeeping and momentum control SES-9 uses a Xenon Ion Propulsion System (XIPS) with a single xenon inert gas. Because xenon is inert it requires less end of life care than chemical propellant fuels. All propulsion subsystem pressure vessels, which have high margins of safety at launch, have even higher margins in orbit, since use of xenon during transfer orbit decreases the propulsion system pressure. Burst tests were performed on all pressure vessels during qualification testing to demonstrate a margin of safety against burst. The xenon tank has a specified proof pressure of 4375 psia and burst pressure of 5250 psia although qualification testing has been demonstrated up to 7800 psia, well above the specified burst pressure. In addition, the xenon tank is designed to leak before burst. On-orbit, 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, all on-board sources of stored energy will be depleted or secured, the batteries will be discharged, and the xenon propellant will be vented per the Satellite Manufacturer's procedure and guidelines to a value below 5% of the tank rated proof pressure of 4375 psia. For the maximum xenon loading of 320 kg, the projected pressure and mass of residual Xenon that could remain in the tank at mission end of life is as follows, well below the specified proof and burst pressures:

Tank	Volume [l]	Pressure [psia]	Temp. [deg C]	Xenon mass [kg]
Xenon	~69	~50	~35	1.2
Xenon	~69	~50	~35	1.2

Safe Flight Profiles

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 nominal 108.3° E.L. orbital 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.

In considering current and planned satellites that may have a station-keeping volume that overlaps the SES-9 satellite, SES has reviewed the FCC databases for FCC licensed satellite networks and those that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been published by the ITU near 108.3° E.L. have also been reviewed. Only those networks that either operate, or are planned to operate, and have an overlapping station-keeping volume with the SES-9 satellite, have been taken into account in the analysis.

Based on these reviews, there are two satellites are operating at the nominal 108° E.L. location – SES-7 at 108.25° E.L. with an east-west station-keeping box of +/- 0.05 degrees and Telkom 4 operating at 108.0° E.L. SES-7 is controlled and operated by SES, and SES has developed a colocation strategy to ensure the satellites can operate safely. Telkom 4 is operating with sufficient separation that its stationkeeping box will not overlap with that of SES-9. There are no other pending applications before the Commission requesting authorization to use an orbital location within ±0.05° of 108.3° E.L., and within this sub-arc, there are no ITU networks within the station-keeping volume of SES-9 other than those submitted on behalf of SES. Based on the preceding, it is concluded that physical coordination of the SES-9 satellite with another party is not required at the present time.

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 de-orbit of a spacecraft is required, the initial phase is treated as a satellite move, and the same precautions are used to ensure collision avoidance.

Post Mission Disposal Plan

Post-mission disposal of the satellite from operational orbit will be accomplished by carrying out maneuvers to a higher orbit. The fuel budget for elevating the satellite to a disposal orbit is included in the satellite design. SES plans to maneuver SES-9 to a disposal orbit with a minimum perigee of 278.9 km above the normal GSO operational orbit. This proposed disposal orbit altitude results from application of the IADC formula based on the following calculation:

Total Solar Pressure Area "A" = 103.8 m2
"M" = Dry Mass of Satellite = 2840 kg
"CR" = Solar Pressure Radiation Coefficient = 1.2

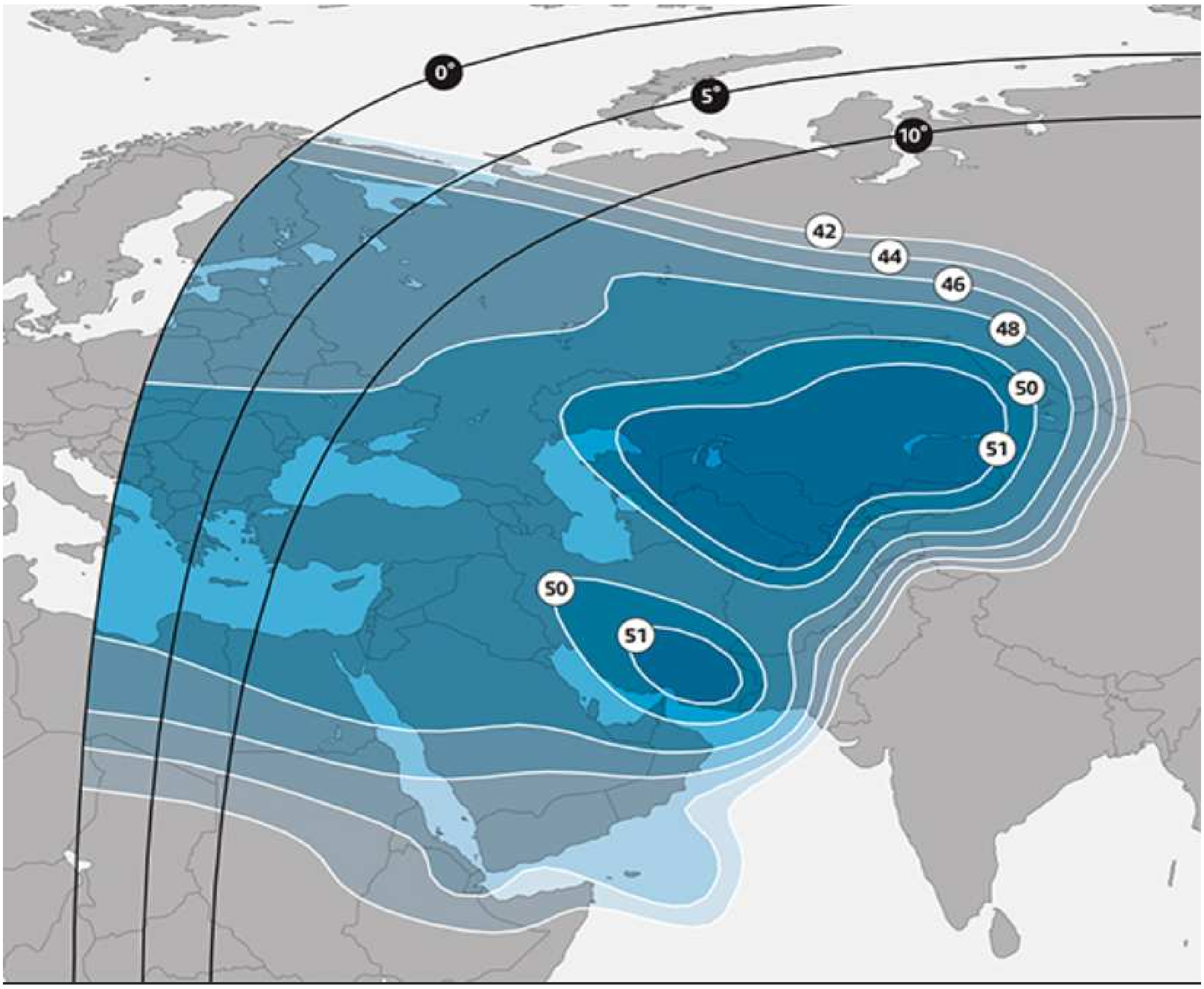
Therefore the Minimum Disposal Orbit Perigee Altitude:

= 36,021 km + 1000 x CR x A/m
= 36,021 km + 1000 x 1.2 x 103.8/2840
= 36,064.9 km
= 278.9 km above GSO (35,786 km)

