

TECHNICAL APPENDIX
IN SUPPORT OF SES-11 (104.95°W.L.)

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

SES-11 is a hybrid C-, Ku- and Ka-band communications satellite that is intended to replace the frequencies currently on AMC-18 at 104.95° W.L. while supplementing the Ku- and Ka-band capacity of AMC-15 at 105.05° W.L. At the nominal 105° W.L. orbital location, the satellite will be serving primarily: (a) the Contiguous U.S. (CONUS), Hawaii and parts of Alaska, Canada and Mexico in the Ku-band, and (b) CONUS and parts of Alaska, Hawaii, Canada, Mexico and the Caribbean in the C-band.

This technical appendix is being filed in support of the following applications:

- SES Americom, Inc. (“SES”) is seeking a U.S. license to launch SES-11 and operate it at 104.95° W.L. in the conventional Ku-band frequencies with downlink frequencies from 11.70 to 12.20 GHz and uplink frequencies from 14.0 to 14.5 GHz.
- SES Satellites (Gibraltar) Ltd. (“SES Gibraltar”) is requesting U.S. market access for the SES-11 conventional C-band frequencies with downlink frequencies from 3.70 to 4.20 GHz and uplink frequencies from 5.925 to 6.425 GHz.

The spacecraft also carries a 20/30 GHz payload with downlink frequencies from 18.3 to 19.3 GHz and 19.45 to 20.2 GHz and uplink frequencies from 28.35 to 29.1 GHz and 29.25 to 30.0 GHz with coverage of North America. No authority is being sought to operate this payload, but a technical summary of the payload is provided herein for informational purposes.

Dual linear polarization is used in both the C- and Ku-bands. Single circular polarization (LHCP) is used in the 20/30 GHz uplink band, and single circular polarization (RHCP) is used in the 20/30 GHz downlink band.

Tables 1 and 2 show the frequency plans of the satellite in Ku- and C-bands, respectively. The frequency bands are divided into 24 Ku-band transponders of 36 MHz bandwidth each and 24 C-band transponders of 36 MHz bandwidth each.

The Ka-band payload consists of three transponders with bandwidths of 750, 500, and 250 MHz, and switchable circular polarization. Any combination of uplink and downlink polarization can be selected (LHCP and RHCP). Table 3 details the frequency plan for a default polarization setting as described in Section 10 of the Schedule S. An optional frequency plan capability allows downlink signals to be transmitted in the 18.30-19.05 GHz band instead of the 18.55-19.30 GHz band.

2.0 Schedule S (§25.114(c))

The Schedule S database is included with this filing. As noted in the narrative section of this application, in preparing the Schedule S, SES relied on the most recent instructions.¹

3.0 Transponder frequency plan (§25.114(c)(4)(i))

Sections S9 and S10 of Schedule S (and Tables 1, 2 and 3 below) show the transponder frequency plans.

Table 1: Ku-band Frequency Plan

Channel	Receive Frequency (MHz)	Polarization	Transmit Frequency (MHz)	Polarization
1	14020	H	11720	V
2	14040	V	11740	H
3	14060	H	11760	V
4	14080	V	11780	H
5	14100	H	11800	V
6	14120	V	11820	H
7	14140	H	11840	V
8	14160	V	11860	H
9	14180	H	11880	V
10	14200	V	11900	H
11	14220	H	11920	V
12	14240	V	11940	H
13	14260	H	11960	V
14	14280	V	11980	H
15	14300	H	12000	V
16	14320	V	12020	H
17	14340	H	12040	V
18	14360	V	12060	H
19	14380	H	12080	V
20	14400	V	12100	H
21	14420	H	12120	V
22	14440	V	12140	H
23	14460	H	12160	V
24	14480	V	12180	H

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.

Table 2: C-band Frequency Plan

Channel	Receive Frequency (MHz)	Polarization	Transmit Frequency (MHz)	Polarization
1	5945	H	3720	V
2	5965	V	3740	H
3	5985	H	3760	V
4	6005	V	3780	H
5	6025	H	3800	V
6	6045	V	3820	H
7	6065	H	3840	V
8	6085	V	3860	H
9	6105	H	3880	V
10	6125	V	3900	H
11	6145	H	3920	V
12	6165	V	3940	H
13	6185	H	3960	V
14	6205	V	3980	H
15	6225	H	4000	V
16	6245	V	4020	H
17	6265	H	4040	V
18	6285	V	4060	H
19	6305	H	4080	V
20	6325	V	4100	H
21	6345	H	4120	V
22	6365	V	4140	H
23	6385	H	4160	V
24	6405	V	4180	H

Table 3: Ka-band Frequency Plan

Channel	Receive Frequency (GHz)	Polarization	Transmit Frequency (GHz)	Polarization
C1	28.725	L	18.925	R
C2	29.375	L	19.575	R
C3	29.750	L	19.950	R

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

Table 4 shows the TT&C carrier center frequencies and bandwidths. TT&C functions will be provided by earth stations located in South Mountain, California and Woodbine, Maryland. In nominal on station operations, the TT&C carriers are received and transmitted through the Ku-band

communication antennas, with vertical or horizontal polarization as seen on Table 4 under Nominal Polarization. The C-band communication antennas may be used to transmit on-station telemetry on either polarization, and telecommands may be received through a vertical linear polarized C-band TC Global horn. C-band TT&C may only be used as an alternative as needed while in normal on station operations. During emergency and transfer/LEOP operations, the TT&C carriers are received through circular polarized Ku-band hemispheric antennas, which may be set to either right- or left-hand polarization in either direction.

Table 4: TT&C Carrier Frequencies

Command carriers (bandwidth: 1.5 MHz, capture range)	Frequency, MHz	Nominal Polarization	Transfer/LEOP and emergency polarization
C-band	5926	V	N/A
C-band	5927	V	N/A
Ku-band	14000.5	V	R or L
Ku-band	14003.5	V	R or L
Ku-band	14497.5	H	R or L
Ku-band	14499.5	H	R or L

Beacons/Telemetry (bandwidth: 400 KHz)	Frequency, MHz	Nominal Polarization	Transfer/LEOP and emergency polarization
C-band pair	3701.5	H	N/A
	4199.9	V	N/A
Ku-band pair	11703.0	H	R or L
	12198.5	V	R or L

4.0 Satellite Antenna Gain Contours (§25.114(c)(4))

The Schedule S provides the typical antenna gain contours for 6 different cases: transmit and receive beams, H- and V-polarizations for Ku- and C-bands and Left- and Right- hand circular polarizations for Ka-band. In the case of the Ka-band contours, the -20 dB contours fall entirely beyond the edge of the visible Earth and therefore are not provided in the GIMS file. **Table 5** shows the peak EIRP and G/T values corresponding to each contour as well as the maximum saturation flux densities (SFD).

Table 5: Payload beam parameters

Beam ID	Band	Pol	Link Direction	GXT filename	Max. EIRP (dBW)	Max. G/T (dB/K)	Max EIRP Density (dBW/4 kHz)	Max SFD (dBW/m ²)
CRH	C	H	Receive	SES-11_NACH_Rx.gxt	42.9	3.1	3.4	-80.1
CRV	C	V	Receive	SES-11_NACV_Rx.gxt		3.1		-80.1
CTH	C	H	Transmit	SES-11_NACH_Tx.gxt	43.0	7.09	3.4	-84.1
CTV	C	V	Transmit	SES-11_NACV_Tx.gxt			3.4	
KURH	Ku	H	Receive	SES-11_NAKH_Rx.gxt	53.6	7.06	14.1	-84.1
KURV	Ku	V	Receive	SES-11_NAKV_Rx.gxt		7.06		-84.1
KUTH	Ku	H	Transmit	SES-11_NAKH_Tx.gxt	53.5	-2.53	13.1	-67.5
KUTV	Ku	V	Transmit	SES-11_NAKV_Tx.gxt				
KARL	Ka	LC	Receive	SES-11_KAL_Rx.gxt	41.7	-2.57	2.1	-67.4
KARR	Ka	RC	Receive	SES-11_KAR_Rx.gxt				
KATL	Ka	LC	Transmit	SES-11_KAL_Tx.gxt				
KATR	Ka	RC	Transmit	SES-11_KAR_Tx.gxt				

In addition, Section S7 of Schedule S shows the maximum gains of transmit and receive antennas, maximum EIRP, and maximum G/T values. Table 6 shows the maximum EIRP and G/T for the telemetry carriers, which are processed through the payload antennas described above. In the case of the horn antennas, the gain characteristics are not provided in a GIMS-readable format because the gain contour at 8 dB below peak falls entirely beyond the edge of the visible Earth.

