

TECHNICAL APPENDIX

SES-15 AT 129.15° W.L.

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

This technical appendix is submitted in support of the petition of SES Satellites (Gibraltar) Limited (“SES”) for U.S. market access for the SES-15 spacecraft to be located at 129.15° W.L. SES-15 is currently under construction by The Boeing Corporation, with payloads operating in portions of the Ku-band and Ka-band.

The spacecraft’s Ku-band transponders will provide coverage of the United States, Canada, Mexico, Central America and the Caribbean via a series of spot beams in the 10.7-11.95 GHz and 14.125-14.375 GHz frequencies. The spot beams will be augmented with a broadcast beam capability across the same service area in two 36 MHz transponders within 10.95-11.2 GHz and 11.45-11.7 GHz. SES-15 will utilize Ka-band spectrum in 18.3-18.8 GHz, 19.7-20.2 GHz, 27.5-28.6 GHz, and 29.25-30 GHz to provide gateway functions for its Ku-band spot beams, via four fixed spot beams located over areas in the U.S. East Coast, Southwest, Northwest and over Colorado/Wyoming.

SES-15 will provide coverage of the United States, Canada, Mexico, Central America and the Caribbean through a wide area beam in the 11.95-12.2 GHz, 14-14.125 GHz and 14.375-14.5 GHz frequencies.

SES-15 will also host a Wide Area Augmentation System (“WAAS”) payload for the Federal Aviation Administration that will support the U.S. Global Positioning System. SES will separately seek market access for the WAAS payload.

2.0 Schedule S (§25.114(c))

The Schedule S database is included with this filing. In preparing the Schedule S, SES relied on the most recent instructions that take into account the changes to Section 25.114 adopted in the Part 25 reform proceeding, which eliminated or modified various requirements for information that must be provided in the Schedule.¹

Considering the large number of connectivities for the forward and return links to the spot beams, the associated uplinks and downlinks are entered separately in Table S10, Space Station Transponders. SES is providing information regarding two representative user beam groups in Section 5 below. In addition, because the bandwidths assigned to each beam vary widely (from 27 MHz to 320 MHz), and hence the maximum absolute EIRPs, SES is providing the maximum EIRP for the beam groups in 36 MHz equivalents in Schedule S, Table S7. The EIRP levels across 36 MHz in each beam of each user beam group are similar. Similarly, the EIRPs for the Ka-band beams (also in Schedule S, Table S7) are given in a common bandwidth of 250 MHz. In addition, the minimum Saturation Flux Density value (SFD) for the command carrier is not provided since it is only a relevant parameter for the communication payload.

¹ Consistent with those instructions, in cases where the Schedule S software requests information that space station applicants are no longer required to provide, SES has omitted data elements, or where necessary to permit validation of the Schedule S file, has entered a “1” as a placeholder. SES specifies that these “1” data entries are outside the scope of the certifications herein regarding accuracy of the information provided with this petition.

In addition, SES notes that the Schedule S includes preliminary, partial information regarding the WAAS payload on SES-15. Due to limitations in the Schedule S software, SES was unable to delete this information when it decided to separately seek market access for the WAAS payload. SES specifies that the information regarding the WAAS payload in the Schedule S is outside the scope of the certifications herein regarding the accuracy of the technical information and compliance with applicable Commission requirements. SES will provide complete information and certifications regarding the WAAS payload in the Schedule S and other technical materials that will be filed with the separate WAAS market access petition.

3.0 Telemetry and Telecommand (TT&C) frequencies and beams

The TT&C beam information and link budgets are included in the Schedule S. Table 1 below shows the satellite's TT&C frequencies, polarizations and associated antennas, and possible configurations. TT&C functions will be provided by earth stations located in South Mountain, California and Woodbine, Maryland. In practice, one command carrier will generally be used for nominal on station operations, and both telemetry carriers will be used. In an emergency, any of the configurations shown in Table 1 may be implemented.

Table 1: TT&C Carrier Frequencies

	Frequency, MHz	On Station Polarization	On Station Antenna	Transfer Orbit/Contingency Polarization	Transfer Orbit/Contingency Antenna
Command carriers (bandwidth: 800 kHz, 1.2 MHz capture range)					
TC1	14001	V	Horn	RHCP or LHCP	Forward/Aft Pipe
TC2	13999	V	Horn	RHCP or LHCP	Forward/Aft Pipe
TC3	14499	H	Horn	RHCP or LHCP	Forward/Aft Pipe
Telemetry (bandwidth: 300 kHz)/Beacon ²					
TM1	10700.5	V	Horn	RHCP or LHCP	Forward/Aft Pipe
TM2	12199.5	H	Horn	RHCP or LHCP	Forward/Aft Pipe
KAB1	20199.5	RHCP	Horn	n/a	n/a

The beacons described above are also used to permit earth stations in Ku-band or Ka-band to track the satellite.

4.0 PFD limits (§25.208 and 25.138)

Tables 2, 3, 4, 5, 6, and 7 demonstrate that the PFD values for SES-15's extended Ku-band payload will comply with §25.208(b).

² The Ka-beacon is a CW carrier and therefore is not modulated.

Table 2: Maximum PFD values and margins relative to permissible limits of §25.208(b) for User Beam Group 1, V polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	57.1	57.1	57.1	57.1	57.1	57.1
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-1.7	-1.2	-0.8	-2.1	-5.5	0.0
EIRP at elevation angle, dBW	52.4	52.9	53.3	52.0	48.6	54.1
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	12.9	13.4	13.8	12.5	9.1	14.6
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-150.4	-149.8	-149.3	-150.5	-153.8	-147.5
Margin, dB, relative to 25.208 (b)(1)	0.4	2.3	4.3	8.0	13.8	7.5

Table 3: Maximum PFD values and margins relative to permissible limits of §25.208(b) for User Beam Group 1, H polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	57.9	57.9	57.9	57.9	57.9	57.9
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-2.8	-2.0	-1.0	-0.2	-1.5	0.0
EIRP at elevation angle, dBW	52.1	52.9	53.9	54.7	53.4	54.9
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	12.5	13.4	14.3	15.2	13.8	15.4
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-150.7	-149.8	-148.7	-147.8	-149.0	-146.7
Margin, dB, relative to 25.208 (b)(1)	0.7	2.3	3.7	5.3	9.0	6.7

Table 4: Maximum PFD values and margins relative to permissible limits of §25.208(b) for User Beam Group 2, V polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	54.9	54.9	54.9	54.9	54.9	54.9
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-3.2	-2.5	-1.6	-0.7	-0.4	0.0
EIRP at elevation angle, dBW	48.7	49.4	50.3	51.2	51.5	51.9
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	9.1	9.9	10.8	11.6	11.9	12.4
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-154.1	-153.3	-152.3	-151.3	-150.9	-149.7
Margin, dB, relative to 25.208 (b)(1)	4.1	5.8	7.3	8.8	10.9	9.7

Table 5: Maximum PFD values and margins relative to permissible limits of §25.208(b) for User Beam Group 2, H polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	57.2	57.2	57.2	57.2	57.2	57.2
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-20.0	-20.0	-20.0	-20.0	0.0	0.0
EIRP at elevation angle, dBW	34.2	34.2	34.2	34.2	54.2	54.2
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	-5.3	-5.3	-5.3	-5.3	14.7	14.7
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-168.6	-168.5	-168.4	-168.3	-148.2	-147.4
Margin, dB, relative to 25.208 (b)(1)	18.6	21.0	23.4	25.8	8.2	7.4

Table 6: Maximum PFD values and margins relative to permissible limits of §25.208(b) for Beam NABV, V polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	50.0	50.0	50.0	50.0	50.0	50.0
Output backoff, dB	0.0	0.0	0.0	0.0	0.0	0.0
Gain roll-off at elevation angle, dBi	-1.4	-1.4	-1.3	-1.2	-0.8	0.0
EIRP at elevation angle, dBW	48.6	48.7	48.7	48.8	49.2	50.0
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	9.1	9.1	9.2	9.3	9.7	10.5
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-154.2	-154.0	-153.9	-153.7	-153.2	-151.6
Margin, dB, relative to 25.208 (b)(1)	4.2	6.5	8.9	11.2	13.2	11.6

Table 7: Maximum PFD values and margins relative to permissible limits of §25.208(b) for Beam NABH, H polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	50.0	50.0	50.0	50.0	50.0	50.0
Output backoff, dB	0.0	0.0	0.0	0.0	0.0	0.0
Gain roll-off at elevation angle, dBi	-1.4	-1.4	-1.3	-1.2	-0.8	0.0
EIRP at elevation angle, dBW	48.6	48.7	48.7	48.8	49.2	50.0
Carrier bandwidth, MHz	36	36	36	36	36	36
EIRP density at elevation angle dBW/4kHz	9.1	9.1	9.1	9.3	9.7	10.5
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-154.2	-154.0	-153.9	-153.7	-153.2	-151.6
Margin, dB, relative to 25.208 (b)(1)	4.2	6.5	8.9	11.2	13.2	11.6

Table 8 demonstrates that the PFD values for SES-15's Telemetry signal at 10700.5 GHz will comply with No. 21.16 of the ITU Radio Regulations with respect to the operation of geostationary satellites.