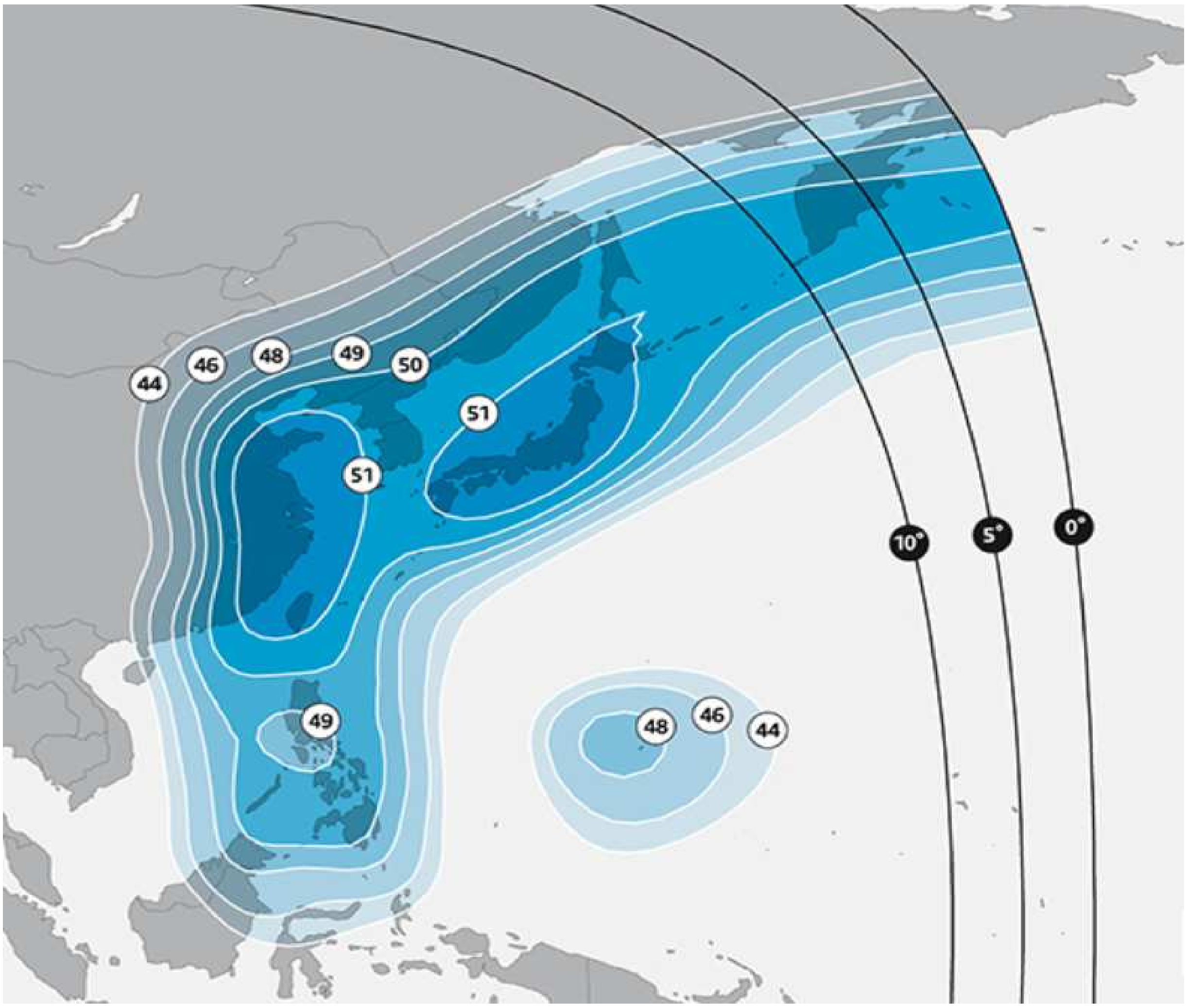
SES intends to reserve 1.20 kg of xenon propellant in order to account for post-mission disposal of SES-9. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