Table 6: TT&C beam parameters

Beam ID	Band	Pol	Link Direction	Max. EIRP (dBW)	Max. G/T (dB/K)	Max EIRP Density (dBW/4 kHz)	Max SFD (dBW/m ²)		
CTMH	C	H	Transmit	36.1	8.5	-3.4	-85.5		
CTMV	C	V	Transmit	37.4		-2.1			
KCM	Ku	L/R	Receive	50.7		11.2			
KTM	Ku	L/R	Transmit						

5.0 Link Budgets (§25.140(a))

The services provided by SES-11 will be wide ranging, including digital TV and digital transmission services ranging from 56 KBPS to high-speed. Below are sample link budgets for these services as well as for the TT&C, which provide the characteristics of the earth stations used for this analysis and estimated link margins. Also included are typical Ka-band link budgets for informational purposes, as no Ka-band operating authority is being sought.

Table 7: Ku-band Link Budgets for 6 Typical Links

Link Parameters	Units	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W
Data rate	Mbps	42.9	3.5	0.1	0.7	1.5	5.3
Mod cod		8PSK 2/3	QPSK 3/4	QPSK 3/4	QPSK 3/4	8PSK 3/4	QPSK 2/3
Carrier bandwidth	MHz	30.000	3.617	0.037	1.675	0.910	6.006
Uplink:							
Uplink Frequency	GHz	14.250	14.250	14.250	14.250	14.250	14.250
Uplink transmit Power	dBW	10.2	13.1	-6.1	10.1	8.8	9.3
Earth Station Diameter	m	9.00	1.20	1.00	1.00	1.80	2.40
Earth Station Gain	dBi	60.0	43.2	41.6	41.6	46.4	48.5
Earth station EIRP	dBW	70.2	56.3	35.5	51.7	55.2	57.8
Atmospheric Losses	dB	2.70	3.50	3.40	3.30	3.30	3.50
Free Space Loss	dB	207.2	207.2	207.2	207.2	207.2	207.2
Satellite G/T	dB/K	2.6	0.1	0.1	0.1	0.1	0.1
C/N Thermal Uplink	dB	16.7	8.7	7.9	7.6	13.8	8.0
C/I XPOL, ACI, IM, ASI	dB	21.5	16.8	15.9	15.5	21.7	16.1
C/(N+I) uplink	dB	15.4	8.1	7.2	7.0	13.1	7.4
Downlink:							
Downlink Frequency	GHz	11.950	11.950	11.950	11.950	11.950	11.950
Satellite EIRP per carrier	dBW	44.3	31.9	11.1	27.2	30.8	33.3
Atmospheric Losses	dB	1.30	6.20	4.40	2.80	2.80	6.20
Free Space Loss	dB	205.7	205.7	205.7	205.7	205.7	205.7
Earth Station Diameter	m	1.20	4.50	3.20	1.80	1.80	4.50
Earth Station Gain	dBi	41.7	53.2	50.2	45.2	45.2	52.4
System Noise Temperature	K	129	173	170	155	123	146
Earth Station G/T	dB/K	20.6	30.8	27.9	23.3	24.3	30.8
C/N Thermal Downlink	dB	11.7	13.8	11.8	8.4	15.6	13.0
C/I XPOL, ACI, IM, ASI	dB	13.3	21.5	17.7	12.2	18.5	20.0
C/(N+I) downlink	dB	9.4	13.1	10.8	6.9	13.8	12.2
Adjacent Satellite Interference:							
Uplink Input Power Density at 2 degrees	dBW/Hz	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0
Downlink EIRP density at 2 degrees	dBW/Hz	-26.0	-26.0	-26.0	-26.0	-26.0	-26.0
C/I up (single satellite)	dB	24.5	19.8	18.9	18.5	24.7	19.1
C/I dn (single satellite)	dB	16.3	24.5	20.7	15.2	21.5	23.0
Aggregate C/I up	dB	21.5	16.8	15.9	15.5	21.7	16.1
Aggregate C/I down	dB	13.3	21.5	17.7	12.2	18.5	20.0
Overall:							
C/(N+I) overall	dB	8.5	6.9	5.7	3.9	10.4	6.1
C/(N+I) required	dB	7.6	5.5	4.5	1.7	10.5	4.6
Margin	dB	0.9	1.3	1.1	2.2	0.0	1.5

Table 8: C-band Link Budgets for 5 Typical Links

Link Parameters	Units	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W
Data rate	Mbps	35.1	17.1	8.6	5.7	1.0
Mod cod		QPSK 3/5	QPSK 3/5	QPSK 3/5	QPSK 3/5	QPSK 3/5
Carrier bandwidth	MHz	35.400	18.000	9.000	6.000	1.000
Uplink:						
Uplink Frequency	GHz	6.085	6.085	6.085	6.085	6.085
Uplink transmit Power	dBW	20.0	13.9	11.0	9.2	1.4
Earth Station Diameter	m	9.00	9.00	9.00	9.00	9.00
Earth Station Gain	dBi	53.3	53.3	53.3	53.3	53.3
Earth station EIRP	dBW	73.3	67.2	64.3	62.5	54.7
Atmospheric Losses	dB	2.00	2.00	2.00	2.00	2.00
Free Space Loss	dB	199.8	199.8	199.8	199.8	199.8
Satellite G/T	dB/K	1.3	1.3	1.3	1.3	1.3
C/N Thermal Uplink	dB	25.8	22.7	22.8	22.7	22.7
C/I XPOL, ACI, IM, ASI	dB	12.6	9.4	9.5	9.5	9.5
C/(N+I) uplink	dB	12.4	9.2	9.3	9.3	9.3
Downlink:						
Downlink Frequency	GHz	3.860	3.860	3.860	3.860	3.860
Satellite EIRP per carrier	dBW	41.7	34.8	31.8	30.0	22.3
Atmospheric Losses	dB	1.23	1.00	1.00	1.00	1.00
Free Space Loss	dB	195.9	195.9	195.9	195.9	195.9
Earth Station Diameter	m	2.40	3.70	3.70	3.70	3.70
Earth Station Gain	dBi	37.9	41.7	41.7	41.7	41.7
System Noise Temperature	K	84	86	86	86	86
Earth Station G/T	dB/K	18.7	22.3	22.3	22.3	22.3
C/N Thermal Downlink	dB	16.4	16.3	16.3	16.2	16.3
C/I XPOL, ACI, IM, ASI	dB	5.4	12.1	15.1	16.9	24.7
C/(N+I) downlink	dB	5.1	10.7	12.7	13.5	15.7
Adjacent Satellite Interference:						
Uplink Input Power Density at 2 degrees	dBW/Hz	-38.7	-38.7	-38.7	-38.7	-38.7
Downlink EIRP density at 2 degrees	dBW/Hz	-25.3	-32.2	-35.2	-37.0	-44.7
C/I up (single satellite)	dB	15.6	12.4	12.5	12.5	12.5
C/I dn (single satellite)	dB	8.4	15.1	18.1	19.9	27.7
Aggregate C/I up	dB	12.6	9.4	9.5	9.5	9.5
Aggregate C/I down	dB	5.4	12.1	15.1	16.9	24.7
Overall:						
C/(N+I) overall	dB	4.4	6.9	7.7	7.9	8.4
C/(N+I) required	dB	3.3	3.5	3.5	3.5	3.5
Margin	dB	1.1	3.4	4.2	4.4	4.9