Table 8: Maximum PFD values and margins relative to permissible limits of No. 21.16 of the ITU Radio Regulations for Telemetry signal at 10700.5 MHz

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	17.0	17.0	17.0	17.0	17.0	17.0
Gain roll-off at elevation angle, dBi	-2.0	-2.0	-2.0	-2.0	0.0	0.0
EIRP at elevation angle, dBW	15.0	15.0	15.0	15.0	17.0	17.0
Carrier bandwidth, MHz	0.30	0.30	0.30	0.30	0.30	0.30
EIRP density at elevation angle dBW/4kHz	-3.8	-3.8	-3.8	-3.8	-1.8	-1.8
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208 (b)(1) pfd limit, dBW/m2/4kHz	-150.0	-147.5	-145.0	-142.5	-140.0	-140.0
pfd, dBW/m2/4KHz	-167.0	-166.9	-166.8	-166.7	-164.6	-163.8
Margin, dB, relative to No. 21.16 of the ITU Radio Regulations	17.0	19.4	21.8	24.2	24.6	23.8

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

Tables 9, 10, 11, and 12 demonstrate that the PFD values for SES-15's Ka-band payload will comply with §25.138. Since §25.138 has stricter PFD limits than §25.208(c) and (d), compliance with §25.138 means that the PFD limits under §25.208(c) and (d) are also met.

Table 9: Maximum PFD values and margins relative to permissible limits of §25.138 for Beam CODR, RHCP polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	55.8	55.8	55.8	55.8	55.8	55.8
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-20.0	-20.0	-20.0	-20.0	0.0	0.0
EIRP at elevation angle, dBW	32.8	32.8	32.8	32.8	52.8	52.8
Carrier bandwidth, MHz	250	250	250	250	250	250
EIRP density at elevation angle dBW/MHz	8.8	8.8	8.8	8.8	28.8	28.8
Minimum spreading loss, dB/m2	-	-	-	-	-	-
25.138 (a) (6) pfd limit (18.3-18.8 GHz, 19.7-20.2 GHz), dBW/m2/MHz	163.3	-163.2	-163.1	-162.9	-162.8	-162.1
	-	-	-	-	-	-
pfd, dBW/m2/MHz	118.0	-118.0	-118.0	-118.0	-118.0	-118.0
	-	-	-	-	-	-
pfd, dBW/m2/MHz	154.5	-154.3	-154.2	-154.1	-134.0	-133.2
Margin, dB, relative to 25.138 (a)(6)	36.5	36.3	36.2	36.1	16.0	15.2

Table 10: Maximum PFD values and margins relative to permissible limits of §25.138 for Beam NWDL, LHCP polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	57.6	57.6	57.6	57.6	57.6	57.6
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-20.0	-20.0	-20.0	-20.0	-16.3	0.0
EIRP at elevation angle, dBW	34.6	34.6	34.6	34.6	38.3	54.6
Carrier bandwidth, MHz	250.00	250.00	250.00	250.00	250.00	250.00
EIRP density at elevation angle dBW/MHz	10.6	10.6	10.6	10.6	14.3	30.6
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.138 (a) (6) pfd limit (18.3-18.8 GHz, 19.7-20.2 GHz), dBW/m2/MHz	-118.0	-118.0	-118.0	-118.0	-118.0	-118.0
	-118.0	-118.0	-118.0	-118.0	-118.0	-118.0
pfd, dBW/m2/MHz	-152.7	-152.5	-152.4	-152.3	-148.5	-131.4
Margin, dB, relative to 25.138 (a)(6)	34.7	34.5	34.4	34.3	30.5	13.4

Table 11: Maximum PFD values and margins relative to permissible limits of §25.138 for Beam SWDL, LHCP polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	58.3	58.3	58.3	58.3	58.3	58.3
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-20.0	-20.0	-20.0	-20.0	0.0	0.0
EIRP at elevation angle, dBW	35.3	35.3	35.3	35.3	55.3	55.3
Carrier bandwidth, MHz	250.00	250.00	250.00	250.00	250.00	250.00
EIRP density at elevation angle dBW/MHz	11.3	11.3	11.3	11.3	31.3	31.3
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.138 (a) (6) pfd limit (18.3-18.8 GHz, 19.7-20.2 GHz), dBW/m2/MHz	-118.0	-118.0	-118.0	-118.0	-118.0	-118.0
pfd, dBW/m2/MHz	-152.0	-151.8	-151.7	-151.6	-131.5	-130.7
Margin, dB, relative to 25.138 (a)(6)	34.0	33.8	33.7	33.6	13.5	12.7

Table 12: Maximum PFD values and margins relative to permissible limits of §25.138 for Beam ECDL, LHCP polarization

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	56.6	56.6	56.6	56.6	56.6	56.6
Output backoff, dB	3.0	3.0	3.0	3.0	3.0	3.0
Gain roll-off at elevation angle, dBi	-10.0	-6.0	-2.0	0.0	0.0	0.0
EIRP at elevation angle, dBW	43.6	47.6	51.6	53.6	53.6	53.6
Carrier bandwidth, MHz	250.00	250.00	250.00	250.00	250.00	250.00
EIRP density at elevation angle dBW/MHz	19.6	23.6	27.6	29.6	29.6	29.6
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.138 (a) (6) pfd limit (18.3-18.8 GHz, 19.7-20.2 GHz), dBW/m2/MHz	-118.0	-118.0	-118.0	-118.0	-118.0	-118.0
pfd, dBW/m2/MHz	-143.7	-139.5	-135.4	-133.3	-133.2	-132.4
Margin, dB, relative to 25.138 (a)(6)	25.7	21.5	17.4	15.3	15.2	14.4

In addition, Table 13 demonstrates that the PFD values for SES-15's Ka-band beacon will comply with the PFD limits in §25.138.

Table 13: Maximum PFD values and margins relative to permissible limits of §25.138 for Ka-band beacon at 20199.5 MHz

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	21.4	21.4	21.4	21.4	21.4	21.4
Gain roll-off at elevation angle, dBi	-2.0	-2.0	-2.0	-2.0	0.0	0.0
EIRP at elevation angle, dBW	19.4	19.4	19.4	19.4	21.4	21.4
Carrier bandwidth, MHz	0.30	0.30	0.30	0.30	0.30	0.30
EIRP density at elevation angle dBW/MHz	24.6	24.6	24.6	24.6	26.6	26.6
Minimum spreading loss, dB/m2	-	-	-	-	-	-
	163.3	-163.2	163.1	162.9	-162.8	-162.1
25.138 (a) (6) pfd limit (18.3-18.8 GHz, 19.7-20.2 GHz), dBW/m2/MHz	-	-	-	-	-	-
	118.0	-118.0	118.0	118.0	-118.0	-118.0
pfd, dBW/m2/MHz	-	-	-	-	-	-
	138.6	-138.5	138.4	138.3	-136.2	-135.4
Margin, dB, relative to 25.138 (a)(6)	20.6	20.5	20.4	20.3	18.2	17.4

5.0 Satellite Antenna Gain Contours (§25.114(c)(4)(vi)(A) & (vii))

The Schedule S and accompanying gxt files provide the typical antenna gain contours for the SES-15 space station beams at 129.15° W.L.

Considering the large number of spot beams utilized in the Ku-band payload, the predicted antenna gain contours and associated performance characteristics are provided for two representative beam types – User Beam Group 1 (called beams U1DV, U1DH, U1UV and U1UH in Schedule S) and User Beam Group 2 (called beams U2DV, U2DH, U2UV and U2UH in Schedule S). In accordance with Section 25.114(c)(4)(vii)(B), Tables A-1 and A-2 in Annex A to this document provide the latitude and longitude of each spot beam’s maximum gain point. Consistent with §25.114(c)(4)(vi)(A) of the Commission’s rules, SES is not providing the gain characteristics for the global horn antennas (TCHV, TCHH, TMHV and TMHH) or the omni antennas (TCPR, TCPL, TMPR and TMPL) in a GIMS-readable format because the 8 dBi contours of these beams fall beyond the edge of the visible Earth.