SES-12

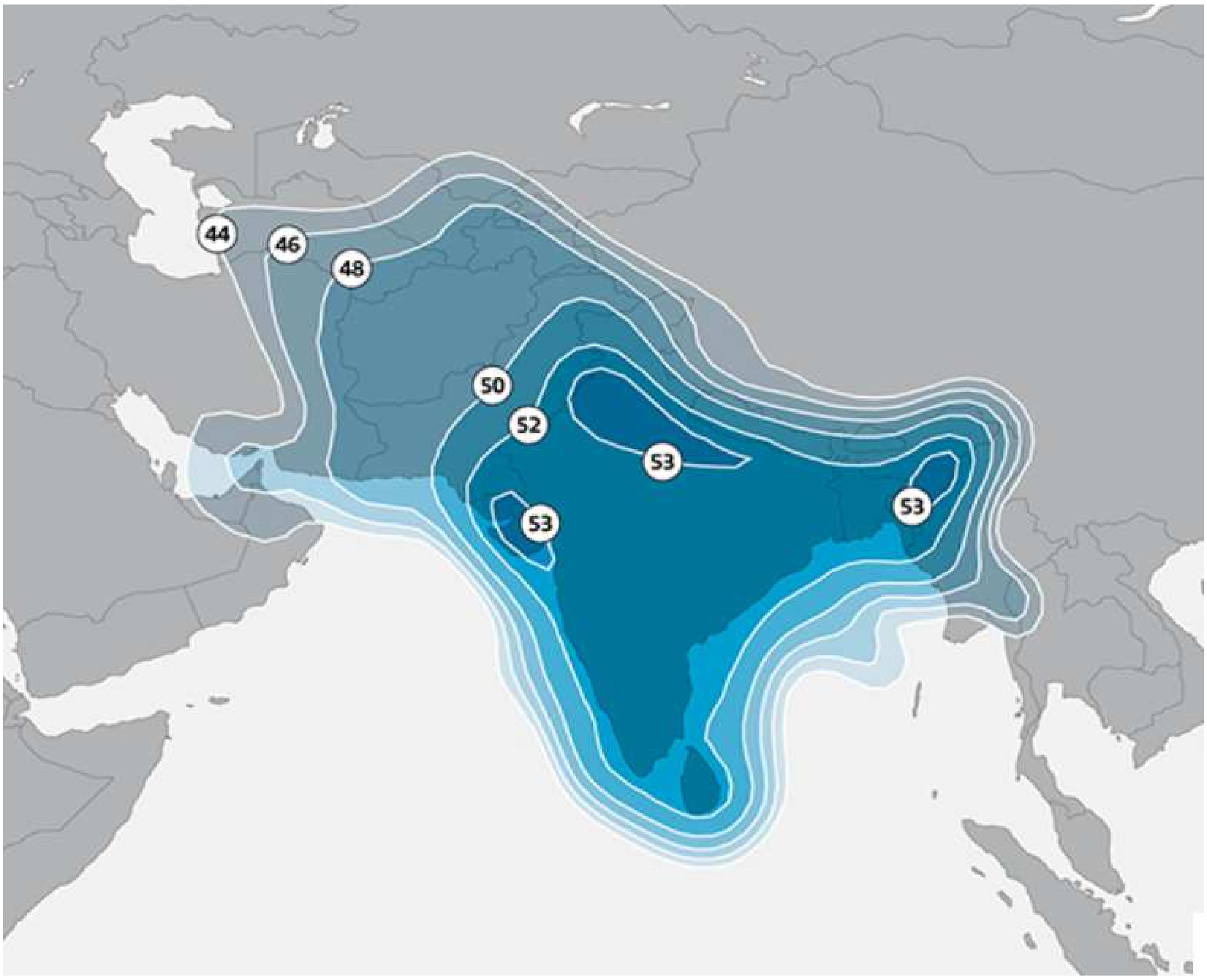
1. **Coverage Maps**



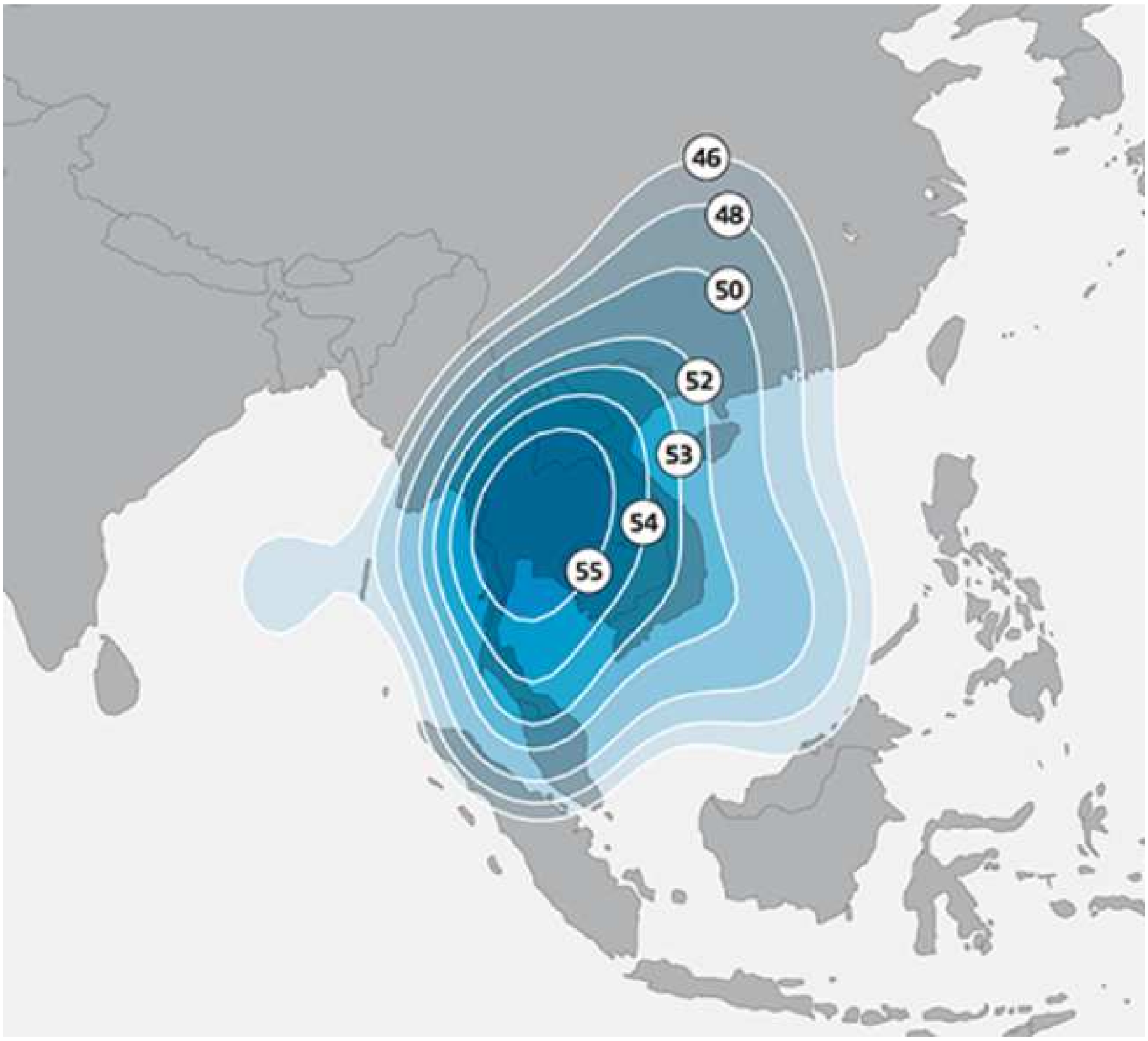
SES-12 West Central Asia Beam EIRP



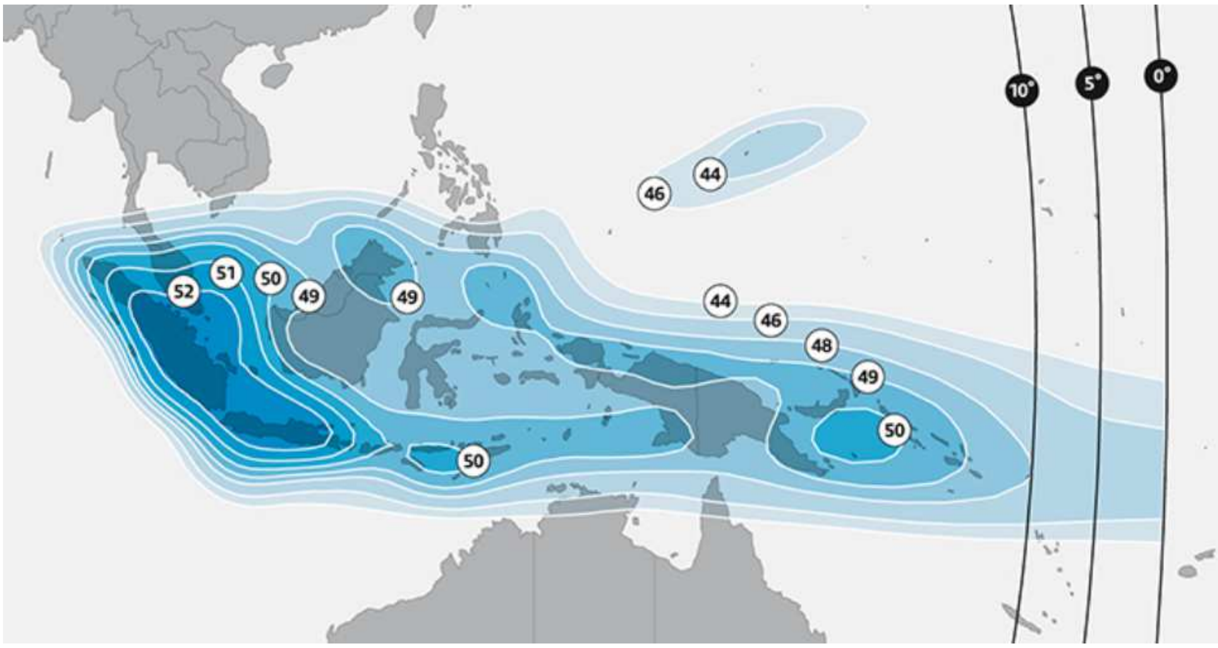
SES-12 North East EIRP



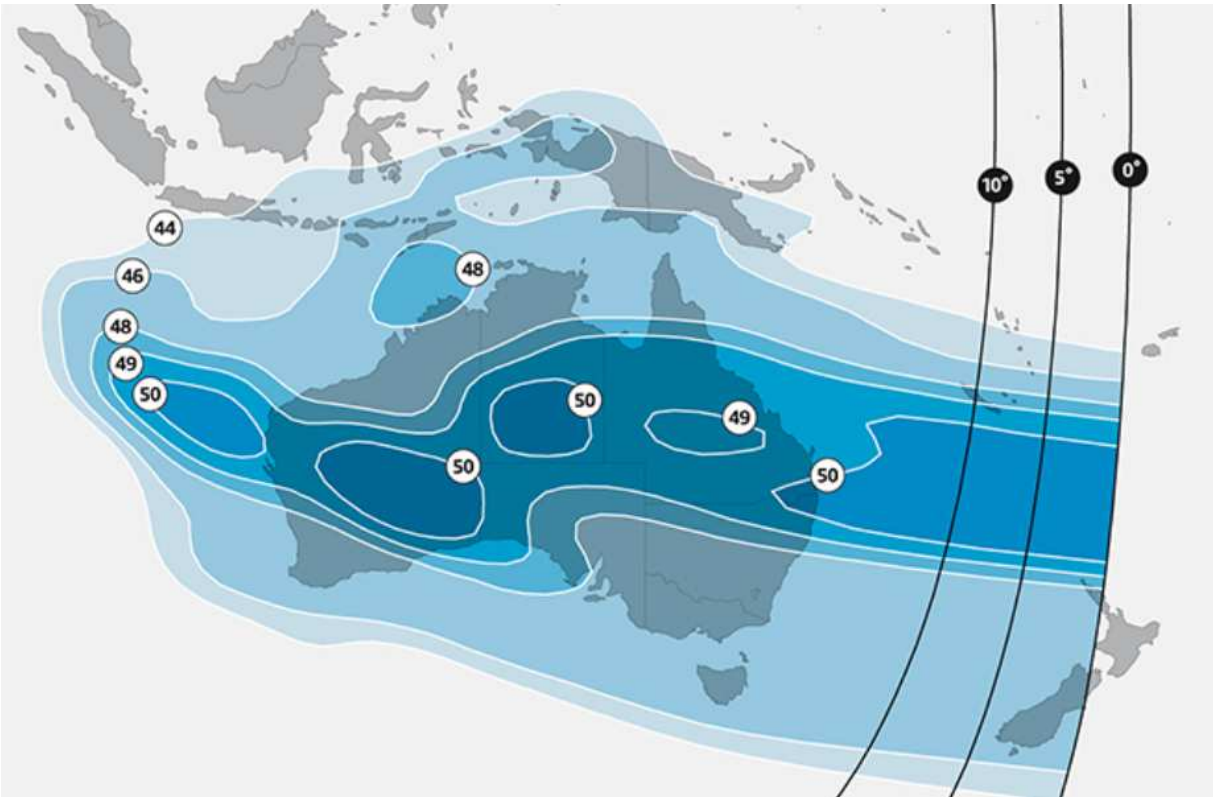
SES-12 South Asia Beam EIRP



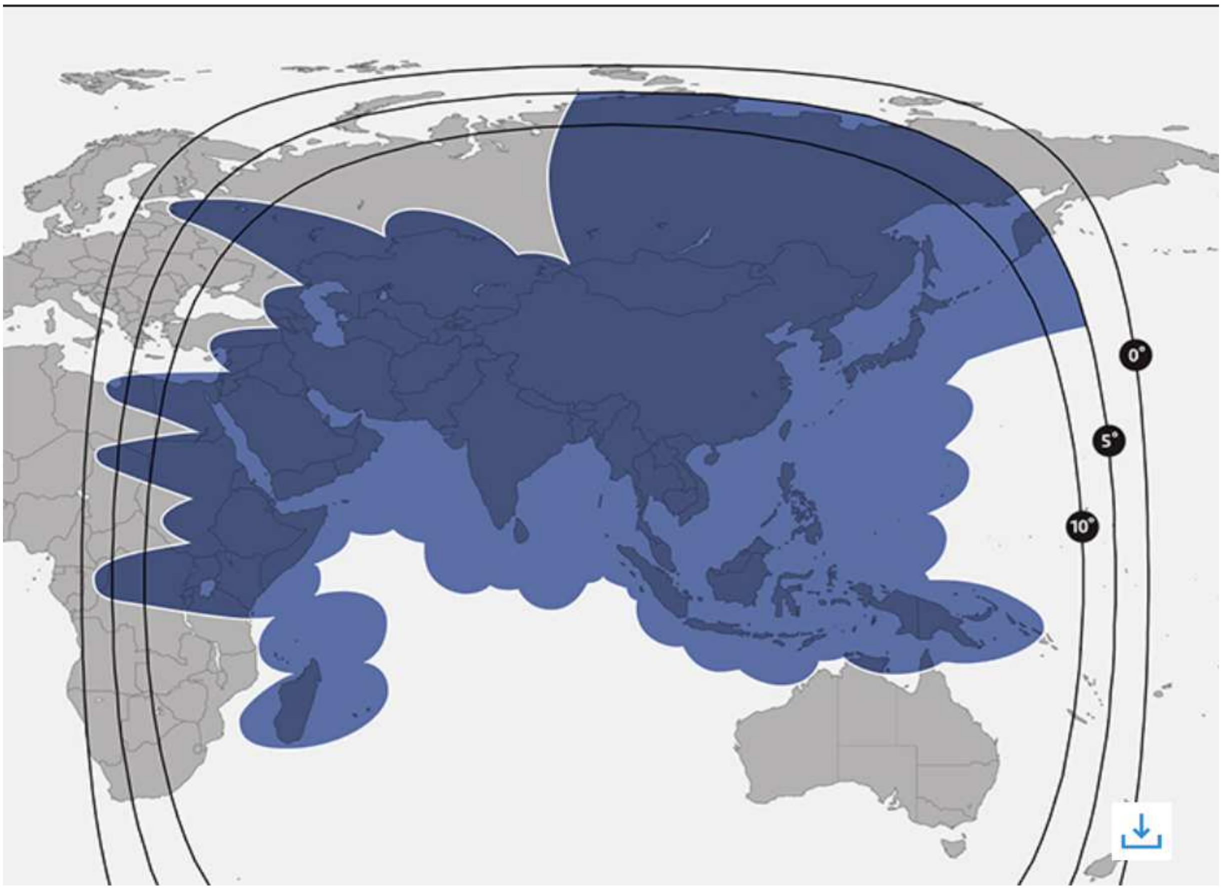
SES-12 Indo China Beam EIRP



SES-12 South East Asia Beam EIRP



SES-12 Australia Beam EIRP



SES-12 HTS Spot Beam Composite Coverage

2. Link Budgets

HR6400 Forward Link			
SEH-J22/SEV-J22	30-Apr-19		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-12	2a. Data Rate (including "Overhead") [kbps]	84823.19
1b. Satellite Longitude [deg]	95	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	8PSK
1c. Uplink/Downlink Beam	SEH/SEV	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	LDPC+BCH
1d. Transponder Id	SEH-J22/SEV-J22	2d. Inner Code Rate (FEC Rate/Code Rate)	0.67
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	0.94
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	HLP	2g. Required Eb/No Threshold [dB]	4.65
1h. DL Beam Polarization (V,H,L,R)	VLP	2h. Bit Error Rate (BER)	1.00E-10
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-82.64		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	Jakarta / Indonesia (Republic	4a. Location Name	/
3b. Terminal Id (Name/Number)	IND-JKT-001	4b. Terminal Id (Name/Number)	Ku_AeroSat_HR6400_0m83_V_TxRx_SES12_SE
3c. Uplink Frequency [GHz]	13.84	4c. Downlink Frequency [GHz]	12.60
3d. Latitude [deg]	-6.17	4d. Latitude [deg]	-6.26
3e. Longitude [deg]	106.83	4e. Longitude [deg]	106.29
3f. Elevation Angle [deg]	74.36	4f. Elevation Angle [deg]	74.87
3g. Tx Dish Size [m]	9.00	4g. Rx Dish Size [m]	0.83
3h. Uplink Tx EIRP@ Tx [dBW]	71.30	4h. G/T of Rx [dB/K]	13.22
3i. Satellite Footprint G/T @ Tx [dB/K]	8.40	4i. Satellite Footprint EIRP @ Rx [dBW]	53.49
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-11.11	6a. Carrier Output Backoff at Transmitting Transponder [dB]	0.00
5b. Up Link Free Space Loss [dB]	206.39	6b. Down Link Free Space Loss [dB]	205.57
5c. C/No Uplink Total [dBHz]	98.72	6c. C/No Downlink Total [dBHz]	84.59
5d. C/(IMo Intermod + Io + X-Po)	100.18	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	88.97
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	83.13	7c.Total Link Availability (end-to-end) [%]	99.0167