Table 9: Typical TT&C Link Budgets

Link Parameters	Units	Command						Telemetry			
		800KF9D	800KF9D	800KF9D	800KF9D	800KF9D	800KF9D	300KF9D	300KF9D	300KF9D	300KF9D
		TC1	TC2	TC3	TC4	TC5	TC6	TM1	TM2	TM3	TM4
Uplink Frequency	MHz	14000.5	14003.5	14499.5	14497.5	5926	5927				
Downlink Frequency	MHz							11703	12198.5	3701.5	4199.9
Carrier Allocated Bandwidth	kHz	856.0	856.0	856.0	856.0	856	856	275	275	275	275
Uplink:											
Nominal Earth Station EIRP per carrier	dBW	76.2	76.2	76.2	76.2	75.0	75.0				
Earth Station Diameter	m	9.0	9.0	9.0	9.0	13.0	13.0				
Earth Station Gain	dBi	59.5	59.5	59.8	59.8	55.2	55.2				
Uplink Input Power per Carrier	dBW	16.7	16.7	16.4	16.4	19.7	19.7				
Input power density	dBW/4 kHz	-6.6	-6.6	-6.9	-6.9	-3.6	-3.6				
Free Space Loss	dB	206.4	206.4	206.8	206.8	199.0	199.0				
G/T Satellite towards E/S	dB/K	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9				
C/N Thermal Uplink	dB	22.1	22.1	21.8	21.8	28.4	28.3				
C/I XPOL, ACI, IM, ASI	dB	42.9	42.9	42.9	42.9	30.4	30.4				
C/(N+I) uplink	dB	22.1	22.1	21.8	21.8	26.3	26.2				
Downlink:											
Satellite e.i.r.p. per carrier	dBW							17.3	17.3	14.1	14.1
Maximum e.i.r.p. density	dBW/4kHz							-1.1	-1.1	-4.3	-4.3
Free Space Loss	dB							204.9	205.3	194.9	196.0
Earth Station Diameter	m							9.0	9.0	13.0	13.0
Earth Station Gain	dBi							58.5	58.8	51.7	52.8
Noise Temperature	K							140.0	140.0	47.0	47.0
Earth Station G/T	dB/K							37.0	37.4	35.0	36.1
C/N Thermal Downlink	dB							23.6	23.6	28.4	28.4
C/I XPOL, ACI, IM, ASI	dB							23.5	23.8	26.9	28.0
C/(N+I) downlink	dB							20.5	20.7	24.6	25.2
Adjacent Satellite Interference:											
Uplink Inp. Pwr. Dens. @ 2 degrees	dBW/Hz	-50.0	-50.0	-50.0	-50.0	-38.7	-38.7				
Downlink e.i.r.p. Dens @ 2 degrees	dBW/Hz							-26.0	-26.0	-39.5	-39.5
C/I up (single satellite)	dB	45.9	45.9	45.9	45.9	33.4	33.4				
C/I dn (single satellite)	dB							26.5	26.8	29.9	31.0
Aggregate C/I up	dB	42.9	42.9	42.9	42.9	30.4	30.4				
Aggregate C/I down	dB							23.5	23.8	26.9	28.0
Overall:											
C/(N+I) overall	dB	22.1	22.1	21.8	21.8	26.3	26.2	20.5	20.7	24.6	25.2
C/(N+I) required	dB	10.0	10.0	10.0	10.0	10.0	10.0	9.0	9.0	9.0	9.0
System Margin	dB	12.1	12.1	11.8	11.8	16.3	16.2	11.5	11.7	15.6	16.2

Table 10: Ka-band Link Budgets for 3 Typical Links

Link Parameters	Units	250MG1W	11M3G1W	5M63G1W
Data rate	Mbps	99.5	4.4	2.2
Mod cod		QPSK 1/4	QPSK 1/4	QPSK 1/4
Carrier bandwidth	MHz	249.6	11.250	5.625
Uplink:				
Uplink Frequency	GHz	29.375	29.375	29.375
Uplink transmit Power	dBW	9.8	-2.2	-5.2
Earth Station Diameter	m	9.00	9.00	9.00
Earth Station Gain	dBi	67.0	67.0	67.0
Earth station EIRP	dBW	76.8	64.8	61.8
Atmospheric Losses	dB	0.40	0.40	0.40
Free Space Loss	dB	213.5	213.5	213.5
Satellite G/T	dB/K	-2.9	-2.9	-2.9
C/N Thermal Uplink	dB	4.6	6.1	6.1
C/I XPOL, ACI, IM, ASI	dB	25.4	26.8	26.9
C/(N+I) uplink	dB	4.6	6.0	6.0
Downlink:				
Downlink Frequency	GHz	18.425	18.425	18.425
Satellite EIRP per carrier	dBW	40.4	25.1	22.1
Atmospheric Losses	dB	0.30	0.30	0.30
Free Space Loss	dB	209.5	209.5	209.5
Earth Station Diameter	m	4.50	4.50	3.70
Earth Station Gain	dBi	56.9	56.9	55.2
System Noise Temperature	K	188	192	188
Earth Station G/T	dB/K	34.2	34.1	32.5
C/N Thermal Downlink	dB	9.5	7.5	5.9
C/I XPOL, ACI, IM, ASI	dB	5.4	3.6	1.9
C/(N+I) downlink	dB	4.0	2.1	0.4
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	-16.0	-16.0	-16.0
C/I up (single satellite)	dB	28.4	29.8	29.9
C/I dn (single satellite)	dB	8.4	6.6	4.9
Aggregate C/I up	dB	25.4	26.8	26.9
Aggregate C/I down	dB	5.4	3.6	1.9
Overall:				
C/(N+I) overall	dB	1.3	0.6	-0.6
C/(N+I) required	dB	-0.8	-0.9	-0.9
Margin	dB	2.0	1.5	0.2

6.0 Power Flux Density Limits (§25.138 and §25.208)

Section 25.208 of the Commission's Rules specifies the maximum allowed pfd in C- and Ka-band. Table 11 shows the pfd and margin computations for the C-band. The margins are all positive. A similar evaluation for the Ka-band is provided in Table 12 showing margin against the strictest pfd limit from Section 25.138. Compliance with the 25.138(a) pfd limits in all of the Ka-band results in compliance to the pfd limits for 18.3-18.8 GHz in Section 25.208(c), for 18.6-18.8 GHz in Section 25.208(d), and for 18.8-19.3 GHz in Section 25.208(e). The margins in Ka-band are all positive.

Table 11: C-band pfd and margin values

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	41.7	41.7	41.7	41.7	41.7	41.7
Output backoff, dB	0.0	0.0	0.0	0.0	0.0	0.0
Gain roll-off at elevation angle, dBi	-2.2	-2.1	-1.9	-1.7	-1.5	0.0
EIRP at elevation angle, dBW	39.5	39.6	39.8	40.0	40.2	41.7
Carrier bandwidth, MHz	35.40	35.40	35.40	35.40	35.40	35.40
EIRP density at elevation angle dBW/4kHz	0.1	0.2	0.3	0.5	0.7	2.2
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.208(a) pfd limit (3650-4200 MHz), dBW/m2/4kHz	-152.0	-149.5	-147.0	-144.5	-142.0	-142.0
pfd, dBW/m2/4KHz	-163.2	-163.0	-162.7	-162.4	-162.1	-159.8
Margin, dB, relative to 25.208	11.2	13.5	15.7	17.9	20.1	17.8

Table 12: Ka-band pfd and margin values

Elevation angle, deg	5.0	10.0	15.0	20.0	25.0	90.0
Max. EIRP, dBW	40.4	40.4	40.4	40.4	40.4	40.4
Output backoff, dB	0.0	0.0	0.0	0.0	0.0	0.0
Gain roll-off at elevation angle, dBi	-1.1	-1.0	-1.0	-0.9	-0.8	0.0
EIRP at elevation angle, dBW	39.4	39.4	39.4	39.5	39.6	40.4
Carrier bandwidth, MHz	30	30	30	30	30	30
EIRP density at elevation angle dBW/1MHz	24.6	24.6	24.7	24.7	24.9	25.6
Minimum spreading loss, dB/m2	-163.3	-163.2	-163.1	-162.9	-162.8	-162.1
25.138 (a)(6) pfd limit, dBW/m2/1MHz	-118.0	-118.0	-118.0	-118.0	-118.0	-118.0
pfd, dBW/m2/4KHz	-138.7	-138.5	-138.4	-138.2	-138.0	-136.4
Margin, dB, relative to 25.138 (a)(6)	20.7	20.5	20.4	20.2	20.0	18.4

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

Annex 1 shows the results of interference analyses for C-, Ku-, and Ka-band operations with respect to an authorized space station within two degrees. Using C/I metrics, the analysis shows that the interference can be restricted to no more than 6% of the noise plus interference at threshold.²

² The interference analysis is done assuming digital wanted and interfering carriers. Analog carriers will be coordinated on a case-by-case basis, and are not addressed here.

8.0 Maximum Theoretical Operation Levels

SES-11 will be operated consistently with applicable coordination agreements with adjacent satellites. In any case, in the Ku-band frequencies, the downlink EIRP density of the SES-11 digital carriers will not exceed -18 dBW/Hz; and the input power density of the uplink digital carriers of earth stations operating with SES-11 will not exceed -45 dBW/Hz. In the C-band frequencies, the downlink EIRP density of the SES-11 digital carriers will not exceed -30 dBW/Hz; and the input power density of the uplink digital carriers of earth stations operating with SES-11 will not exceed -38.7 dBW/Hz. No Ka-band operating authority is being sought, but for informational purposes SES specifies that in the Ka-band frequencies, the downlink EIRP density of the SES-11 digital carriers would not exceed -16 dBW/Hz; and the input power density of the uplink digital carriers of earth stations operating with SES-11 would not exceed -56.5 dBW/Hz.