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

Annex C shows typical link budgets for the various payloads on the satellite, including emission designators.

7.0 Maximum Theoretical Operation Levels

SES-15 will be operated consistent with coordination agreements with adjacent GSO satellites and co-frequency NGSO systems. In any case, in the 10.7-11.7 and 11.7-12.2 GHz bands, the downlink EIRP density of the SES-15 digital carriers will not exceed -18 dBW/Hz; and in the 14-14.5 GHz band, the input power density of the uplink digital carriers of earth stations operating with SES-15 will not exceed -42 dBW/Hz. In the 18.3-18.8 and 19.7-20.2 GHz bands, the downlink EIRP density of the SES-15 digital carriers will not exceed -12 dBW/Hz. In the 27.5-28.6 and 29.25-30 GHz bands, the input power density of the uplink digital carriers of earth stations operating with SES-15 will not exceed -50 dBW/Hz.

8.0 Coordination Matters including Two Degree Spacing Analysis (§25.114(d)(7) and §25.140(b)(2))

Annex D provides analyses demonstrating the compatibility of SES-15 at 129.15° W.L. with neighboring spacecraft in the Ku-band and Ka-band.

In addition to the analysis of the Ka-band portions of the payload with respect to the two degree spacing provisions in §25.138, SES also commits to complete coordination with U.S.

government systems operating across 17.8-20.2 GHz under footnote US334 to the U.S. Table of Frequency Allocations in §2.106. SES is also in the process of coordinating with Iridium pursuant to §25.258 in the 29.25-29.3 GHz band where there is overlap between the Iridium feeder links and SES-15 gateways.

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

9.1 Spacecraft Hardware Design

SES has assessed and limited the amount of debris released in a planned manner during normal operations of SES-15. During the satellite ascent, after separation from the launcher, no debris will be generated. As with all recent SES satellite launches, all deployments will be conducted using release devices designed to retain all physical debris. 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.

9.2 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-15 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. SES-15 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. No gases other than xenon will be used in the space station's propulsion system. 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 are 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 4500 psia and burst pressure of 7500 psia although qualification testing has been demonstrated up to 9300 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, 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, 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 4500 psia. For the maximum Xenon loading

of 320 kg, the projected pressure and mass of residual Xenon which 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	~233	~50	~35	4.2

9.3 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.

SES-15 will be positioned at 129.15° W.L., where it will replace the AMC-1 spacecraft. In considering current and planned satellites that may have a station-keeping volume that overlaps the SES-15 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 129.15° W.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-15 satellite, have been taken into account in the analysis.

Based on these reviews, there are three satellites operating at the nominal 129° W.L. location – Galaxy 12 at 129.0° W.L. with an east-west station-keeping box of +/- 0.05 degrees, Ciel 2 at 128.85° W.L. with an east-west station-keeping box of +/- 0.05 degrees, and AMC-1 at 129.15° W.L. The station-keeping boxes of Galaxy 12 and Ciel 2 do not overlap with SES-15's. With respect to AMC-1, which is also controlled and operated by SES, SES will develop a colocation strategy to allow both spacecraft to operate safely during traffic transfer. During the period of colocation, SES will likely use the proven inclination-eccentricity technique to ensure adequate separation between the satellites within a shared station-keeping volume. This strategy is presently in use by SES at several orbital locations to ensure proper operation and safety of multiple satellites within one orbital box. Should the final colocation strategy that SES develops require a change in the orbital position of AMC-1 or SES-15 during traffic transfer, then SES will apply for Special Temporary Authorization to cover those temporary changes in orbital location for the two satellites. There are no other pending applications before the Commission requesting authorization to use an orbital location within $\pm 0.05^\circ$ of 129.15° W.L., and within this sub-arc, there are no ITU networks within the station-keeping volume of SES-15 other than those submitted on behalf of SES. Based on the preceding, it is concluded that physical coordination of the SES-15 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.

9.4 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-15 to a disposal orbit with a minimum perigee of 272.6 km above the normal GSO operational orbit. This proposed disposal orbit altitude results from application of the IADC formula based on the following calculation:

$$\text{Total Solar Pressure Area "A"} = 66.2 \text{ m}^2$$

$$\text{"M"} = \text{Dry Mass of Satellite} = 2040 \text{ kg}$$

$$\text{"C}_R\text{"} = \text{Solar Pressure Radiation Coefficient} = 1.16$$

Therefore the Minimum Disposal Orbit Perigee Altitude:

$$\begin{aligned} &= 36,021 \text{ km} + 1000 \times C_R \times A/m \\ &= 36,021 \text{ km} + 1000 \times 1.16 \times 66.2/2040 \\ &= 36,058.6 \text{ km} \\ &= 272.6 \text{ km above GSO (35,786 km)} \end{aligned}$$

SES intends to reserve 1.16 kg of Xenon propellant in order to account for post-mission disposal of SES-15. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

ANNEX A

Latitude and Longitude of Maximum Antenna Gain Point(s) in User Beam Groups 1 and 2

Table A-1. Latitude and Longitude of Maximum Gain Points for User Beam Group 1

Beam Number	Latitude (deg. N)	Longitude (deg. E)
1	61.65	-144.42
2	56.03	-83.55
3	59.15	-94.27
4	61.25	-107.09
5	59.95	-158.15
6	25.4	-64.75
7	63.38	-118.48
8	42.96	-82.95
9	44.11	-94.47
10	46.61	-102.82
11	49.2	-111.88
12	49.89	-122.96
13	33.63	-74
14	34.56	-86.93
15	36.44	-96.35
16	37.92	-104.93
17	41.17	-111.07
18	41.43	-120.18
19	27.64	-75.48

Beam Number	Latitude (deg. N)	Longitude (deg. E)
20	28.51	-87.33
21	30.11	-96.54
22	31.03	-105.15
23	32.61	-112.66
24	34.5	-118.8
25	20.68	-81.84
26	22.94	-89.33
27	23.96	-97.73
28	25.56	-105.1
29	25.73	-111.86
30	19.37	-71.32
31	17.29	-91.07
32	18.81	-98.23
33	20.35	-104.51
34	13.02	-71.31
35	15.04	-83.86
36	10.58	-81.87
37	41.54	-69.29
38	52.3	-75.08

Table A-2. Latitude and Longitude of Maximum Gain Points for User Beam Group 2

Beam Number	Latitude (deg. N)	Longitude (deg. E)
39	59.49	-132.26
40	43	-130.96
41	39	-139.6
42	23.29	-154.83
43	33.55	-126.16
44	31.64	-133.93
45	30.59	-142.67
46	27.52	-148.97

ANNEX B

SES-15 Link Budgets

Table B-1
TT&C Link Budgets

Link Parameters	Units	Command			Telemetry		Beacon
		800KF9D	800KF9D	800KF9D	300KF9D	300KF9D	K001N0D
		TC1	TC2	TC3	TM1	TM2	KAB1
Uplink Frequency	MHz	14001	13999	14499			
Downlink Frequency	MHz				10700.5	12199.5	20199.5
Carrier Allocated Bandwidth	kHz	800.0	800	800	300	300	0.001
Uplink:							
Nominal Earth Station EIRP per carrier	dBW	84.0	84.0	84.0			
Earth Station Diameter	m	9.0	9.0	9.0			
Earth Station Gain	dBi	59.5	59.5	59.8			
Uplink Input Power per Carrier	dBW	24.5	24.5	24.2			
Input power density	dBW/4 kHz	1.5	1.5	1.2			
Free Space Loss	dB	206.4	206.4	206.8			
G/T Satellite towards E/S	dB/K	-16.0	-16.0	-16.0			
C/N Thermal Uplink	dB	31.1	31.1	30.8			
C/I XPOL, ACI, IM, ASI	dB	51.0	51.0	51.0			
C/(N+I) uplink	dB	31.1	31.1	30.8			
Downlink:							
Satellite e.i.r.p. per carrier	dBW				16.0	17.3	20.0
Maximum e.i.r.p. density	dBW/4kHz				-2.8	-1.5	20.0
Free Space Loss	dB				204.1	205.3	209.6
Earth Station Diameter	m				9.0	9.0	7.0
Earth Station Gain	dBi				57.7	59.2	61.2
Noise Temperature	K				185.0	185.0	280.0
Earth Station G/T	dB/K				35.0	36.5	36.7
C/N Thermal Downlink	dB				20.8	22.4	75.7
C/I XPOL, ACI, IM, ASI	dB				21.0	23.8	73.2
C/(N+I) downlink	dB				17.9	20.0	71.3
Adjacent Satellite Interference:							
Uplink Inp. Pwr. Dens. @ 2 degrees	dBW/Hz	-50	-50	-50			
Downlink e.i.r.p. Dens @ 2 degrees	dBW/Hz				-26	-26	-16
C/I up (single satellite)	dB	54.0	54.0	54.0			
C/I dn (single satellite)	dB				24.0	26.8	76.2
Aggregate C/I up	dB	51.0	51.0	51.0			
Aggregate C/I down	dB				21.0	23.8	73.2
Overall:							
C/(N+I) overall	dB	31.1	31.1	30.8	17.9	20.0	71.3
C/(N+I) required	dB	9.0	9.0	9.0	9.0	9.0	9.0
System Margin	dB	22.1	22.1	21.8	8.9	11.0	62.3