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	5.75
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	100.00%	9a. Required Power Equivalent BW (PEB) [%]	100.00%
8b. Required Bandwidth [MHz]	54.0	9b. Required Power Equivalent BW (PEB) [MHz]	54.0

HR6400 Return Link			
SEH-D21/SEV-D21	30-Apr-19		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-12	2a. Data Rate (including "Overhead") [kbps]	666.67
1b. Satellite Longitude [deg]	95	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	BPSK
1c. Uplink/Downlink Beam	SEH/SEV	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	2D16S
1d. Transponder Id	SEH-D21/SEV-D21	2d. Inner Code Rate (FEC Rate/Code Rate)	0.67
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	HLP	2g. Required Eb/No Threshold [dB]	3.27
1h. DL Beam Polarization (V,H,L,R)	VLP	2h. Bit Error Rate (BER)	N/A
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-82.57		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	/	4a. Location Name	Jakarta / Indonesia (Republic c
3b. Terminal Id (Name/Number)	Ku_AeroSat_HR6400_0m83_H_TxRx_SES12_SE	4b. Terminal Id (Name/Number)	IND-JKT-001
3c. Uplink Frequency [GHz]	14.28	4c. Downlink Frequency [GHz]	11.48
3d. Latitude [deg]	-7.10	4d. Latitude [deg]	-6.17
3e. Longitude [deg]	107.12	4e. Longitude [deg]	106.83
3f. Elevation Angle [deg]	73.54	4f. Elevation Angle [deg]	74.36
3g. Tx Dish Size [m]	0.83	4g. Rx Dish Size [m]	9.00
3h. Uplink Tx EIRP@ Tx [dBW]	36.65	4h. G/T of Rx [dB/K]	36.83
3i. Satellite Footprint G/T @ Tx [dB/K]	8.09	4i. Satellite Footprint EIRP @ Rx [dBW]	53.90
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-2.78	6a. Carrier Output Backoff at Transmitting Transponder [dB]	-33.56
5b. Up Link Free Space Loss [dB]	206.67	6b. Down Link Free Space Loss [dB]	204.77
5c. C/No Uplink Total [dBHz]	65.32	6c. C/No Downlink Total [dBHz]	68.24
5d. C/(IMo Intermod + Io + X-Po)	90.36	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	67.18
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	62.51	7c.Total Link Availability (end-to-end) [%]	99.0000
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	4.27
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	4.44%	9a. Required Power Equivalent BW (PEB) [%]	0.09%
8b. Required Bandwidth [MHz]	2.4	9b. Required Power Equivalent BW (PEB) [MHz]	0.0