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

Spacecraft Hardware design. SES has assessed and limited the amount of debris released in a planned manner during normal operations of SES-11. 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 pyrotechnic 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.

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-11 spacecraft is such that the risk of explosion is minimized both during and after mission operations. In designing and building the spacecraft, the manufacturer took steps to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. 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 will be vented, pressure vessels will be relieved, 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 stationkeeping 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-11 will be positioned at 104.95° W.L. In considering current and planned satellites that may have a station-keeping volume that overlaps the SES-11 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 within ± 0.15 degrees of 104.95° 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-11 satellite, have been taken into account in the analysis.

Based on these reviews, the satellites operating nominally at 105° W.L. are AMC-15 and AMC-18, which are also controlled and operated by SES. There are no pending applications before the Commission requesting authorization to use an orbital location within $\pm 0.15^\circ$ of 104.95° W.L., and within this sub-arc, there are no ITU networks other than those at nominal 105° W.L., all of which were submitted on behalf of SES. Based on the preceding, it is concluded that physical coordination of the SES-11 satellite with another party is not required at the present time.

On-station operations require station-keeping within the ± 0.1 degree N-S and ± 0.05 degree E-W control box, thereby ensuring adequate collision avoidance distance from other satellites in geosynchronous orbit. SES-11 will be temporarily co-located with AMC-18 as traffic is transferred to SES-11. After traffic transfer is complete, AMC-18 will be relocated to another orbital location such that there will be no station-keeping volume overlap with SES-11.³ AMC-15, however, will continue to operate adjacent to SES-11 at 105.05° W.L.

During collocations, SES will use the proven inclination-eccentricity technique to ensure adequate separation between the satellites. This strategy is presently in use by SES at several orbital locations to ensure proper operation and safety of multiple satellites within one orbital box.

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

During any relocation, the moving spacecraft is maneuvered such that it is at least 30 km away from the synchronous radius at all times. In most cases, much larger deviation from the synchronous

³ SES will request the necessary Commission approval prior to any spacecraft relocation.

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-11 to a disposal orbit with a minimum perigee of 266 km above the normal operational altitude. The proposed disposal orbit altitude complies with the altitude resulting from application of the IADC formula based on the following calculation:

Area of the satellite (average aspect area): 48.5 m^2

Mass of the spacecraft: 1902.7 kg

C_R (solar radiation pressure coefficient): 1.21

Therefore the Minimum Disposal Orbit Perigee Altitude, as calculated under the IADC formula is:

$36,021 \text{ km} + (1000 \times C_R \times A/m) = 36052 \text{ km}$, or 266 km above the GSO arc (35,786 km)

SES intends to reserve 10.8 kg of fuel in order to account for post-mission disposal of SES-11. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

ANNEX 1

Interference Analyses in support of SES-11

1.0 Two Degree Spacing Analysis

SES demonstrates below that the SES-11 network is compatible with a co-coverage, co-frequency satellite, spaced two degrees away. For the SES-11 C- and Ku-band operations, SES provides an analysis with respect to SES-3 at 103° W.L. Operations of SES-11 at this location will conform to the existing coordination arrangements SES has with adjacent satellite networks. No operational authority is sought for the SES-11 Ka-band payload, but the analysis below demonstrates that this payload is capable of operating in a two-degree spacing environment.

1.1 Analysis

For this portion of the analysis, the C/I 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. 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 following equations can be used to express the uplink and downlink C/I:

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

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

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 Section 25.209 of the Commission's rules. 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 station-keeping tolerance and earth station pointing error.

System characteristics used in the analysis are shown in the following tables. Three space stations are considered: SES-11 and two adjacent stations, SES's SES-3 at 103.0° W.L., and a hypothetical satellite at 106.95° W.L. assumed to be transmitting at the same maximum uplink power density and downlink EIRP density levels as those for SES-11.

Table 2-1 provides the space station name and orbital information, and assumed earth station parameters of the networks.

Table 2-1: Station Parameters

Parameter	System 1	System 2	System 3
Space station name	SES-3	SES-11	Hypothetical Satellite
Nominal orbit location (+E, -W)	-103	-104.95	-107
Station-keeping tolerance (deg)	0.05	0.05	0.05
Earth station pointing error (deg)	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.

1.1.1 C-band

Table 2-2 and Table 2-3 show the C-band emission characteristics considered here for SES-3 at 103.0° W.L. and a hypothetical satellite at 106.95° W.L. The emissions characteristics for SES-3 have been derived from its Schedule S file. All off-axis EIRP densities and off-axis gain values shown in Tables C-4a and C-4b were calculated with respect to the off-axis angle towards the adjacent satellite.

Table 2-2: Typical SES-3 C-band Emissions

Uplink: SES-3 Carriers							
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density
36M0G7W	36.00	75.8	0.2	9.0	53.4	29	-32.2
27M0G7W	27.000	70.7	-3.6	9.0	53.4	29	-36.0
6M95G1W	7.000	60.3	-8.2	9.0	53.4	29	-40.6
5M00G1W	5.000	62.7	-4.3	9.0	53.4	29	-36.7
100KG1W	0.100	41.3	-8.7	4.5	47.4	29	-35.1
1M60G1W	1.600	56.5	-5.5	4.5	47.4	29	-32.0
Downlink: SES-3 Carriers							
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain
36M0G7W	39.0	36.00	-36.6	3.8	42.1	29	21.0
27M0G7W	37.8	27.000	-36.5	3.8	42.1	29	21.0
6M95G1W	31.9	7.000	-36.6	3.8	42.1	29	21.0
5M00G1W	30.4	5.000	-36.6	3.8	42.1	29	21.0
100KG1W	13.4	0.100	-36.6	3.8	42.1	29	21.0
1M60G1W	25.5	1.600	-36.5	3.8	42.1	29	21.0

Table 2-3: Hypothetical satellite at 106.95° W.L. Typical C-band Emissions

Uplink: Hypothetical Carriers							
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density
36M0G7W	35.40	73.3	-2.2	9.0	53.4	29	-34.6
18M0G7W	18.000	67.2	-5.4	9.0	53.4	29	-37.8
9M00G7W	9.000	64.3	-5.2	9.0	53.4	29	-37.7
6M00G7W	6.000	62.5	-5.3	9.0	53.4	29	-37.7
1M00G7W	1.000	54.7	-5.3	9.0	53.4	29	-37.7
1M00G7W	1.000	54.7	-5.3	9.0	53.4	29	-37.7
Downlink: Hypothetical Carriers							
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain
36M0G7W	41.7	35.40	-33.8	2.4	38.1	29	21.0
18M0G7W	34.8	18.000	-37.8	3.7	41.8	29	21.0
9M00G7W	31.8	9.000	-37.7	3.7	41.8	29	21.0
6M00G7W	30.0	6.000	-37.8	3.7	41.8	29	21.0
1M00G7W	22.3	1.000	-37.7	3.7	41.8	29	21.0
1M00G7W	22.3	1.000	-37.7	3.7	41.8	29	21.0

Table 2-4 shows the SES-11 emission characteristics considered here (derived from the Schedule S file). Similar to Table 2-2 and Table 2-3, all off-axis EIRP densities and off-axis gain values shown in Table 2-4 were calculated with respect to the off-axis angle towards the adjacent satellite.

Table 2-4: Typical SES-11 C-band Emissions

Uplink: SES-11 Carriers						
Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W
Bandwidth (MHz)	35.400	18.000	9.000	6.000	1.000	1.000
Uplink EIRP	73.3	67.2	64.3	62.5	54.7	54.7
Uplink Power	19.9	13.8	10.9	9.1	1.3	1.3
Uplink Power density	-55.6	-58.8	-58.7	-58.7	-58.7	-58.7
Uplink Earth Station (m)	9.0	9.0	9.0	9.00	9.0	9.00
Earth Station Gain	53.4	53.4	53.4	53.4	53.4	53.4
Upl. EIRP density	-2.2	-5.4	-5.2	-5.3	-5.3	-5.3
Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0
Off-axis Eirp density	-34.6	-37.8	-37.7	-37.7	-37.7	-37.7
Downlink: SES-11 Carriers						
Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W
Bandwidth	35.40	18.000	9.000	6.00	1.00	1.00
Receive Earth Station (m)	2.40	3.70	3.70	3.70	3.70	3.70
Satellite EIRP	41.7	34.8	31.8	30.0	22.3	22.3
Downlink EIRP density	-33.8	-37.8	-37.7	-37.8	-37.7	-37.7
RX Earth Station Gain	38.1	41.8	41.8	41.8	41.8	41.8
Sidelobe Characteristic	29	29	29	29	29	29
Off-axis Gain	21.0	21.0	21.0	21.0	21.0	21.0

Applying the methodology described above to the emission characteristics shown in Table 2-2, Table 2-3, and Table 2-4 results in the C/I levels shown in Appendix A 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-band C/I values, including the worst cases, are shown in Appendix A.