Table B-2
NA Beam Link Budgets

Link Parameters	Units	1M58G7W	175KG7W	36M0G7W	3M15G7W	36M0G7W	691KG7W
Data rate	Mbps	2.048	0.256	58.069	4	43.562	0.256
Mod cod		QPSK 7/8 turbo	8PSK, 2/3 turbo	8PSK 2/3 DVB-S2	QPSK 6/7 turbo	QPSK 3/4 DVB-S2	BPSK 1/2 turbo
Carrier bandwidth	MHz	1.580	0.175	36.000	3.151	36.000	0.691
Uplink:							
Uplink Frequency	GHz	14.377	14.377	14.417	14.377	14.417	14.377
Uplink transmit Power	dBW	5.8	-2.8	16.5	12.2	16.5	1.3
Earth Station Diameter	m	2.40	2.40	6.30	1.20	6.30	0.55
Earth Station Gain	dB _i	49.3	49.3	57.7	43.3	57.7	36.5
Earth station EIRP	dBW	55.1	46.5	74.2	55.5	74.2	37.8
Atmospheric Losses	dB	0.19	0.19	0.19	0.19	0.19	0.02
Free Space Loss	dB	207.3	207.3	207.3	207.3	207.3	207.3
Satellite G/T	dB/K	2.3	2.3	2.3	2.3	2.3	2.3
C/N Thermal Uplink	dB	16.5	17.5	22.0	13.9	22.0	3.0
C/I XPOL, ACI, IM, ASI	dB	19.2	20.1	24.7	16.6	24.7	5.5
C/(N+I) uplink	dB	14.6	15.6	20.1	12.0	20.1	1.0
Downlink:							
Downlink Frequency	GHz	12.077	12.077	12.117	12.077	12.117	12.077
Satellite EIRP per carrier	dBW	30.8	22.3	49.0	31.2	49.0	13.2
Atmospheric Losses	dB	0.15	0.15	0.15	0.15	0.02	0.15
Free Space Loss	dB	205.8	205.8	205.8	205.8	205.8	205.8
Earth Station Diameter	m	2.40	2.80	1.20	6.30	0.55	6.30
Earth Station Gain	dB _i	47.8	49.1	41.8	56.2	35.0	56.2
System Noise Temperature	K	195	156	170	173	175	173
Earth Station G/T	dB/K	24.9	27.2	19.5	33.8	12.6	33.8
C/N Thermal Downlink	dB	16.4	19.7	15.6	22.7	8.8	11.3
C/I XPOL, ACI, IM, ASI	dB	18.7	21.1	17.3	24.5	10.5	13.0
C/(N+I) downlink	dB	14.4	17.3	13.3	20.5	6.6	9.0
Adjacent Satellite Interference:							
Uplink Input Power Density at 2 deg	dBW/Hz	-50	-50	-50	-50	-50	-50
Downlink EIRP density at 2 deg	dBW/Hz	-26	-26	-26	-26	-26	-26
C/I up (single satellite)	dB	22.2	23.1	27.7	19.6	27.7	8.5
C/I dn (single satellite)	dB	21.7	24.1	20.3	27.5	13.5	16.0
Aggregate C/I up	dB	19.2	20.1	24.7	16.6	24.7	5.5
Aggregate C/I down	dB	18.7	21.1	17.3	24.5	10.5	13.0
Overall:							
C/(N+I) overall	dB	11.5	13.4	12.5	11.4	6.4	0.4
C/(N+I) required	dB	8.1	10.0	7.8	7.7	5.0	0.3
Margin	dB	3.4	3.4	4.7	3.7	1.4	0.1

Table B-3
HTS Beams Forward Link Budgets

Link Parameters	Units	36M0G7W	36M0G7W	36M0G7W
Data rate	Mbps	27.801	46.52	62.712
Mod cod		QPSK 1/2 DVB-S2	QPSK 5/6 DVB-S2	8PSK 3/4 DVB-S2
Carrier bandwidth	MHz	36.0	36.0	36.0
Uplink:				
Uplink Frequency	GHz	28.002	28.018	29.636
Uplink transmit Power	dBW	5.4	5.4	4.9
Earth Station Diameter	m	7.30	7.30	7.30
Earth Station Gain	dBi	64.8	64.8	65.3
Earth station EIRP	dBW	70.2	70.2	70.2
Atmospheric Losses	dB	0.39	0.39	0.39
Free Space Loss	dB	213.1	213.1	213.6
Satellite G/T	dB/K	14.1	12.5	14.1
C/N Thermal Uplink	dB	23.8	22.2	23.4
C/I XPOL, ACI, IM, ASI	dB	27.2	27.2	27.2
C/(N+I) uplink	dB	22.2	21.0	21.9
Downlink:				
Downlink Frequency	GHz	11.202	11.218	11.318
Satellite EIRP per carrier	dBW	47.5	47.5	47.5
Atmospheric Losses	dB	0.02	0.14	0.14
Free Space Loss	dB	205.1	205.2	205.2
Earth Station Diameter	m	0.55	1.00	1.20
Earth Station Gain	dBi	34.4	39.6	41.2
System Noise Temperature	K	188	125	126
Earth Station G/T	dB/K	11.6	18.6	20.2
C/N Thermal Downlink	dB	7.0	13.8	15.4
C/I XPOL, ACI, IM, ASI	dB	8.3	13.5	15.2
C/(N+I) downlink	dB	4.6	10.7	12.3
Adjacent Satellite Interference:				
Uplink Input Power Density at 2 degrees	dBW/Hz	-56.5	-56.5	-56.5
Downlink EIRP density at 2 degrees	dBW/Hz	-26	-26	-26
C/I up (single satellite)	dB	30.2	30.2	30.2
C/I dn (single satellite)	dB	11.3	16.5	18.2
Aggregate C/I up	dB	27.2	27.2	27.2
Aggregate C/I down	dB	8.3	13.5	15.2
Overall:				
C/(N+I) overall	dB	4.5	10.3	11.8
C/(N+I) required	dB	2.0	6.2	9.1
Margin	dB	2.5	4.1	2.7

Table B-4
HTS Beams Return Link Budgets

Link Parameters	Units	5M20G7W	3M90G7W	3M90G7W
Data rate	Mbps	4	4	4
Mod cod		QPSK 1/2 turbo	QPSK 2/3 turbo	BPSK 2/3 turbo
Carrier bandwidth	MHz	5.2	3.90	3.90
Uplink:				
Uplink Frequency	GHz	14.311	14.311	14.311
Uplink transmit Power	dBW	8.5	6.9	5.3
Earth Station Diameter	m	0.55	1.00	1.20
Earth Station Gain	dBi	36.5	41.7	43.3
Earth station EIRP	dBW	45.0	48.6	48.6
Atmospheric Losses	dB	0.02	0.19	0.19
Free Space Loss	dB	207.3	207.3	207.3
Satellite G/T	dB/K	13.0	13.0	13.0
C/N Thermal Uplink	dB	12.1	16.8	16.8
C/I XPOL, ACI, IM, ASI	dB	3.9	8.7	8.7
C/(N+I) uplink	dB	3.3	8.1	8.1
Downlink:				
Downlink Frequency	GHz	19.886	19.886	19.886
Satellite EIRP per carrier	dBW	31.4	31.8	31.8
Atmospheric Losses	dB	0.38	0.38	0.38
Free Space Loss	dB	210.1	210.1	210.1
Earth Station Diameter	m	7.30	7.30	7.30
Earth Station Gain	dBi	61.8	61.8	61.8
System Noise Temperature	K	457	457	204
Earth Station G/T	dB/K	35.2	35.2	38.7
C/N Thermal Downlink	dB	17.5	19.2	22.7
C/I XPOL, ACI, IM, ASI	dB	21.1	19.7	19.7
C/(N+I) downlink	dB	15.9	16.4	18.0
Adjacent Satellite Interference:				
Uplink Input Power Density at 2 degrees	dBW/Hz	-50	-50	-50
Downlink EIRP density at 2 degrees	dBW/Hz	-16	-16	-16
C/I up (single satellite)	dB	6.9	11.7	11.7
C/I dn (single satellite)	dB	21.1	22.7	22.7
Aggregate C/I up	dB	3.9	8.7	8.7
Aggregate C/I down	dB	21.1	19.7	19.7
Overall:				
C/(N+I) overall	dB	3.1	7.5	7.7
C/(N+I) required	dB	2.4	4.6	4.6
Margin	dB	0.7	2.9	3.1