HR129 Forward Link			
SEH-J22/SEV-J22	**30-Apr-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-12	2a. Data Rate (including "Overhead") [kbps]	27698.90
1b. Satellite Longitude [deg]	95	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	QPSK
1c. Uplink/Downlink Beam	SEH/SEV	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	LDPC+BCH
1d. Transponder Id	SEH-J22/SEV-J22	2d. Inner Code Rate (FEC Rate/Code Rate)	0.33
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	0.92
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	HLP	2g. Required Eb/No Threshold [dB]	1.41
1h. DL Beam Polarization (V,H,L,R)	VLP	2h. Bit Error Rate (BER)	1.00E-10
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-82.64		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	Jakarta / Indonesia (Republic of)	4a. Location Name	/
3b. Terminal Id (Name/Number)	IND-JKT-001	4b. Terminal Id (Name/Number)	HR129_SES12_SE
3c. Uplink Frequency [GHz]	13.84	4c. Downlink Frequency [GHz]	12.60
3d. Latitude [deg]	-6.17	4d. Latitude [deg]	-6.26
3e. Longitude [deg]	106.83	4e. Longitude [deg]	105.87
3f. Elevation Angle [deg]	74.36	4f. Elevation Angle [deg]	75.29
3g. Tx Dish Size [m]	9.00	4g. Rx Dish Size [m]	0.29
3h. Uplink Tx EIRP@ Tx [dBW]	71.30	4h. G/T of Rx [dB/K]	12.82
3i. Satellite Footprint G/T @ Tx [dB/K]	8.40	4i. Satellite Footprint EIRP @ Rx [dBW]	53.34
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-11.11	6a. Carrier Output Backoff at Transmitting Transponder [dB]	0.00
5b. Up Link Free Space Loss [dB]	206.39	6b. Down Link Free Space Loss [dB]	205.57
5c. C/No Uplink Total [dBHz]	100.62	6c. C/No Downlink Total [dBHz]	81.67
5d. C/(IMo Intermod + Io + X-Po)	101.81	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	77.31
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	75.93	7c.Total Link Availability (end-to-end) [%]	94.8691
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	2.51
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	100.00%	9a. Required Power Equivalent BW (PEB) [%]	100.00%
8b. Required Bandwidth [MHz]	54.0	9b. Required Power Equivalent BW (PEB) [MHz]	54.0

HR129 Return Link			
SEH-D21/SEV-D21	**30-Apr-19**		
Satellite & Carrier Characteristics			
1. Satellite Characteristics		**2. Carrier Parameters**	
1a. Satellite Name	SES-12	2a. Data Rate (including "Overhead") [kbps]	666.67
1b. Satellite Longitude [deg]	95	2b. Modulation Scheme (BPSK, QPSK, 8PSK … others)	BPSK
1c. Uplink/Downlink Beam	SEH/SEV	2c. Coding Type (Conv., Conv+RS, TPC, LDPC)	2D16S
1d. Transponder Id	SEH-D21/SEV-D21	2d. Inner Code Rate (FEC Rate/Code Rate)	0.67
1e. Type of Band (C,Ku,C/Ku,Ku/C,X)	Ku	2e. Outer Code Rate (e.g. Reed/Solomon)	
1f. Xpdr Total Bandwidth [MHz]	54.00	2f. Rolloff Factor/Spacing Factor	0.20
1g. UL Beam Polarization (V,H,L,R)	HLP	2g. Required Eb/No Threshold [dB]	3.27
1h. DL Beam Polarization (V,H,L,R)	VLP	2h. Bit Error Rate (BER)	N/A
1i. Xpdr SFD (@ 0 dbi/K G/T) [dBW/m2]	-82.57		
Terminal Characteristics			
3. Transmitting Terminal Tx		**4. Receiving Terminal Rx**	
3a. Location Name	/	4a. Location Name	Jakarta / Indonesia (Republic of)
3b. Terminal Id (Name/Number)	HR129_SES12_SE	4b. Terminal Id (Name/Number)	IND-JKT-001
3c. Uplink Frequency [GHz]	14.28	4c. Downlink Frequency [GHz]	11.48
3d. Latitude [deg]	-6.26	4d. Latitude [deg]	-6.17
3e. Longitude [deg]	105.87	4e. Longitude [deg]	106.83
3f. Elevation Angle [deg]	75.29	4f. Elevation Angle [deg]	74.36
3g. Tx Dish Size [m]	0.29	4g. Rx Dish Size [m]	9.00
3h. Uplink Tx EIRP@ Tx [dBW]	36.59	4h. G/T of Rx [dB/K]	36.83
3i. Satellite Footprint G/T @ Tx [dB/K]	8.09	4i. Satellite Footprint EIRP @ Rx [dBW]	53.90
Link Budgets (including Rain statistics)			
5. Uplink & Intermod		**6. Downlink & Intermod**	
5.a. Carrier Output Backoff at Tx Earth Station [dB]	-4.17	6a. Carrier Output Backoff at Transmitting Transponder [dB]	-33.60
5b. Up Link Free Space Loss [dB]	206.66	6b. Down Link Free Space Loss [dB]	204.77
5c. C/No Uplink Total [dBHz]	65.32	6c. C/No Downlink Total [dBHz]	68.35
5d. C/(IMo Intermod + Io + X-Po)	90.39	6d. C/(IMo Intermod + Io + X-Po) Downlink [dBHz]	67.15
7. Total (Uplink + Downlink + Intermod + Other Interference)			
7a. C/No Overall [dBHz]	62.51	7c.Total Link Availability (end-to-end) [%]	99.0001
7b. System Link Margin (including Rain Model) [dB]	1.00	7d. Required Thresh. Eb/No + Sys. Link Margin [dB]	4.27
8. Transponder Bandwidth Utilization		**9. Transponder Power Bandwidth Utilization**	
8a. Required Bandwidth [%]	4.44%	9a. Required Power Equivalent BW (PEB) [%]	0.09%
8b. Required Bandwidth [MHz]	2.4	9b. Required Power Equivalent BW (PEB) [MHz]	0.0

3. Orbital Debris Mitigation Statement for SES-12 (Airbus E3000 Bus)

Spacecraft Hardware Design.

SES has assessed and limited the amount of debris that will be released in a planned manner during normal operations of SES-12. No debris is generated during normal on-station operations, and the spacecraft will be in a stable configuration.

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 SES's spacecraft 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 the following steps to limit the effects of such collisions: (1) critical spacecraft components are located inside the protective body of the spacecraft and properly shielded; and (2) all spacecraft subsystems have redundant components to ensure no single-point failures. The spacecraft will not use any subsystems for end-of-life disposal that are not used for normal operations.

Minimizing Accidental Explosions.

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 SES 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 SES-12 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. 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, will be monitored by telemetry. At the end of operational life, after the satellite has reached its final disposal orbit, all on-board sources of stored energy will be depleted or secured, excess propellant remaining in the chemical propulsion tanks will be vented, excess pressurant remaining in the helium tanks will be vented, and the batteries will be discharged.

Safe Flight Profiles.

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, 95° E.L. 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.

In considering current and planned satellites that may have a station-keeping volume that overlaps the SES-12 satellite, SES has reviewed the FCC database for FCC licensed satellite networks and those that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been published by the ITU within ±0.15 degrees of 95° E.L. have also been reviewed. Only those networks that either operate, or are planned to operate, and have an overlapping station-keeping volume with the SES-12 satellite, have been taken into account in the analysis.

Based on these reviews, the only satellite operating nominally at 95° E.L. is SES-8. This satellite is also controlled and operated by SES, and SES has developed a colocation strategy to ensure the satellites can operate safely. Luch 5V operated by Roscosmos and Skynet 5A operated by Paradigm Secure Communications Ltd are operating near the nominal 95° E.L. at 94.7° E.L+/- 0.1° and 95.25°E.L.+/- 0.1° respectively, with sufficient separation that neither satellite's stationkeeping box will overlap with that of SES-12. There are no pending applications before the Commission requesting authorization to use an orbital location within ±0.15° of 95° E.L. Furthermore, SES is not aware of any other system with an overlapping station-keeping volume with SES-12 that is either in orbit or progressing towards launch. Based on the preceding, it is concluded that physical coordination of the SES-12 satellite with another party is not required at the present time.