1.1.2 Ku-band C/I Estimates

Similar to the above, the tables below show the typical Ku-band emission characteristics considered here for SES-3 at 103.0° W.L. and a hypothetical satellite at 107.0° W.L. The emissions characteristics for SES-3 have been derived from its Schedule S file. As before, all off-axis EIRP densities and off-axis gain values shown in Table 2-5 and Table 2-6 were calculated with respect to the off-axis angle towards the adjacent satellite.

Table 2-5: Typical SES-3 Ku-band Emissions

Uplink: SES-3 Carriers							
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density
36M0G7W	36.00	74.7	-0.9	6.00	57.2	29	-37.0
27M0G7W	27.00	74.7	0.4	6.00	57.2	29	-35.8
6M95G1W	7.000	63.6	-4.9	6.00	57.2	29	-41.0
5M00G1W	5.000	63.6	-3.4	6.00	57.2	29	-39.6
100KG1W	0.100	52.7	2.7	6.00	57.2	29	-33.5
1M60G1W	1.600	62.7	0.7	6.00	57.2	29	-35.5
Downlink: SES-3 Carriers							
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain
36M0G7W	49.5	36.00	-26.1	1.2	41.7	29	21.0
27M0G7W	48.3	27.000	-26.0	1.2	41.7	29	21.0
6M95G1W	38.4	7.000	-30.1	1.2	41.7	29	21.0
5M00G1W	36.9	5.000	-30.1	1.8	45.2	29	21.0
100KG1W	19.9	0.100	-30.1	1.8	45.2	29	21.0
1M60G1W	32.0	1.600	-30.0	1.8	45.2	29	21.0

Table 2-6: Hypothetical satellite at 106.95° W.L. Typical Ku-band Emissions

Uplink: Hypothetical Carriers							
Emission	Occupied Bandwidth (MHz)	Uplink EIRP	Uplink Eirp density	Transm. Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Eirp density
36M0G7W	30.00	70.2	-4.6	9.00	60.7	29	-44.3
5M00G1W	3.62	56.3	-9.3	1.20	43.2	29	-31.5
100KG1D	0.037	35.5	-10.2	1.00	41.6	29	-30.8
1M40G1D	1.675	51.7	-10.5	1.00	41.6	29	-31.1
2M00G7W	0.910	55.2	-4.4	1.80	46.7	29	-30.1
8M00G7W	6.006	57.8	-10.0	2.40	49.2	29	-38.2
Downlink: Hypothetical Carriers							
Emission	Satellite EIRP	Bandwidth (MHz)	Downlink EIRP density	Receive Ant. (m)	Earth Station Gain	Sidelobe Charact.	Off-axis Gain
36M0G7W	44.3	30.00	-30.5	1.2	41.7	29	21.0
5M00G1W	31.9	3.617	-33.7	4.5	53.1	29	21.0
100KG1D	11.1	0.037	-34.6	3.2	50.2	29	21.0
1M40G1D	27.2	1.675	-35.0	1.8	45.2	29	21.0
2M00G7W	30.8	0.910	-28.8	1.8	45.2	29	21.0
8M00G7W	33.3	6.006	-34.5	4.5	53.1	29	21.0

Table 2-7 shows the SES-11 typical Ku-band emission characteristics considered here (derived from the Schedule S file). Similar to previous tables, all off-axis EIRP densities and off-axis gain values shown in Table 2-7 were calculated with respect to the off-axis angle towards the adjacent satellite.

Table 2-7: Typical SES-11 Ku-band Emissions

Uplink: SES-11 Carriers						
Emission	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W
Bandwidth (MHz)	30.000	3.617	0.037	1.675	0.910	6.006
Uplink EIRP	70.2	56.3	35.5	51.7	55.2	57.8
Uplink Power	9.5	13.1	-6.1	10.1	8.5	8.6
Uplink Power density	-65.3	-52.5	-51.8	-52.1	-51.1	-59.2
Uplink Earth Station (m)	9.0	1.2	1.0	1.00	1.8	2.40
Earth Station Gain	60.7	43.2	41.6	41.6	46.7	49.2
Upl. EIRP density	-4.6	-9.3	-10.2	-10.5	-4.4	-10.0
Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0
Off-axis Eirp density	-44.3	-31.5	-30.8	-31.1	-30.1	-38.2
Downlink: SES-11 Carriers						
Emission	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W
Bandwidth	30.00	3.617	0.037	1.68	0.91	6.01
Receive Earth Station (m)	1.20	4.50	3.20	1.80	1.80	4.50
Satellite EIRP	44.3	31.9	11.1	27.2	30.8	33.3
Downlink EIRP density	-30.5	-33.7	-34.6	-35.0	-28.8	-34.5
RX Earth Station Gain	41.7	53.1	50.2	45.2	45.2	53.1
Sidelobe Characteristic	29	29	29	29	29	29
Off-axis Gain	21.0	21.0	21.0	21.0	21.0	21.0

Applying the methodology described in section 1.1 of this Annex to the emission characteristics shown in Table 2-5, Table 2-6, and Table 2-7 results in the C/I levels shown in Appendix B 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 Ku-band C/I values, including the worst cases, are shown in Appendix B.

1.1.3 Ka-band Two-Degree Spacing Analysis

Even though no operating authority is being sought for the 20/30 GHz payload, information is provided here to demonstrate that the payload is capable of complying with Commission rules for operation in a two-degree spacing environment. Note that no transmissions of the SES-11 satellite network will exceed the uplink off-axis EIRP density and the downlink PFD levels of §25.138, regardless of whether the frequency band used is subject to §25.138.

1.1.3.1 SES-11 Frequency Bands Subject to §25.138

The SES-11 frequency bands 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; and
- 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 typical transmitting earth stations is below this value of -56.5 dBW/Hz.

For a typical SES-11 transmitting gateway earth station, the maximum EIRP density level is 54.3 dBW/MHz. The minimum antenna size for a typical SES-11 transmitting gateway earth station will be 9.0 m. This corresponds to a PSD level into the antenna of approximately -72.7 dBW/Hz, which is 16.2 dB below the above mentioned limit value.

The maximum EIRP that could be generated by any SES-11 TWTA is 40.4 dBW. This EIRP is associated with a 250 MHz bandwidth resulting in a maximum EIRP density of 16.4 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 -145.6 dBW/m²/MHz. This level meets the -118 dBW/m²/MHz PFD limit at the Earth's surface, with a margin of 27.6 dB. Accordingly, all downlink Ka-band transmissions from SES-11 will be compliant with §25.138(a)(6) of the rules.

1.1.3.2 SES-11 Frequency Bands Not Subject to §25.138

The only Ka-band frequency segment used by SES-11 that is not covered by §25.138 is the 18.8-19.3 GHz downlink band.

Currently there are no operational GSO Ka-band satellites that use the above listed band within two degrees of the 104.95° 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-11 satellite have been assumed as both the wanted and victim carriers, and the C/I level is calculated.

With the smallest antenna size being 3.7 meters for the downlink earth station, the downlink C/I calculation is simplified. Further, considering the SES-11 gain contours in this frequency band, it is reasonable to assume that the receive space station gain at the transmitting wanted and interfering earth station sites will be nearly the same.

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

$$\begin{aligned} C/I_u &= \text{on-axis gain (dBi)} - \text{off-axis gain towards the wanted satellite (dBi)} \\ &= 55.2 \text{ dBi (on-axis gain of 3.7 m earth station antenna)} - 29 + 25 * \log(1.535^\circ) \\ &= 30.9 \text{ dB} \end{aligned}$$

For purposes of the above calculation, the orbital separation is taken as the difference between 104.95° W.L. and the closest adjacent slot, 103°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 downlink earth station antennas, and demonstrates that the operations proposed herein are two degree compatible.

1.1.3.3 Sharing with NGSO FSS in the 28.6-29.1 GHz and 18.8-19.3 GHz bands

While the 28.6-29.1 GHz and 18.8-19.3 GHz bands are allocated internationally for GSO and NGSO use on a co-primary basis, these bands are allocated to NGSO FSS on a primary basis in the U.S. Table of Allocations. The U.S. Table allocates the 28.6-29.1 GHz band to GSO FSS on a secondary basis, while the 18.8-19.3 GHz band has no GSO FSS allocation.