Table B-5
Broadcast Beam Link Budgets

Link Parameters	Units	36M0G7W	36M0G7W
Data rate	Mbps	38.723	52.187
Mod cod		QPSK 2/3 DVB-S2	8PSK 3/5 DVB-S2
Carrier bandwidth	MHz	36.00	36.00
Uplink:			
Uplink Frequency	GHz	28.354	27.836
Uplink Transmit Power	dBW	-3.9	-3.7
Earth Station Diameter	m	7.30	7.30
Earth Station Gain	dB	64.9	64.7
Earth Station Transmit EIRP/Carrier	dBW	61.0	61.0
Atmospheric Losses	dB	0.36	0.37
Free Space Loss	dB	213.2	213.1
Satellite G/T	dB/K	15.8	15.8
C/N Thermal Uplink	dB	16.3	16.4
C/I XPOL, ACI, IM, ASI	dB	18.0	18.0
C/(N+I) uplink	dB	14.0	14.1
Downlink:			
Downlink Frequency	GHz	11.554	11.036
Satellite EIRP per carrier	dBW	49.0	49.0
Atmospheric Losses	dB	0.01	0.14
Free Space Loss	dB	205.4	205.0
Earth Station Diameter	m	0.55	0.85
Earth Station Gain	dB	34.6	38.0
System Noise Temperature	K	171	174
Earth Station G/T	dB/K	12.3	15.6
C/N Thermal Downlink	dB	8.9	12.5
C/I XPOL, ACI, IM, ASI	dB	10.1	13.5
C/(N+I) downlink	dB	6.5	9.9
Adjacent Satellite Interference:			
Uplink Input Power Density at 2 degrees	dBW/Hz	-56.5	-56.5
Downlink EIRP density at 2 degrees	dBW/Hz	-26	-26
C/I up (single satellite)	dB	21.0	21.0
C/I dn (single satellite)	dB	13.1	16.5
Aggregate C/I up	dB	18.0	18.0
Aggregate C/I down	dB	10.1	13.5
Overall:			
C/(N+I) overall	dB	5.8	8.5
C/(N+I) required	dB	4.1	6.7
Margin	dB	1.7	1.8

ANNEX C

Interference Analysis

Interference Analyses

1- SES-15 TT&C:

Managing interference potential from TT&C carriers is done on a case-by-case basis and relies on frequency diversity, polarization diversity and other tools to avoid interference.

For the Ku-band, to ensure that SES-15's Ku-band TT&C operations do not cause harmful interference into the adjacent satellite networks, coordination of the TT&C channels will be completed with JSAT, which operates the Horizons 1 Ku-band payload at 127° W.L. This approach is consistent with industry practice, in which TT&C operations are typically addressed with adjacent satellite licensees on a case-by-case basis considering the actual characteristics of the respective networks.

For the Ka-band, there is no adjacent satellite operator within two degrees; however, compliance with §25.138 has been demonstrated in section 4.

2- SES-15 Communications Payload:

a) Ku-band Two Degree Spacing Analysis for 129.15° W.L:

i. SES-15 Frequency Bands 10.7-12.2 GHz and 14.0-14.5 GHz

For the 11.7-12.2 GHz and 14.0-14.5 GHz bands, the only operational Ku-band satellite adjacent to the 129.15° W.L. position is JSAT's Horizons 1 at 127° W.L. with more than 2° geocentric separation. Given that there is currently no Ku-band satellite at 131° W.L., a hypothetical satellite assumed to be transmitting at the same maximum uplink power density and downlink EIRP density levels as those being sought for the SES-15 satellite is used to estimate interference levels at that orbital location.

For this portion of the analysis, the carrier-to-interference ratio between two adjacent systems is estimated for a set of competing emissions. The analysis methodology consists of defining the

emission characteristics for each network and computing the interference levels resulting from co-channel operation. C/I levels are calculated for each combination of overlapping emissions (*i.e.*, the same frequency band and link direction). Results are presented in tables providing the interference levels for combinations of emissions pairs.

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

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

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

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

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

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

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

System characteristics used in the analysis are shown in the following tables. Three space stations are considered: SES-15 and two adjacent stations: JSAT's Horizons 1 at 127° W.L., and a hypothetical satellite at 131° W.L. assumed to be transmitting at the same maximum uplink power density and downlink EIRP density levels as those for SES-15.

Table C-1 provides the space station name and orbital information, and assumed earth station parameters of the networks.

Table C-1: Station Parameters

Parameter	System 1	System 2	System 3
Space station name	Horizons-1	SES-15	Hypothetical satellite
Nominal orbit location (+E, -W)	-127.00	-129.15	-131.00
Station keeping tolerance (°)	0.05	0.05	0.05
Earth station pointing error (°)	0.15	0.15	0.15
Earth station antenna efficiency (fraction)	0.65	0.65	0.65

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

Tables C-2 and C-3 show the emission characteristics considered here for Horizons-1 and a hypothetical satellite at 131° W.L. (The emissions characteristics for Horizons-1 have been derived from its Schedule S file).

Table C-2: Horizons 1 Typical Emissions

Uplink: Horizons-1 Carriers								
Emission	Occupied Bandwidth (MHz)	Uplink SFD	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density
36M0G7W	36.00	-89.0	74.0	-1.6	6.1	57.4	29	-38.8
6M00G7W	5.57	-82.0	68.9	1.4	6.1	57.4	29	-35.8
1M454G7W	1.229	-82.0	62.3	1.4	6.1	57.4	29	-35.8
200KG7W	0.154	-82.0	53.3	1.4	6.1	57.4	29	-35.8
100KG7W	0.077	-82.0	50.3	1.4	6.1	57.4	29	-35.8
400KG7W	0.307	-82.0	56.3	1.4	3.0	51.2	29	-29.6

DOWNLINK -- Horizons 1 Carriers							
Emission	Satellite EIRP	Bandw. (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain
36M0G7W	51.8	36.0	-23.8	1.8	45.2	29	20.2
6M00G7W	51.8	5.565	-26.8	3.7	51.4	29	20.2
1M45G7W	51.8	1.229	-26.8	1.8	45.2	29	20.2
200KG7W	51.8	0.154	-26.8	2.4	47.7	29	20.2
100KG7W	51.8	0.077	-26.8	2.4	47.7	29	20.2
400KG7W	51.8	0.307	-26.8	6.1	55.8	29	20.2

Table C-3: Hypothetical satellite at 131° W.L. Typical Emissions

Uplink: Carriers for Hypothetical Satellite at 131W							
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density
1M58G7W	1.58	55.1	-6.9	2.40	49.3	29	-34.3
175KG7W	0.175	46.5	-5.9	2.4	49.3	29	-33.3
3M15G7W	3.151	55.5	-9.5	1.2	43.3	29	-30.9
5M20G7W	5.20	45.0	-22.2	0.55	36.5	29	-36.8
3M90G7W	3.90	48.6	-17.3	1.0	41.7	29	-37.1
3M90G7W	3.90	48.6	-17.3	1.20	43.3	29	-38.7

Downlink: Carriers for Hypothetical Satellite at 131W							
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain
1M58G7W	30.8	1.58	-31.2	2.4	47.7	29	21.9
175KG7W	22.3	0.175	-30.1	2.8	49.0	29	21.9
3M15G7W	31.2	3.151	-33.8	6.3	56.1	29	21.9
36M0G7W	47.5	36.00	-28.1	0.55	34.9	29	21.9
36M0G7W	47.5	36.00	-28.1	1.0	40.1	29	21.9
36M0G7W	47.5	36.00	-28.1	1.2	41.7	29	21.9

Table C-4 shows the SES-15 emission characteristics considered here.