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 de-orbit of a spacecraft is required, the initial phase is treated as a satellite move, and the same precautions are used to ensure collision avoidance.

Post-Mission Disposal.

Post-mission disposal of the satellite from operational orbit will be accomplished by carrying out maneuvers 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. SES plans to maneuver SES-12 to a disposal orbit with a minimum perigee of 264 km above the normal GSO operational orbit. This proposed disposal orbit altitude results from application of the IADC formula based on the following calculation:

Total Solar Pressure Area “A” = 121.0 m2
“M” = Dry Mass of Satellite = 4178.0 kg
“CR” = Solar Pressure Radiation Coefficient = 1.00

Therefore the Minimum Disposal Orbit Perigee Altitude:

= 36,021 km + 1000 x CR x A / m
= 36,021 km + 1000 x 1.00 x 121.0 / 4178.0
= 36,050 km
= 264 km above GSO (35,786 km)

SES intends to reserve 15.5 kg of propellant in order to account for post-mission disposal of SES-12. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

ANNEX 5: Technical Description

This Technical Description provides an overview of the operational characteristics of SES's proposed Ku-band earth stations onboard aircraft ("ESAA") network. The SES ESAA network will consist of three elements: (i) ESAA terminals, (ii) space stations, and (iii) ground terminals. Technical and operational information regarding each of these elements demonstrating compliance with the Commission's rules (except to the extent waivers have been requested) is provided below and in associated attachments. In addition, the table in Annex 1 identifies which application section(s) address compliance with individual rule provisions.

1. ESAA Terminals

The SES ESAA network will use the Astronics Aerosat HR6400 and HR129 antennas, both of which have been previously authorized by the Commission and were specifically designed for the aeronautical environment. Subject aircraft will be installed with either the HR6400 or HR129 terminal for operations in U.S. and international airspace.

The ESAA terminal operations will be managed by a terminal controller containing a modem with a DVB-S2 demodulator and deterministic time division multiple access ("D-TDMA") modulator. Each terminal uses aircraft attitude data (*i.e.*, yaw, roll, pitch, yaw rate, roll rate, pitch rate, and heading vector), together with location information (latitude, longitude, and altitude) to calculate the command vectors. The attitude and position data are provided to the antenna by an inertial reference unit and are used in conjunction with the satellite coordinates to yield continuously updated steering commands for the antenna elevation, azimuth, and polarization. The terminal controller can inhibit transmissions as a function of location and skew angle, control the terminals' transmit power using predefined carrier tables and EIRP density maps, and select the serving satellite based on terminal location, using preloaded maps to determine when to change satellites or beams as the aircraft travels. The map-based technology also allows SES to adjust operating parameters and if necessary cease ESAA transmissions based on location in order to comply with coordinated levels, protect other services operating in the Ku-band, and satisfy other applicable regulatory limitations. The terminal controller also utilizes modem power control, cable loss calibration and output power measurement, allowing the system to monitor the system's precise output EIRP density in real time. Numerous additional functions serve to monitor pointing accuracy at a periodic interval faster than 50 milliseconds. This monitoring tracks both the system's operating envelope and potential fault elements. The EIRP density operating envelope is monitored at a point projected into the future by approximately 100 milliseconds, allowing for nearly instantaneous power adjustments or complete shutdown of transmission. Power control is implemented via the antenna control and modem unit and a discrete line to the high/low power transceiver, eliminating latency and enabling complete shutdown of transmission. In all out-of-bounds cases, any fault will result in direct inhibition of transmission through shutdown of the output power amplifier.

1.1. Astronics Aerosat HR6400

The HR6400 terminal is configured for installation on an aircraft's fuselage. As described in the legal narrative, SES is seeking authority to operate the HR6400 terminal with satellites on the Commission's Permitted List pursuant to Section 25.227(a)(1) as well as with specified satellites using coordinated power levels pursuant to Section 25.227(a)(2). The Commission has previously approved the HR6400 terminal for both categories of operations,[1] and the technical parameters of the terminal are therefore already on file with the Commission.[2] SES's operations under Section 25.227(a)(1) will use off-axis EIRP spectral density ("ESD") levels that comply with the applicable ESD masks in Section 25.227(a)(1)(i) of the Commission's rules designed to protect co-frequency operations from harmful interference. Operations under Section 25.227(a)(2) will meet the limits in applicable coordination agreements with neighboring satellites.

1.2. Astronics Aerosat HR129

The HR129 terminal is configured for installation on an aircraft's tail. As described in the legal narrative, SES is seeking authority to operate the HR129 terminal with satellites on the Commission's Permitted List pursuant to Section 25.227(a)(1) as well as with specified satellites using coordinated power levels pursuant to Section 25.227(a)(2). The Commission has previously approved the HR129 terminal for both categories of operations,[3] and the technical parameters of the terminal are therefore already on file with the Commission.[4] SES's operations under Section 25.227(a)(1) will use ESD levels that comply with the applicable ESD masks in Section 25.227(a)(1)(i) of the Commission's rules designed to protect co-frequency operations from harmful interference. Operations under Section 25.227(a)(2) will meet the limits in the applicable coordination agreements with neighboring satellites.

1.3. Automatic Cessation of Emissions

The terminals will not transmit until the appropriate outbound signal from the satellite is received and will cease transmission immediately in certain instances to avoid causing interference. Specifically, both terminals are self-monitoring and will automatically cease or reduce emissions

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[1] *See Astronics AeroSat Corp.*, Call Sign E140087, File No. SES-MFS-20170319-00302, granted June 19, 2017 ("Astronics ESAA License"), Section D.

[2] *See Astronics AeroSat Corp.*, Call Sign E140087, File No. SES-LIC-20140902-00688, Technical Annex at 3, 8-14, and Annex B (describing the HR6400 terminal's technical characteristics and providing antenna performance data).

[3] *See* Astronics ESAA License, Section D.

[4] *See Astronics AeroSat Corp.*, Call Sign E140087, File No. SES-MFS-20161003-00823, Technical Appendix at 1-3 and Section III (describing the HR129 terminal's technical characteristics and providing antenna performance data).

within 100 milliseconds if the authorized off-axis EIRP density specifications are exceeded. For operations under Section 25.227(a)(1), the automatic cessation or reduction will be triggered if the off-axis EIRP density exceeds the masks set forth in the rule. For operations under Section 25.227(a)(2), the automatic cessation or reduction will be triggered if the off-axis EIRP density exceeds the levels required to conform to the coordination agreements with adjacent satellites. In either case, the terminal will not resume transmission until the condition that caused the off-axis EIRP density limit to be exceeded is corrected.

The system design also ensures that aggregate power density from simultaneously transmitting terminals will not cause the applicable limits to be exceeded. The hub manages the frequency and timeslot assignments and ensures that no assignments are duplicated among the terminals. Timeslots and carriers are uniquely assigned, ensuring that only a single terminal can transmit in an assigned return link timeslot at a time (*i.e.*, there is no aggregation). Terminals transmit a single carrier in each assigned return link time slot, and the hub adjusts the timeslot assignments as user demand varies. Finally, any event that results in the loss of modem lock to the DVB-S2 downlink will cause the modem to cease transmissions, ensuring that operation of the HR6400 and HR129 and terminals will not increase the potential for harmful interference.

2. Space Stations

As discussed in the legal narrative, the space segment will consist of capacity on SES satellites using conventional and extended Ku-band frequencies. SES also seeks a waiver to permit it to use portions of the 12.2-12.75 GHz band for ESAA receive operations. SES's proposed ESAA operations with the listed satellites are consistent with the coordination agreements it has reached with operators of adjacent space stations located within +/- 6 degrees of each serving satellite. A composite map showing the combined coverage of these space stations is attached.

SES also seeks authority for its ESAA terminals to communicate with satellites on the Permitted Space Station List for operations compliant with the Commission's off-axis EIRP density masks.