Although SES is not seeking Commission authorization to operate in the 28.6-29.1 GHz and 18.8-19.3 GHz bands (i.e., the “NGSO” bands) within U.S. territory, the analyses contained herein nonetheless demonstrates the compatibility of the SES-11 satellite with NGSO systems currently and previously authorized by the Commission.

O3b Limited (“O3b”) has received U.S. market access for its constellation of NGSO satellites. O3b has Commission authorization to use the 28.6-29.1 GHz and 18.8-19.3 GHz bands to communicate

with fixed earth stations located in Hawaii, Texas, and Virginia, as well as for earth stations on vessels (“ESV”) operating within U.S. waters. O3b also has received Commission authorization for blanket license operation of fixed earth stations (1.2 meter, 1.8 meter, 2.2 meter and 2.4 meter) in CONUS, Hawaii, Puerto Rico and the U.S. Virgin Islands. The interference analysis contained herein demonstrates that no harmful interference between the O3b system’s U.S. operations and the SES-11 satellite network will occur.

Currently no other NGSO networks are authorized by the Commission to use the 28.6-29.1 GHz and 18.8-19.3 GHz bands. Northrop Grumman Space and Mission Systems Corp. (“Northrop Grumman”) previously received Commission authorization for a Global EHF Satellite Network (“GESN”) and ATCONTACT Communications, LLC (“ATCONTACT”) previously received Commission authorization for its NGSO network. Both networks were to utilize highly elliptical orbits (“HEO”). The interference analysis below demonstrates that the operations of the SES-11 satellite network also would protect the types of HEO satellite systems previously licensed to Northrop Grumman and ATCONTACT from harmful interference.

1.1.3.4 Sharing with the O3b System

As described above, O3b has a number of Commission authorizations for operation of land-based fixed earth stations and for the operation of ESVs within U.S. coastal waters. SES has examined all of the O3b scenarios and has found that the highest potential for interference from the SES-11 network into the O3b network would occur into O3b’s ESV operations because these are the O3b ground antennas that can be located closest to the equator. Due to a GSO network’s equatorial orbit, the closer to the equator that an O3b earth station is located, the more interference it can receive from the GSO network. Similarly, the closer to the equator that a GSO earth station is located, the more interference it can receive from the O3b network. The location closest to the equator that is within U.S. territory, and visible to both the SES-11 and O3b satellite networks, is in U.S. waters south of St. Croix, U.S. Virgin Islands (approximately 17.6°N, 64.75°W). The following analysis assumes the SES-11 and O3b networks both have an ESV located at these geographic coordinates.

Table 2-8 shows the pertinent transmission parameters of the SES-11 network and the O3b system.

Table 2-8: Summary of SES-11 and O3b parameters

Parameters	SES-11	O3b System
Uplink Input Power Density	-72.7 dBW/Hz	-53.4 dBW/Hz

Satellite Rx Antenna Gain	24.8 dBi	34.5 dBi
Satellite Rx System Noise Temp	545 K	1000 K
Satellite Tx EIRP Density	-42.3 dBW/Hz	-28.32 dBW/Hz
Earth Station Rx System Noise Temperature	188 K	307 K

Table 2-9 shows the interference calculations for the assumed worst case static situation described above. The results show that the O3b system is adequately protected. The calculated $\Delta T/T$ values are very small in all cases, indicating the technical compatibility of the SES-11 satellite network with the O3b network and therefore with an O3b earth station located anywhere within U.S. territory. For areas outside of U.S. territory, SES will operate in a manner consistent with ITU coordination rules.

Table 2-9: Interference calculations between SES-11 and O3b

Victim network		O3b	SES-11
Interfering network		SES-11	O3b
Uplink:			
Frequency band	GHz	28.85	28.85
Interfering uplink input power density	dBW/Hz	-72.7	-53.4
Angular separation between interfering E/S and victim satellite	degrees	8.5	8.5
Slant range (Interfering path)	km	9768	37775
Free space path loss (Interfering path)	dB	201.4	213.2
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	24.8
Victim Satellite's Antenna Discrimination towards Interfering E/S	dB	0	0
Victim satellite Rx system noise temperature	K	1000	545
No	dBW/Hz	-198.6	-201.2
Io	dBW/Hz	-235.0	-237.2
Io/No	dB	-36.4	-36.0
$\Delta T/T$	%	0.02	0.03
Downlink:			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-42.3	-28.32
Slant range (Interfering path)	dB	37775	9768
Free space path loss (Interfering path)	dB	209.6	197.8
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degrees	8.5	8.5
Interfering Satellite's Antenna Discrimination towards Victim E/S	dB	0	0
Victim Rx earth station system noise temperature	K	307	188
No	dBW/Hz	-203.7	-205.9
Io	dBW/Hz	-247.1	-221.4
Io/No	dB	-43.3	-15.5
$\Delta T/T$	%	0.005	2.8

1.1.3.5 Sharing with HEO Systems

This section analyzes the compatibility of the SES-11 satellite network with HEO systems. Table 2-10 summarizes the salient parameters of the SES-11 satellite network and the GESN and ATCONTACT HEO satellite networks. The HEO network parameters are identical to those used

by Northrop Grumman and ATCONTACT to demonstrate independently that their GSO operations in the 28.6-29.1 GHz and 18.8-19.3 GHz bands were compatible with the other's proposed NGSO operations.⁴ The parameters of the two HEO networks are identical, allowing a single interference analysis to be performed with respect to the SES-11 network.

Table 2-10: Summary of SES-11 and GESN / ATCONTACT Parameters

Parameters	SES-11	GESN / ATCONTACT Systems
Minimum Operational Altitude	GSO	16000 km
Uplink Input Power Density	-72.7 dBW/Hz	-63.45 dBW/Hz
Satellite Rx Antenna Gain	24.8 dBi	46.5 dBi
Satellite Rx System Noise Temp	545 K	504 K
Satellite Tx EIRP Density	-42.3 dBW/Hz	-18 dBW/Hz
Earth Station Rx System Noise Temperature	188 K	315 K

In order to demonstrate compatibility with these two HEO networks, a worst case, static interference analysis is performed. The smallest possible angle will occur when the GSO satellite, the HEO satellite and the relevant earth station are all on the same longitude, the HEO satellite is at its lowest operational latitude, and the earth station is at a high latitude. Assuming a minimum 10° elevation angle for the GSO earth station, this sets the latitude to 71.4°N. The minimum transmitting altitude for the GESN and ATCONTACT satellites is 16000 km, which translates to their lowest operational latitude being 31.9°N. With this information, the smallest possible angular separation is then calculated to be 27.4 degrees.

Table 2-11 shows the results of interference calculations from the SES-11 network into the GESN and ATCONTACT networks and vice versa. Both the GSO and HEO earth stations have been assumed to be at a latitude of 71.4°N. The calculated $\Delta T/T$ values are very small in all cases, indicating the technical compatibility of the SES-11 network with the GESN and ATCONTACT networks.

⁴ See SAT-AMD-20040719-00138 and SAT-AMD-20040719-00141.

Table 2-11: Interference calculations between SES-11 and GESN/ATCONTACT

Victim network		GESN / ATCONTACT	SES-11
Interfering network		SES-11	GESN / ATCONTACT
Uplink:			
Frequency band	GHz	28.85	28.85
Interfering uplink input power density	dBW/Hz	-72.7	-63.45
Angular separation	degrees	27.4	27.4
Slant range (Interfering path)	km	21046	40586
Space loss (Interfering path)	dB	208.1	213.8
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	46.5	24.8
Victim satellite Rx system noise temperature	K	504	545
No	dBW/Hz	-201.6	-201.2
Io	dBW/Hz	-239.5	-257.6
Io/No	dB	-37.9	-56.4
$\Delta T/T$	%	0.016	0.0002
Downlink:			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-42.3	-18
Slant range (Interfering path)	dB	40586	21046
Space loss (Interfering path)	dB	210.2	204.5
Atmospheric losses	dB	1	1
Angular separation	degrees	27.4	27.4
Victim Rx earth station system noise temperature	K	188	224
No	dBW/Hz	-205.9	-205.1
Io	dBW/Hz	-257.5	-227.4
Io/No	dB	-51.6	-22.3
$\Delta T/T$	%	0.001	0.582