Table C-4: SES-15 Typical Emissions

Uplink: SES-15 Carriers						
Emission	1M58G7W	175KG7W	3M15G7W	5M20G7W	3M90G7W	3M90G7W
Bandwidth (MHz)	2.40	0.175	3.15	5.20	3.90	3.90
Uplink EIRP	55.1	46.5	55.5	45.0	48.6	48.6
Uplink Power	5.8	-2.8	12.2	8.5	6.9	5.3
Uplink Power density	-58.0	-55.2	-52.7	-58.6	-59.0	-60.6
Uplink Earth Station (m)	2.40	2.4	1.2	0.55	1.0	1.20
Earth Station Gain	49.3	49.3	43.3	36.5	41.7	43.3
Upl. EIRP density	-8.7	-5.9	-9.5	-22.2	-17.3	-17.3
Sidelobe Characteristic	29	29	29	29	29	29
Off-axis Eirp density	-37.8	-35.0	-32.6	-38.5	-38.8	-40.4

Downlink: SES-15 Carriers						
Emission	1M58G7W	175KG7W	3M15G7W	36M0G7W	36M0G7W	36M0G7W
Bandwidth	1.58	0.175	3.151	36.00	36.00	36.00
Receive Earth Station (m)	2.40	2.80	6.30	0.55	1.00	1.20
Satellite EIRP	30.8	22.3	31.2	47.5	47.5	47.5
Downlink EIRP density	-31.2	-30.1	-33.8	-28.1	-28.1	-28.1
RX Earth Station Gain	47.7	49.0	56.1	34.9	40.1	41.7
Sidelobe Characteristic	29	29	29	29	29	29
Off-axis Gain	20.2	20.2	20.2	20.2	20.2	20.2

Applying the methodology presented above to the emission characteristics shown in Tables C-2, C-3 and C-4 results in the C/I levels shown in Appendix 1 to this Annex. A separate table is provided for each frequency band/link direction pair that shows the C/I level for each emission pair. All the calculated C/I values, including the worst cases, are shown in Appendix 1 to this Annex.

ii. SES-15 Frequency Bands 10.95-11.2 and 11.45-11.7 GHz

Currently there are no operational GSO Extended Ku-band satellites that use the 10.95-11.2 GHz band or the 11.45-11.7 GHz band within two degrees of the 129.15° W.L. location, nor are there any pending applications before the Commission for use of these bands by a GSO satellite within two degrees.

Therefore, in order to demonstrate two-degree compatibility in these frequency ranges, the transmission parameters of the SES-15 satellite have been assumed as both the wanted and victim carriers, and the C/I level is calculated.

As the SES operations in this band are for the Broadcast beam, with the smallest antenna size being 0.55m for the downlink earth stations, the downlink C/I calculation is simplified. One can reasonably assume that the EIRP is the same from the wanted satellite and interfering satellite at the wanted location on the Earth, and hence only the receive earth station antenna discrimination factors in.

Therefore, the downlink C/I for similar operations can be simplified as the off-axis discrimination of the receive earth station antenna, as follows:

$$\begin{aligned}
 C/I_d &= \text{on-axis gain (dBi)} - \text{off-axis gain of the receive earth station antenna (dBi)} \\
 &= 34.6 \text{ dBi (on-axis gain of the 0.55 m receive earth station antenna)} - 29 + 25 * \\
 &\quad \log (1.925^\circ) \\
 &= 12.7 \text{ dB}
 \end{aligned}$$

Where the orbital separation is taken as the difference between 129.15° W.L. and the closest adjacent slot, 131°W.L., minus the station-keeping tolerance of each satellite (+/- 0.5°) and approximating the topocentric angle by adding 10% to the geocentric angular separation.

The resulting C/I is high and demonstrates that the operations proposed herein are two degree compatible.

b) Ka-band Two Degree Spacing Analysis for 129.15° W.L.:

No transmissions of the SES-15 satellite network will exceed the uplink off-axis EIRP density and downlink PFD levels of §25.138, regardless of whether the frequency band used is subject to §25.138.

i. SES-15 Frequency Bands Subject to §25.138

The frequency bands used by SES-15 that are subject to §25.138 are 18.3-18.8 GHz, 19.7-20.2 GHz, 28.35-28.6 GHz and 29.25-30.0 GHz. Compliance with the Commission's two-degree spacing policy is assured in these bands provided:

- The uplink off-axis EIRP density levels of §25.138(a)(1) are not exceeded;
- The maximum downlink PFD levels are lower than the PFD value of -118 dBW/m²/MHz given in §25.138(a)(6) of the rules.

The clear sky uplink off-axis EIRP density limits of §25.138(a)(1) are equivalent to a maximum uplink input power spectral density ("PSD") of -56.5 dBW/Hz, assuming the antenna gain meets the off-axis gain mask of §25.209. As shown below, the maximum PSD level from any of the transmitting earth stations to be located in U.S. territory is below this value of -56.5 dBW/Hz. For the SES-15 transmitting gateway earth stations, the maximum EIRP density level is 51.4 dBW/MHz. The minimum antenna size for the SES-15 transmitting gateway earth stations will be 7.3m. This corresponds to a PSD level into the antenna of approximately -73.5 dBW/Hz, which is 17 dB below the above mentioned limit value.

The maximum EIRP that could be generated by any SES-15 TWTA is 59.6 dBW. This EIRP is associated with a 250 MHz bandwidth resulting in a maximum EIRP density of 35.6 dBW/MHz.

The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of 162.07 dB. Therefore, the maximum possible PFD at the Earth's surface in the Ka-band gateway downlink beams cannot exceed -126.5 dBW/m²/MHz (i.e. 35.6 -162.07). This level meets the -118 dBW/m²/MHz PFD limit at the Earth's surface, with a margin of 8.5 dB.

For the SES-15 Ka-band Beacon, Table 14 of Section 4 demonstrates that the PFD values will comply with the limits in §25.138.

Accordingly, all downlink Ka-band transmissions from SES-15 will be compliant with §25.138(a)(6) of the rules.

ii. SES-15 Frequency Bands Not Subject to §25.138

The only Ka-band frequency segment used by SES-15 that is not covered by §25.138 is the 27.5-28.35 GHz uplink band for the gateway links.

Currently there are no operational GSO Ka-band satellites that use the above listed band within two degrees of the 129.15° W.L. location, nor are there any applications pending before the Commission for use of this band by a GSO satellite within two degrees.

Therefore, in order to demonstrate two-degree compatibility in this frequency range, the transmission parameters of the SES-15 satellite have been assumed as both the wanted and victim carriers and the C/I level is calculated.

As the SES operations in this band are feeder links, with the smallest antenna size being 7.3 meters for the uplink earth station gateways, the uplink C/I calculation is simplified. Further, as operations in this band are spot beams, one can reasonably assume that the receive space station gain at the transmitting wanted and interfering earth station sites is the same. Therefore, the uplink C/I for similar operations at both slots can be simplified as the off-axis discrimination of the earth station antenna, as follows:

$$\begin{aligned} C/I_u &= \text{on-axis gain (dBi)} - \text{off-axis gain towards the wanted satellite (dBi)} \\ &= 64.09 \text{ dBi (on-axis gain of 7.3 m earth station antenna)} - 29 + 25 * \log(1.925^\circ) \\ &= 42.2 \text{ dB} \end{aligned}$$

Where the orbital separation is taken as the difference between 129.15° W.L. and the closest adjacent slot, 131°W.L., minus the station-keeping tolerance of each satellite (+/- 0.5°) and approximating the topocentric angle by adding 10% to the geocentric angular separation. The off-axis gain of the earth station antenna is modeled using Part 25 Section 25.209.

The resulting C/I is high, as one would expect for such large uplink earth station antennas, and demonstrates that the operations proposed herein are two degree compatible.

iii. Sharing with Terrestrial Services in the 27.5-28.35 GHz band

A showing regarding terrestrial sharing between the proposed U.S. gateway earth stations and the LMDS service in the 27.5-28.35 GHz band is set forth in the SES-15 gateway earth station applications, which are being filed contemporaneously with this petition.