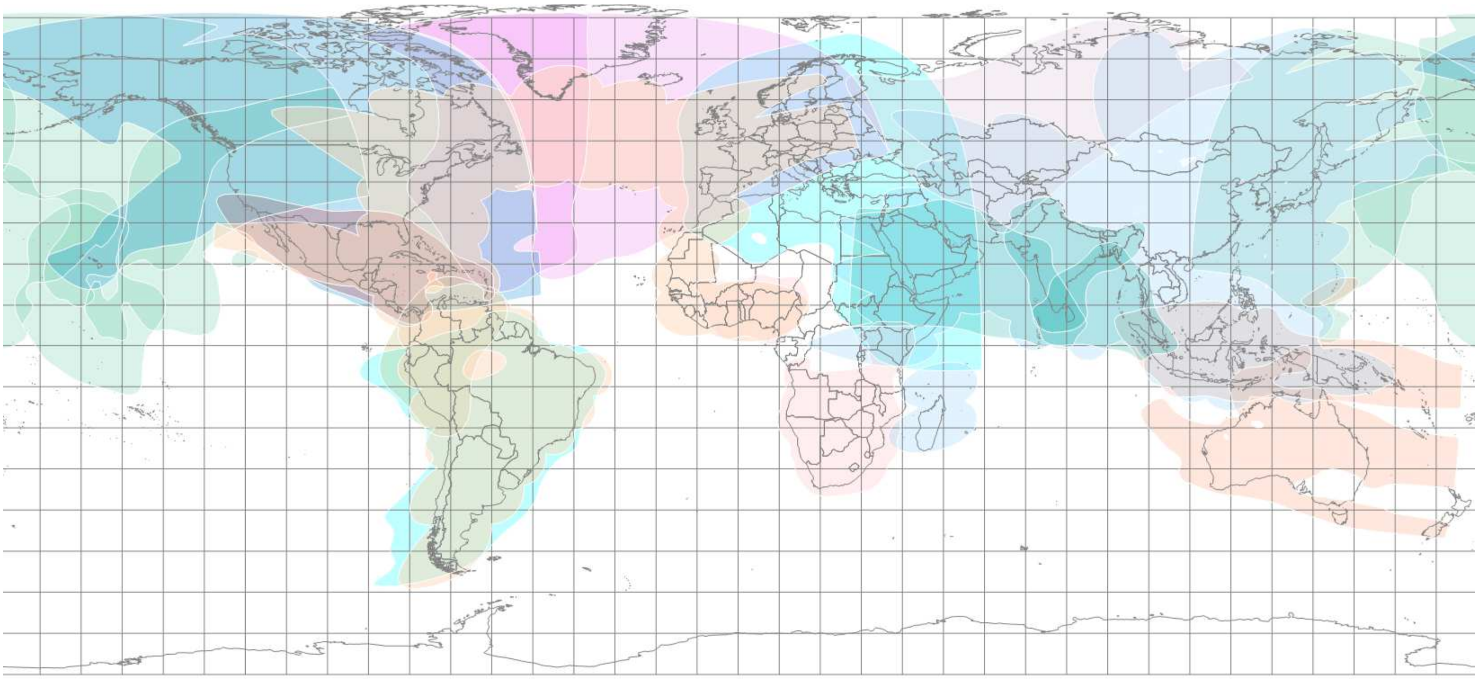
3. Ground Stations

The ground segment consists of hub controllers operated by SES and located at SES and commercial teleport facilities. The earth stations associated with ESAA terminal operations are listed in Annex 2.

Control and monitoring of the SES ESAA network will be provided by the SES Network Operations Center in Manassas, Virginia, United States on a 24/7 basis. The NOC can be reached at:

12811 Randolph Ridge Lane Manassas, VA 20109
Phone: +1 703 366 1500
Email: noc-sesnetworks@ses.com

Combined Coverage Map of Specified Satellites



ANNEX 6: Radiation Hazard Analysis

HR6400 FCC RF Hazard Compliance Analysis

In connection with a license application by SES Americom, Inc. (“SES”) for operation of a Ku-band aircraft remote antenna (HR6400), the following assessment is provided in compliance with the FCC limits for maximum permissible exposure (MPE) to RF fields.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna radiating surface are expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians will receive training specifying this area as a high exposure area. Procedures will be established to ensure that all transmitters are turned off before this area may be accessed by operators, maintenance or other authorized personnel.

The sections that follow provide the analysis and conclusions regarding compliance.

1 Operational Data

In calculating compliance with the applicable exposure limits, SES used the technical data for HR6400 operations described elsewhere in this application.

2 Applicable MPE Limits

The MPE limits are described in the FCC Rules and Regulations. For the frequency range of interest here, the applicable limit for acceptable, continuous exposure of the general population is 1.0 milliwatt per square centimeter (mW/cm^2), and for “controlled” occupational exposure, it is 5.0 mW/cm^2. Access to the antenna is restricted to trained personnel, and thus the latter limit is generally applicable. However, it is possible that untrained members of the general population could be within certain distances from the aircraft. Therefore, the MPE limit for the general population has also been examined.

3 FCC Formulas and Calculations

FCC Bulletin OET 65 provides standardized formulas for calculating the power density in the areas of interest here. Using the formulas from Bulletin OET 65, we report the exposure levels (1) directly in front of the antenna, (2) in the main beam at the transition from near to far field, and (3) farther away but still in the main beam where the MPE limit is met for both controlled and general population exposure; and (4) to the side of the antenna. Each area of interest will be addressed below and the results of the calculations are given.

3.1 Potential exposure level directly in front of the antenna

The worst-case possible exposure occurs right at the surface (aperture) of the antenna. According to Bulletin OET 65, the applicable formula for power density, **S**, at the antenna surface is as follows:

S = 4 * P / A

Where: **P** represents the antenna input power; and,

A is the surface area of the antenna.

Based on the formula in Bulletin OET 65 and using the technical parameters of the antenna, SES calculates that the power density at the antenna surface is 309.62 mW/cm^2, which exceeds the 5.0 mW/cm^2 MPE limit for controlled access. However, there is no way to approach this close to the antenna when the aircraft is in flight. Furthermore, the antenna will be switched off completely (i.e. unpowered) when a technician needs to perform work in this area (which is more than 24 feet above ground level). Standard RF safety procedures will be applied and the power to the antenna will be removed during the period of the work.

The formula for near-field, on-axis power density, directly in front of the antenna is as follows:

$$S = 16 * | * P / (pi * D^2)$$

Where: **P** represents the antenna input power

| represents the antenna illumination efficiency; and,

D is the antenna diameter.

Based on the formula in Bulletin OET 65, using the technical parameters of the antenna and an illumination efficiency of 70%, SES calculates that the near-field, on-axis power density, directly in front of the antenna is 216.6 mW/cm^2, which exceeds the occupational MPE limit. This is the exposure level directly in front of the antenna at a distance of 0.69 meters. For the reasons stated above, there is no way for a technician or the general public to approach this close to the antenna while it is transmitting.

We can calculate the distance at which the antenna emissions would meet the MPE limits for controlled access and for the general population using the following formula:

$$RMPE = (G * P) / (4 * pi * MPE)$$

Where: **G** represents the Gain of the antenna;

P represents the antenna input power: and,

MPE represents the maximum permissible exposure limit.

SES calculated the distance at which the antenna emissions would meet the MPE limits for controlled access and for the general population and determined that the MPE limits for controlled access are met at 6.65 m (21.8 feet) directly in front of the antenna. The MPE limits for the general population are met at 14.87 m (48.8 feet) directly in front of the antenna.

The results of this calculation are also used in the analysis of potential exposure to the immediate side of the antenna, which is addressed in the subsection that follows.

3.2 Potential exposure level to the side of the antenna

The near-field power density drops off dramatically outside the imaginary cylinder extending from the surface along the axis of the main beam of an aperture antenna. According to Bulletin OET 65, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 5 lower (7 dB) than the value calculated for the equivalent distance in the main beam.

In this particular case, the antenna is mounted 7.5 m (24 feet) above the ground. Therefore, the closest that ground personnel and passengers could approach an operational antenna would be at the very least 20 antenna diameters below the main beam.

The previous calculation of the power density immediately in the near field in front of the antenna) resulted in a value of 216.6 mW/cm^2. Using the analysis provided in Bulletin OET 65, standing more than 31 antenna diameters off axis would decrease the exposure level by at least 34 dB to where the power density on the ground below the fuselage mounted antenna was less than 2.5 % of the MPE limits for the general population. It is highly unlikely that the general population would ever be permitted to approach the fuselage of an operational aircraft that closely. Even so, the exposure level at that distance complies with the MPE requirements. At any greater distance (such as boarding the aircraft), the exposure level would be lower still.