APPENDIX A

C-Band C/I Calculations

Table 2A- 1: SES-11 into SES-3 C-Band Uplink C/I

Uplink C/I analysis SES-11 into SES-3				Uplink: SES-11 Carriers									
Frequency	6.175	GHz		Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W			
				Bandwidth (MHz)	35.400	18.000	9.00	6.00	1.00	1.00			
				Uplink EIRP	73.3	67.2	64.3	62.5	54.7	54.7			
				Uplink Power	19.9	13.8	10.9	9.1	1.3	1.3			
SES-11 Orbital Position	104.95	W		Uplink Power density	-55.6	-58.8	-58.7	-58.7	-58.7	-58.7			
SES-3 Orbital Position	103.0	W		Uplink Earth Station (m)	9.0	9.0	9.0	9.00	9.0	9.0			
Geocentric Separation	1.9	degrees		Earth Station Gain	53.4	53.4	53.4	53.4	53.4	53.4			
Topocentric Separation	2.0	degrees		Upl. EIRP density	-2.2	-5.4	-5.2	-5.3	-5.3	-5.3			
				Sidelobe Characteristic	29	29	29	29	29	29			
				Off-axis Eirp density	-34.3	-37.5	-37.4	-37.4	-37.4	-37.4			
Uplink: SES-3 Carriers				Uplink C/I: SES-11 into SES-3 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	75.8	0.2	9.0	53.4	29	-31.9	34.6	37.7	37.6	37.7	37.7	37.7
27M0G7W	27.000	70.7	-3.6	9.0	53.4	29	-35.8	30.7	33.9	33.8	33.8	33.8	33.8
6M95G1W	7.000	60.3	-8.2	9.0	53.4	29	-40.3	26.2	29.3	29.2	29.3	29.3	29.3
5M00G1W	5.000	62.7	-4.3	9.0	53.4	29	-36.4	30.0	33.2	33.1	33.1	33.2	33.2
100KG1W	0.100	41.3	-8.7	4.5	47.4	29	-34.8	25.6	28.8	28.7	28.7	28.7	28.7
1M60G1W	1.600	56.5	-5.5	4.5	47.4	29	-31.7	28.8	32.0	31.8	31.9	31.9	31.9

Table 2A- 2: SES-11 into SES-3 C-Band Downlink C/I

Downlink C/I analysis SES-11 into SES-3				Downlink: SES-11 Carriers									
Frequency	3.95	GHz		Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W			
				Bandwidth	35.40	18.000	9.000	6.00	1.00	1.00			
				Receive Earth Station (m)	2.40	3.70	3.70	3.70	3.70	3.70			
				Satellite EIRP	41.7	34.8	31.8	30.0	22.3	22.3			
SES-11 Orbital Position	104.95	W		Downlink EIRP density	-33.8	-37.8	-37.7	-37.8	-37.7	-37.7			
SES-3 Orbital Position	103.0	W		RX Earth Station Gain	38.1	41.8	41.8	41.8	41.8	41.8			
Geocentric Separation	1.9	degrees		Sidelobe Characteristic	29	29	29	29	29	29			
Topocentric Separation	2.0	degrees		Off-axis Gain	21.3	21.3	21.3	21.3	21.3	21.3			
Downlink: SES-3 Carriers				Downlink C/I: SES-11 into SES-3 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
36M0G7W	39.0	36.00	-36.6	3.8	42.1	29	21.3	18.0	22.0	22.0	22.0	21.9	21.9
27M0G7W	37.8	27.000	-36.5	3.8	42.1	29	21.3	18.0	22.0	22.0	22.0	22.0	22.0
6M95G1W	31.9	7.000	-36.6	3.8	42.1	29	21.3	18.0	22.0	22.0	22.0	21.9	21.9
5M00G1W	30.4	5.000	-36.6	3.8	42.1	29	21.3	18.0	21.9	21.9	22.0	21.9	21.9
100KG1W	13.4	0.100	-36.6	3.8	42.1	29	21.3	18.0	21.9	21.9	22.0	21.9	21.9
1M60G1W	25.5	1.600	-36.5	3.8	42.1	29	21.3	18.0	22.0	22.0	22.0	21.9	21.9

Table 2A- 3: SES-3 into SES-11 C-Band Uplink C/I

Uplink C/I analysis SES-3 into SES-11				Uplink: SES-11 Carriers										
SES-11 Orbital Position SES-3 Orbital Position Geocentric Separation Topocentric Separation	Frequency	6.175	GHz					Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W
								Bandwidth (MHz)	35.400	18.000	9.000	6.000	1.000	1.000
								Uplink EIRP	73.3	67.2	64.3	62.5	54.7	54.7
								Uplink Power	19.9	13.8	10.9	9.1	1.3	1.3
								Uplink Power density	-55.6	-58.8	-58.7	-58.7	-58.7	-58.7
								Uplink Earth Station (m)	9.0	9.0	9.0	9.00	9.0	9.00
								Earth Station Gain	53.4	53.4	53.4	53.4	53.4	53.4
								Upl. EIRP density	-2.2	-5.4	-5.2	-5.3	-5.3	-5.3
								Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0
							Off-axis Eirp density	-34.3	-37.5	-37.4	-37.4	-37.4	-37.4	
Uplink: SES-3 Carriers								Uplink C/I: SES-3 into SES-11 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	75.8	0.2	9.00	53.4	29	-31.9	29.7	26.6	26.7	26.6	26.6	26.6	
27M0G7W	27.00	70.7	-3.6	9.00	53.4	29	-35.8	33.6	30.4	30.5	30.5	30.5	30.5	
6M95G1W	7.000	60.3	-8.2	9.00	53.4	29	-40.3	38.1	34.9	35.0	35.0	35.0	35.0	
5M00G1W	5.000	62.7	-4.3	9.00	53.4	29	-36.4	34.2	31.1	31.2	31.1	31.1	31.1	
100KG1W	0.100	41.3	-8.7	4.50	47.4	29	-34.8	32.6	29.5	29.6	29.5	29.5	29.5	
1M60G1W	1.600	56.5	-5.5	4.50	47.4	29	-31.7	29.5	26.3	26.4	26.4	26.4	26.4	

Table 2A- 4: SES-3 into SES-11 C-Band Downlink C/I

Downlink C/I analysis SES-3 into SES-11			Downlink: SES-11 Carriers										
Frequency	3.95	GHz		Emission				36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W
				Bandwidth				35.40	18.000	9.000	6.00	1.00	1.00
SES-11 Orbital Position	104.95	W		Receive Earth Station (m)				2.40	3.70	3.70	3.70	3.70	3.70
SES-3 Orbital Position	103.0	W		Satellite EIRP				41.7	34.8	31.8	30.0	22.3	22.3
Geocentric Separation	1.9	degrees		Downlink EIRP density				-33.8	-37.8	-37.7	-37.8	-37.7	-37.7
Topocentric Separation	2.0	degrees		RX Earth Station Gain				38.1	41.8	41.8	41.8	41.8	41.8
				Sidelobe Characteristic				29	29	29	29	29	29
				Off-axis Gain				21.3	21.3	21.3	21.3	21.3	21.3
Downlink: SES-3 Carriers								Downlink C/I: SES-3 into SES-11 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	39.0	36.00	-36.6	3.8	42.1	29	21.3	19.6	19.4	19.4	19.3	19.4	19.4
27M0G7W	37.8	27.000	-36.5	3.8	42.1	29	21.3	19.5	19.3	19.3	19.3	19.4	19.4
6M95G1W	31.9	7.000	-36.6	3.8	42.1	29	21.3	19.5	19.3	19.3	19.3	19.4	19.4
5M00G1W	30.4	5.000	-36.6	3.8	42.1	29	21.3	19.6	19.4	19.4	19.3	19.4	19.4
100KG1W	13.4	0.100	-36.6	3.8	42.1	29	21.3	19.6	19.4	19.4	19.4	19.4	19.4
1M60G1W	25.5	1.600	-36.5	3.8	42.1	29	21.3	19.5	19.3	19.3	19.3	19.4	19.4

Table 2A- 5: SES-11 into Hypothetical satellite at 106.95° W.L. C-band Uplink C/I