APPENDIX 1 TO ANNEX C

C/I CALCULATIONS

Table A1-1: SES-15 into Horizons 1 Ku-Band Uplink C/I

Uplink C/I analysis SES-15 into Horizons-1				Uplink: SES-15 Carriers									
Frequency	14.375	GHz		Emission	1M58G7W	175K0G7W	3M151G7W	5M20G7W	3M90G7W	3M90G7W			
				Bandwidth (MHz)	1.58	0.175	3.15	5.20	3.90	3.90			
				Uplink EIRP	55.1	46.5	55.5	45.0	48.6	48.6			
SES-15 Orbital Position	129.15	W		Uplink Power	5.8	-2.8	12.2	8.5	6.9	5.3			
Horizons-1 Orbital Position	127.0	W		Uplink Power density	-56.2	-55.2	-52.7	-58.6	-59.0	-60.6			
Geocentric Separation	2.1	degrees		Uplink Earth Station (m)	2.4	2.4	1.2	0.55	1.0	1.2			
Topocentric Separation	2.3	degrees		Earth Station Gain	49.3	49.3	43.3	36.5	41.7	43.3			
				Upl. EIRP density	-6.9	-5.9	-9.5	-22.2	-17.3	-17.3			
				Sidelobe Characteristic	29	29	29	29	29	29			
				Off-axis Eirp density	-36.0	-35.0	-32.6	-38.5	-38.8	-40.4			
Uplink: Horizons-1 Carriers								Uplink C/I: SES-15 into Horizons-1 Carriers					
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density	C/I	C/I	C/I	C/I	C/I	C/I
36M0G7W	36.00	74.0	-1.6	6.1	57.4	29	-38.8	34.4	33.5	31.0	36.9	37.3	38.8
6M00G7W	5.565	68.9	1.4	6.1	57.4	29	-35.8	37.4	36.5	34.0	39.9	40.3	41.9
1M454G7W	1.229	62.3	1.4	6.1	57.4	29	-35.8	37.4	36.4	34.0	39.9	40.2	41.8
200KG7W	0.154	53.3	1.4	6.1	57.4	29	-35.8	37.4	36.5	34.0	39.9	40.2	41.8
100KG7W	0.077	50.3	1.4	6.1	57.4	29	-35.8	37.4	36.5	34.0	39.9	40.3	41.8
400KG7W	0.307	56.3	1.4	3.0	51.2	29	-29.6	37.4	36.5	34.0	39.9	40.2	41.8

Table A1-2: SES-15 into Horizons 1 Ku-Band Downlink C/I

Downlink C/I analysis		SES-15 into Horizons-1				Downlink: SES-15 Carriers						
Frequency	11.95	GHz				Emission	1M58G7W	175K0G7W	3M151G7W	36M0G7W	36M0G7W	36M0G7W
SES-15 Orbital Position	129.15	W				Bandwidth	1.58	0.175	3.151	36.00	36.00	36.00
Horizons-1 Orbital Position	127.0	W				Receive Earth Station (m)	2.40	2.80	6.30	0.55	1.00	1.20
Geocentric Separation	2.1	degrees				Satellite EIRP	30.8	22.3	31.2	47.5	47.5	47.5
Topocentric Separation	2.3	degrees				Downlink EIRP density	-31.2	-30.1	-33.8	-28.1	-28.1	-28.1
						RX Earth Station Gain	47.7	49.0	56.1	34.9	40.1	41.7
						Sidelobe Characteristic	29	29	29	29	29	29
						Off-axis Gain	20.2	20.2	20.2	20.2	20.2	20.2
Downlink: Horizons-1 Carriers								Downlink C/I: SES-15 into Horizons-1 Carriers				
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain	C/I	C/I	C/I	C/I	C/I
36M0G7W	51.8	36.00	-23.8	1.8	45.2	29	20.2	32.4	31.4	35.0	29.3	29.3
6M00G7W	51.8	5.565	-26.8	3.7	51.4	29	20.2	35.7	34.6	38.3	32.6	32.6
1M454G7W	51.8	1.229	-26.8	1.8	45.2	29	20.2	29.4	28.4	32.0	26.3	26.3
200KG7W	51.8	0.154	-26.8	2.4	47.7	29	20.2	31.9	30.9	34.5	28.8	28.8
100KG7W	51.8	0.077	-26.8	2.4	47.7	29	20.2	31.9	30.9	34.5	28.8	28.8
400KG7W	51.8	0.307	-26.8	6.1	55.8	29	20.2	40.0	39.0	42.6	36.9	36.9

Table A1-3: Horizons 1 into SES-15 Ku-Band Uplink C/I

Uplink C/I analysis		Horizons-1 into SES-15				Uplink: SES-15 Carriers						
Frequency	14.375	GHz				Emission	1M58G7W	175K0G7W	3M151G7W	5M20G7W	3M90G7W	3M90G7W
SES-15 Orbital Position	129.15	W				Bandwidth (MHz)	1.58	0.175	3.151	5.20	3.90	3.90
Horizons-1 Orbital Position	127.0	W				Uplink EIRP	55.1	46.5	55.5	45.0	48.6	48.6
Geocentric Separation	2.1	degrees				Uplink Power	5.8	-2.8	12.2	8.5	6.9	5.3
Topocentric Separation	2.3	degrees				Uplink Power density	-56.2	-55.2	-52.7	-58.6	-59.0	-60.6
						Uplink Earth Station (m)	2.4	2.4	1.2	0.55	1.0	1.20
						Earth Station Gain	49.3	49.3	43.3	36.5	41.7	43.3
						Upl. EIRP density	-6.9	-5.9	-9.5	-22.2	-17.3	-17.3
						Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0
						Off-axis Eirp density	-36.0	-35.0	-32.6	-38.5	-38.8	-40.4
Uplink: Horizons-1 Carriers								Uplink C/I: Horizons-1 into SES-15 Carriers				
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density	C/I	C/I	C/I	C/I	C/I
36M0G7W	36.00	74.0	-1.6	6.10	57.4	29	-38.8	31.9	32.8	29.3	16.6	21.5
6M00G7W	5.57	68.9	1.4	6.10	57.4	29	-35.8	28.9	29.8	26.3	13.6	18.5
1M454G7W	1.229	62.3	1.4	6.10	57.4	29	-35.8	28.9	29.9	26.3	13.7	18.5
200KG7W	0.154	53.3	1.4	6.10	57.4	29	-35.8	28.9	29.9	26.3	13.6	18.5
100KG7W	0.077	50.3	1.4	6.10	57.4	29	-35.8	28.9	29.9	26.3	13.6	18.5
400KG7W	0.307	56.3	1.4	3.00	51.2	29	-29.6	22.7	23.7	20.1	7.5	12.3

Table A1-4: Horizons 1 into SES-15 Ku-Band Downlink C/I

Downlink C/I analysis		Horizons-1 into SES-15				Downlink: SES-15 Carriers							
Frequency	11.95	GHz				Emission	1M58G7W	175K0G7W	3M151G7W	36M0G7W	36M0G7W	36M0G7W	36M0G7W
						Bandwidth	1.58	0.175	3.151	36.00	36.00	36.00	36.00
SES-15 Orbital Position	129.15	W				Receive Earth Station (m)	2.40	2.80	6.30	0.55	1.00	1.20	1.20
Horizons-1 Orbital Position	127.0	W				Satellite EIRP	30.8	22.3	31.2	47.5	47.5	47.5	47.5
Geocentric Separation	2.1	degrees				Downlink EIRP density	-31.2	-30.1	-33.8	-28.1	-28.1	-28.1	-28.1
Topocentric Separation	2.3	degrees				RX Earth Station Gain	47.7	49.0	56.1	34.9	40.1	41.7	41.7
						Sidelobe Characteristic	29	29	29	29	29	29	29
						Off-axis Gain	20.2	20.2	20.2	20.2	20.2	20.2	20.2
Downlink: Horizons-1 Carriers								Downlink C/I: Horizons-1 into SES-15 Carriers					
Emission	Satellite EIRP	Bandw. (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain	C/I	C/I	C/I	C/I	C/I	C/I
36M0G7W	51.8	36.00	-23.8	1.8	45.2	29	20.2	20.1	22.5	25.9	10.4	15.6	17.2
6M00G7W	51.8	5.565	-26.8	3.7	51.4	29	20.2	23.1	25.5	28.9	13.4	18.6	20.2
1M454G7W	51.8	1.229	-26.8	1.8	45.2	29	20.2	23.1	25.5	28.9	13.4	18.6	20.2
200KG7W	51.8	0.154	-26.8	2.4	47.7	29	20.2	23.1	25.5	28.9	13.4	18.6	20.2
100KG7W	51.8	0.077	-26.8	2.4	47.7	29	20.2	23.1	25.5	28.9	13.4	18.6	20.2
400KG7W	51.8	0.307	-26.8	6.1	55.8	29	20.2	23.1	25.5	28.9	13.4	18.6	20.2