4 Compliance Conclusion

SES will observe standard safety precautions with respect to operations and maintenance of the HR6400 antenna, including powering the antenna off in advance of maintenance activities. In addition, given the location of the antenna on the fuselage of business jets, there is no possibility that members of the general public will be located in regions where MPE values may be exceeded.

Based on the results of the analysis with regard to the potential exposure levels in all respects – directly in front of the antenna, to the side of the antenna, and at ground level – and taking into account the access restrictions for both trained and untrained persons and standard safety procedures, we conclude that the operation of the Astronics AeroSat HR6400 Ku-band antenna as a fuselage-mounted aircraft antenna satisfies the MPE compliance requirements in the FCC regulations.

Report prepared by

/s/ George Varkey

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HR129 FCC RF Hazard Compliance Analysis

In connection with a license application by SES Americom, Inc. ("SES") for operation of a Ku-band aircraft remote antenna (HR129), the following assessment is provided in compliance with the FCC limits for maximum permissible exposure (MPE) to RF fields.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna radiating surface are expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians will receive training specifying this area as a high exposure area. Procedures will be established to ensure that all transmitters are turned off before this area may be accessed by operators, maintenance or other authorized personnel.

The sections that follow provide the analysis and conclusions regarding compliance.

1 Operational Data

In calculating compliance with the applicable exposure limits, SES used the technical data for HR129 operations described elsewhere in this application.

2 Applicable MPE Limits

The MPE limits are described in the FCC Rules and Regulations. For the frequency range of interest here, the applicable limit for acceptable, continuous exposure of the general population is 1.0 milliwatt per square centimeter (mW/cm^2), and for "controlled" occupational exposure, it is 5.0 mW/cm^2. Access to the antenna is restricted to trained personnel, and thus the latter limit is generally applicable. However, it is possible that untrained members of the general population could be within certain distances from the aircraft. Therefore, the MPE limit for the general population has also been examined.

3 FCC Formulas and Calculations

FCC Bulletin OET 65 provides standardized formulas for calculating the power density in the areas of interest here. Using the formulas from Bulletin OET 65, we report the exposure levels (1) directly in front of the antenna, (2) in the main beam at the transition from near to far field, and (3) farther away but still in the main beam where the MPE limit is met for both controlled and general population exposure; and (4) to the side of the antenna. Each area of interest will be addressed below and the results of the calculations are given.

3.1 Potential exposure level directly in front of the antenna

The worst-case possible exposure occurs right at the surface (aperture) of the antenna. According to Bulletin OET 65, the applicable formula for power density, **S**, at the antenna surface is as follows:

$$\mathbf{S = 4 * P / A}$$

Where: **P** represents the antenna input power; and,

A is the surface area of the antenna.

Based on the formula in Bulletin OET 65 and using the technical parameters of the antenna, SES calculates that the power density at the antenna surface is 60.6 mW/cm^2, which exceeds the 5.0 mW/cm^2 MPE limit for controlled access. However, there is no way to approach this close to the antenna when the aircraft is in flight. Furthermore, the antenna will be switched off completely (i.e. unpowered) when a technician needs to perform work in this area (which is more than 24 feet above ground level). Standard RF safety procedures will be applied and the power to the antenna will be removed during the period of the work.

The formula for near-field, on-axis power density, directly in front of the antenna is as follows:

$$S = 16 * | * P / (pi * D^2)$$

Where: **P** represents the antenna input power

| represents the antenna illumination efficiency; and,

D is the antenna diameter.

Based on the formula in Bulletin OET 65, using the technical parameters of the antenna and an illumination efficiency of 80%, SES calculates that the near-field, on-axis power density, directly in front of the antenna is 48.53 mW/cm^2, which exceeds the occupational MPE limit. This is the exposure level directly in front of the antenna at a distance of 1.02 meters. For the reasons stated above, there is no way for a technician or the general public to approach this close to the antenna while it is transmitting.

We can calculate the distance at which the antenna emissions would meet the MPE limits for controlled access and for the general population using the following formula:

$$RMPE = (G * P) / (4 * pi * MPE)$$

Where: **G** represents the Gain of the antenna;

P represents the antenna input power: and,

MPE represents the maximum permissible exposure limit.

SES calculated the distance at which the antenna emissions would meet the MPE limits for controlled access and for the general population and determined that the MPE limits for controlled access are met at 4.98 m (16.3 feet) directly in front of the antenna. The MPE limits for the general population are met at 11.13 m (36.5 feet) directly in front of the antenna.

The results of this calculation are also used in the analysis of potential exposure to the immediate side of the antenna, which is addressed in the subsection that follows.

3.2 Potential exposure level to the side of the antenna

The near-field power density drops off dramatically outside the imaginary cylinder extending from the surface along the axis of the main beam of an aperture antenna. According to Bulletin OET 65, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 lower (20 dB) than the value calculated for the equivalent distance in the main beam.

In this particular case, the antenna is mounted 8.8 m (29 feet) above the ground. Therefore, the closest that ground personnel and passengers could approach an operational antenna would be at the very least 30 antenna diameters below the main beam.

The previous calculation of the power density immediately in the near field in front of the antenna) resulted in a value of 48.53 mW/cm^2. Using the analysis provided in Bulletin OET 65, standing more than 26 antenna diameters off axis would decrease the exposure level by at least 34 dB to where the power density on the ground below the tail mounted antenna was less than 2.5 % of the MPE limits for the general population. It is highly unlikely that the general population would ever be permitted to approach the tail of an operational aircraft that closely. Even so, the exposure level at that distance complies with the MPE requirements. At any greater distance (such as boarding the aircraft), the exposure level would be lower still.

4 Compliance Conclusion

SES will observe standard safety precautions with respect to operations and maintenance of the HR129 antenna, including powering the antenna off in advance of maintenance activities. In addition, given the location of the antenna on the top of the tail of business jets, there is no possibility that members of the general public will be located in regions where MPE values may be exceeded.

Based on the results of the analysis with regard to the potential exposure levels in all respects – directly in front of the antenna, to the side of the antenna, and at ground level – and taking into account the access restrictions for both trained and un-trained persons and standard safety procedures, we conclude that the operation of the Astronics HR129 Ku-band antenna as a tail mounted aircraft antenna satisfies the MPE compliance requirements in the FCC regulations.

Report prepared by

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ANNEX 7: SES AMERICOM, INC. CERTIFICATIONS

SES Americom, Inc. ("SES"), in support of the foregoing application for an ESAA License, hereby certifies as follows:

1. Consistent with Section 25.227(a)(9) of the Commission's rules, each SES ESAA terminal shall automatically cease transmitting within 100 milliseconds upon loss of reception of the satellite downlink signal or when it detects that unintended satellite tracking has happened or is about to happen.
2. Consistent with Section 25.227(a)(10) of the Commission's rules, each SES ESAA terminal will be subject to the monitoring and control by the SES Network Operations Center ("NOC") in Manassas, Virginia. Each SES ESAA terminal will be able to receive "enable transmission" and "disable transmission" commands from the NOC and will automatically cease transmissions immediately on receiving any "parameter change command," which may cause harmful interference during the change, until it receives an "enable transmission" command from its NOC. In addition, the NOC will be able to monitor the operation of an ESAA terminal to determine if it is malfunctioning.
3. SES's target space station operators have confirmed that SES's proposed ESAA operations over international waters are within coordinated parameters for adjacent satellites up to 6 degrees away on the geostationary arc, as required by Section 25.227(a)(15) of the Commission's rules.
4. As required by Section 25.227(a)(11) of the Commission's rules, each SES ESAA terminal will be self-monitoring and, should a fault which can cause harmful interference to fixed-satellite service networks be detected, the terminal will automatically cease transmissions.
5. Pursuant to the requirements of new Section 25.115(m)(3)(i) adopted in IB Docket No. 17-95, FCC 18-138, SES further certifies that each SES ESAA terminal is self-monitoring and capable of automatically ceasing or reducing emissions within 100 milliseconds if the ESIM transmitter exceeds the relevant off-axis EIRP density limits.

By: *<u>/s/ Steven Osman</u>*
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June 3, 2019