Table A1-5: SES-15 into Hypothetical satellite at 131° W.L. Ku-Band Uplink C/I

Uplink C/I analysis SES-15 into Hypothetical Sat at 131W				Uplink: SES-15 Carriers									
Frequency	14.375			Emission	1M58G7W	175K0G7W	3M151G7W	5M20G7W	3M90G7W	3M90G7W			
				Bandwidth (MHz)	1.580	0.175	3.151	5.20	3.90	3.90			
				Uplink EIRP	55.1	46.5	55.5	45.0	48.6	48.6			
SES-15 Orbital Position	129.15	W		Uplink Power	5.8	-2.8	12.2	8.5	6.9	5.3			
Hypothetical Sat at 131W Orbital Position	131.0	W		Uplink Power density	-56.2	-55.2	-52.7	-58.6	-59.0	-60.6			
Geocentric Separation	1.7	degrees		Uplink Earth Station (m)	2.4	2.4	1.2	0.55	1.0	1.20			
Topocentric Separation	1.9	degrees		Earth Station Gain	49.3	49.3	43.3	36.5	41.7	43.3			
				Upl. EIRP density	-6.9	-5.9	-9.5	-22.2	-17.3	-17.3			
				Sidelobe Characteristic	29	29	29	29	29	29			
				Off-axis Eirp density	-34.3	-33.3	-30.9	-36.8	-37.1	-38.7			
Uplink: Hypothetical Sat at 131W Carriers								Uplink C/I: SES-15 into Hypothetical Sat at 131W Carriers					
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density	C/I	C/I	C/I	C/I	C/I	C/I
1M58G7W	1.58	55.1	-6.9	2.4	49.3	29	-34.3	27.4	26.4	24.0	29.9	30.2	31.8
175K0G7W	0.175	46.5	-5.9	2.4	49.3	29	-33.3	28.4	27.4	24.9	30.8	31.2	32.8
3M151G7W	3.151	55.5	-9.5	1.2	43.3	29	-30.9	24.8	23.8	21.4	27.3	27.6	29.2
5M20G7W	5.20	45.0	-22.2	0.6	36.5	29	-36.8	12.1	11.2	8.7	14.6	14.9	16.5
3M90G7W	3.90	48.6	-17.3	1.0	41.7	29	-37.1	17.0	16.0	13.6	19.4	19.8	21.4
3M90G7W	3.90	48.6	-17.3	1.20	43.3	29	-38.7	17.0	16.0	13.6	19.4	19.8	21.4

Table A1-6: SES-15 into Hypothetical satellite at 131° W.L. Ku-Band Downlink C/I

Downlink C/I analysis SES-15 into Hypothetical Sat at 131W						Downlink: SES-15 Carriers							
Frequency	11.95	GHz				Emission	1M58G7W	175K0G7W	3M151G7W	36M0G7W	36M0G7W	36M0G7W	
						Bandwidth	1.58	0.175	3.151	36.00	36.00	36.00	
SES-15 Orbital Position	129.15	W				Receive Earth Station (m)	2.40	2.80	6.30	0.55	1.00	1.20	
Hypothetical Sat at 131W Orbital Position	131.0	W				Satellite EIRP	30.8	22.3	31.2	47.5	47.5	47.5	
Geocentric Separation	1.7	degrees				Downlink EIRP density	-31.2	-30.1	-33.8	-28.1	-28.1	-28.1	
Topocentric Separation	1.9	degrees				RX Earth Station Gain	47.7	49.0	56.1	34.9	40.1	41.7	
						Sidelobe Characteristic	29	29	29	29	29	29	
						Off-axis Gain	21.9	21.9	21.9	21.9	21.9	21.9	
Downlink: Hypothetical Sat at 131W Carriers								Downlink C/I: SES-15 into Hypothetical Sat at 131W Carriers					
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain	C/I	C/I	C/I	C/I	C/I	C/I
1M58G7W	30.8	1.58	-31.2	2.4	47.7	29	21.9	25.8	24.7	28.4	22.7	22.7	22.7
175K0G7W	22.3	0.175	-30.1	2.8	49.0	29	21.9	28.2	27.1	30.8	25.1	25.1	25.1
3M151G7W	31.2	3.151	-33.8	6.3	56.1	29	21.9	31.6	30.5	34.2	28.5	28.5	28.5
36M0G7W	47.5	36.00	-28.1	0.55	34.9	29	21.9	16.1	15.1	18.7	13.0	13.0	13.0
36M0G7W	47.5	36.00	-28.1	1.0	40.1	29	21.9	21.3	20.3	23.9	18.2	18.2	18.2
36M0G7W	47.5	36.00	-28.1	1.2	41.7	29	21.9	22.9	21.8	25.5	19.8	19.8	19.8

Table A1-7: Hypothetical satellite at 131° W.L. into SES-15 Ku-Band Uplink C/I

Uplink C/I analysis				Hypothetical Sat at 131W into SES-15				Uplink: SES-15 Carriers						
Frequency	14.375	GHz						Emission	1M58G7W	175K0G7W	3M151G7W	5M20G7W	3M90G7W	3M90G7W
								Bandwidth (MHz)	1.580	0.175	3.151	5.20	3.90	3.90
								Uplink EIRP	55.1	46.5	55.5	45.0	48.6	48.6
SES-15 Orbital Position	129.15	W						Uplink Power	5.8	-2.8	12.2	8.5	6.9	5.3
Hypothetical Sat at 131W Orbital Position	131.0	W						Uplink Power density	-56.2	-55.2	-52.7	-58.6	-59.0	-60.6
Geocentric Separation	1.7	degrees						Uplink Earth Station (m)	2.40	2.4	1.2	0.55	1.0	1.20
Topocentric Separation	1.9	degrees						Earth Station Gain	49.3	49.3	43.3	36.5	41.7	43.3
								Upl. EIRP density	-6.9	-5.9	-9.5	-22.2	-17.3	-17.3
								Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0
								Off-axis Eirp density	-34.3	-33.3	-30.9	-36.8	-37.1	-38.7
Uplink: Hypothetical Sat at 131W Carriers								Uplink C/I: Hypothetical Sat at 131W into SES-15 Carriers						
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density	C/I	C/I	C/I	C/I	C/I	C/I	
1M58G7W	1.58	55.1	-6.9	2.4	49.3	29	-34.3	27.4	28.4	24.8	12.1	17.0	17.0	
175K0G7W	0.175	46.5	-5.9	2.4	49.3	29	-33.3	26.4	27.4	23.8	11.2	16.0	16.0	
3M151G7W	3.151	55.5	-9.5	1.2	43.3	29	-30.9	24.0	24.9	21.4	8.7	13.6	13.6	
5M20G7W	5.20	45.0	-22.2	0.55	36.5	29	-36.8	29.9	30.8	27.3	14.6	19.4	19.4	
3M90G7W	3.90	48.6	-17.3	1.0	41.7	29	-37.1	30.2	31.2	27.6	14.9	19.8	19.8	
3M90G7W	3.90	48.6	-17.3	1.2	43.3	29	-38.7	31.8	32.8	29.2	16.5	21.4	21.4	

Table A1-8: Hypothetical satellite at 131° W.L. into SES-15 Ku-Band Downlink C/I

Downlink C/I analysis		Hypothetical Sat at 131W into SES-15					Downlink: SES-15 Carriers						
Frequency	11.95	GHz				Emission	1M58G7W	175K0G7W	3M151G7W	36M0G7W	36M0G7W	36M0G7W	
SES-15 Orbital Position Hypothetical Sat at 131W Orbital Position Geocentric Separation Topocentric Separation	129.15	W				Bandwidth	1.58	0.175	3.151	36.00	36.00	36.00	
	131.0	W				Receive Earth Station (m)	2.4	2.8	6.3	0.55	1.0	1.2	
						Satellite EIRP	30.8	22.3	31.2	47.5	47.5	47.5	
	1.7	degrees				Downlink EIRP density	-31.2	-30.1	-33.8	-28.1	-28.1	-28.1	
	1.9	degrees				RX Earth Station Gain	47.7	49.0	56.1	34.9	40.1	41.7	
						Sidelobe Characteristic	29	29	29	29	29	29	
						Off-axis Gain	21.9	21.9	21.9	21.9	21.9	21.9	
Downlink: Hypothetical Sat at 131W Carriers								Downlink C/I: Hypothetical Sat at 131W into SES-15 Carriers					
Emission	Satellite EIRP	Bandw. (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain	C/I	C/I	C/I	C/I	C/I	
1M58G7W	30.8	1.58	-31.2	2.4	47.7	29	21.9	25.8	28.2	31.6	16.1	21.3	22.9
175K0G7W	22.3	0.175	-30.1	2.8	49.0	29	21.9	24.7	27.1	30.5	15.1	20.3	21.8
3M151G7W	31.2	3.151	-33.8	6.3	56.1	29	21.9	28.4	30.8	34.2	18.7	23.9	25.5
36M0G7W	47.5	36.00	-28.1	0.55	34.9	29	21.9	22.7	25.1	28.5	13.0	18.2	19.8
36M0G7W	47.5	36.00	-28.1	1.0	40.1	29	21.9	22.7	25.1	28.5	13.0	18.2	19.8
36M0G7W	47.5	36.00	-28.1	1.2	41.7	29	21.9	22.7	25.1	28.5	13.0	18.2	19.8

DECLARATION

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

/s/ Pascale Dumit

Pascale Dumit
Manager, Spectrum Management & Development
SES Americom, Inc.

Dated: January 26, 2016