Uplink C/I analysis SES-11 into Hypothetical				Uplink: SES-11 Carriers									
Frequency	6.175	GHz		Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W			
				Bandwidth (MHz)	35.400	18.000	9.00	6.00	1.00	1.00			
				Uplink EIRP	73.3	67.2	64.3	62.5	54.7	54.7			
SES-11 Orbital Position	104.95	W		Uplink Power	19.9	13.8	10.9	9.1	1.3	1.3			
Hypothetical Orbital Position	106.95	W		Uplink Power density	-55.6	-58.8	-58.7	-58.7	-58.7	-58.7			
Geocentric Separation	1.9	degrees		Uplink Earth Station (m)	9.0	9.0	9.0	9.00	9.0	9.0			
Topocentric Separation	2.1	degrees		Earth Station Gain	53.4	53.4	53.4	53.4	53.4	53.4			
				Upl. EIRP density	-2.2	-5.4	-5.2	-5.3	-5.3	-5.3			
				Sidelobe Characteristic	29	29	29	29	29	29			
				Off-axis Eirp density	-34.6	-37.8	-37.7	-37.7	-37.7	-37.7			
Uplink: Hypothetical Carriers					Uplink C/I: SES-11 into Hypothetical 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	35.40	73.3	-2.2	9.0	53.4	29	-34.6	32.4	35.6	35.5	35.5	35.5	35.5
18M0G7W	18.000	67.2	-5.4	9.0	53.4	29	-37.8	29.3	32.4	32.3	32.4	32.4	32.4
9M00G7W	9.000	64.3	-5.2	9.0	53.4	29	-37.7	29.4	32.5	32.4	32.5	32.5	32.5
6M00G7W	6.000	62.5	-5.3	9.0	53.4	29	-37.7	29.3	32.5	32.4	32.4	32.4	32.4
1M00G7W	1.000	54.7	-5.3	9.0	53.4	29	-37.7	29.3	32.5	32.4	32.4	32.4	32.4
1M00G7W	1.000	54.7	-5.3	9.0	53.4	29	-37.7	29.3	32.5	32.4	32.4	32.4	32.4

Table 2A- 6: SES-11 into Hypothetical satellite at 106.95° W.L. C-Band Downlink C/I

Downlink C/I analysis SES-11 into Hypothetic				Downlink: SES-11 Carriers									
Frequency	3.95	GHz			Emission		36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W	
					Bandwidth		35.40	18.000	9.000	6.00	1.00	1.00	
SES-11 Orbital Position	104.95	W			Receive Earth Station (m)		2.40	3.70	3.70	3.70	3.70	3.70	
Hypothetical Orbital Position	106.95	W			Satellite EIRP		41.7	34.8	31.8	30.0	22.3	22.3	
Geocentric Separation	1.9	degrees			Downlink EIRP density		-33.8	-37.8	-37.7	-37.8	-37.7	-37.7	
Topocentric Separation	2.1	degrees			RX Earth Station Gain		38.1	41.8	41.8	41.8	41.8	41.8	
					Sidelobe Characteristic		29	29	29	29	29	29	
					Off-axis Gain		21.0	21.0	21.0	21.0	21.0	21.0	
Downlink: Hypothetical Carriers								Downlink C/I: SES-11 into Hypothetical 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
36M0G7W	41.7	35.40	-33.8	2.4	38.1	29	21.0	17.1	21.0	21.0	21.1	21.0	21.0
18M0G7W	34.8	18.000	-37.8	3.7	41.8	29	21.0	16.9	20.8	20.8	20.9	20.8	20.8
9M00G7W	31.8	9.000	-37.7	3.7	41.8	29	21.0	16.9	20.8	20.8	20.9	20.8	20.8
6M00G7W	30.0	6.000	-37.8	3.7	41.8	29	21.0	16.8	20.8	20.8	20.8	20.7	20.7
1M00G7W	22.3	1.000	-37.7	3.7	41.8	29	21.0	16.9	20.9	20.9	20.9	20.8	20.8
1M00G7W	22.3	1.000	-37.7	3.7	41.8	29	21.0	16.9	20.9	20.9	20.9	20.8	20.8

Table 2A- 7: Hypothetical satellite at 106.95° W.L. into SES-11 C-band Uplink C/I

Uplink C/I analysis Hypothetical into SES-11				Uplink: SES-11 Carriers										
Frequency	6.175	GHz						Emission	36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W
								Bandwidth (MHz)	35.400	18.000	9.000	6.000	1.000	1.000
								Uplink EIRP	73.3	67.2	64.3	62.5	54.7	54.7
								Uplink Power	19.9	13.8	10.9	9.1	1.3	1.3
SES-11 Orbital Position	104.95	W						Uplink Power density	-55.6	-58.8	-58.7	-58.7	-58.7	-58.7
Hypothetical Orbital Position	106.95	W						Uplink Earth Station (m)	9.0	9.0	9.0	9.00	9.0	9.00
Geocentric Separation	1.9	degrees						Earth Station Gain	53.4	53.4	53.4	53.4	53.4	53.4
Topocentric Separation	2.1	degrees						Upl. EIRP density	-2.2	-5.4	-5.2	-5.3	-5.3	-5.3
								Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0
								Off-axis Eirp density	-34.6	-37.8	-37.7	-37.7	-37.7	-37.7
Uplink: Hypothetical Carriers								Uplink C/I: Hypothetical into SES-11 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	35.40	73.3	-2.2	9.00	53.4	29	-34.6	32.4	29.3	29.4	29.3	29.3	29.3	
18M0G7W	18.00	67.2	-5.4	9.00	53.4	29	-37.8	35.6	32.4	32.5	32.5	32.5	32.5	
9M00G7W	9.000	64.3	-5.2	9.00	53.4	29	-37.7	35.5	32.3	32.4	32.4	32.4	32.4	
6M00G7W	6.000	62.5	-5.3	9.00	53.4	29	-37.7	35.5	32.4	32.5	32.4	32.4	32.4	
1M00G7W	1.000	54.7	-5.3	9.00	53.4	29	-37.7	35.5	32.4	32.5	32.4	32.4	32.4	
1M00G7W	1.000	54.7	-5.3	9.00	53.4	29	-37.7	35.5	32.4	32.5	32.4	32.4	32.4	

Table 2A- 8: Hypothetical satellite at 106.95° W.L. into SES-11 C-Band Downlink C/I

Downlink C/I analysis		Hypothetical into SES-1			Downlink: SES-11 Carriers								
Frequency	3.95	GHz			Emission			36M0G7W	18M0G7W	9M00G7W	6M00G7W	1M00G7W	1M00G7W
SES-11 Orbital Position Hypothetical Orbital Position Geocentric Separation Topocentric Separation	104.95	W			Bandwidth			35.40	18.000	9.000	6.00	1.00	1.00
					Receive Earth Station (m)			2.40	3.70	3.70	3.70	3.70	3.70
	106.95	W			Satellite EIRP			41.7	34.8	31.8	30.0	22.3	22.3
	1.9	degrees			Downlink EIRP density			-33.8	-37.8	-37.7	-37.8	-37.7	-37.7
	2.1	degrees			RX Earth Station Gain			38.1	41.8	41.8	41.8	41.8	41.8
					Sidelobe Characteristic			29	29	29	29	29	29
					Off-axis Gain			21.0	21.0	21.0	21.0	21.0	21.0
Downlink: Hypothetical Carriers								Downlink C/I: Hypothetical into SES-11 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
36M0G7W	41.7	35.40	-33.8	2.4	38.1	29	21.0	17.1	16.9	16.9	16.8	16.9	16.9
18M0G7W	34.8	18.000	-37.8	3.7	41.8	29	21.0	21.0	20.8	20.8	20.8	20.9	20.9
9M00G7W	31.8	9.000	-37.7	3.7	41.8	29	21.0	21.0	20.8	20.8	20.8	20.9	20.9
6M00G7W	30.0	6.000	-37.8	3.7	41.8	29	21.0	21.1	20.9	20.9	20.8	20.9	20.9
1M00G7W	22.3	1.000	-37.7	3.7	41.8	29	21.0	21.0	20.8	20.8	20.7	20.8	20.8
1M00G7W	22.3	1.000	-37.7	3.7	41.8	29	21.0	21.0	20.8	20.8	20.7	20.8	20.8

APPENDIX B

Ku-Band C/I Calculations

Table 2B- 1: SES-11 into SES-3 Ku-Band Uplink C/I

Uplink C/I analysis SES-11 into SES-3				Uplink: SES-11 Carriers									
Frequency	14.250	GHz		Emission	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W			
				Bandwidth (MHz)	30.000	3.617	0.04	1.68	0.91	6.01			
				Uplink EIRP	70.2	56.3	35.5	51.7	55.2	57.8			
				Uplink Power	9.5	13.1	-6.1	10.1	8.5	8.6			
SES-11 Orbital Position	104.95	W		Uplink Power density	-65.3	-52.5	-51.8	-52.1	-51.1	-59.2			
SES-3 Orbital Position	103.0	W		Uplink Earth Station (m)	9.0	1.2	1.0	1.00	1.8	2.4			
Geocentric Separation	1.9	degrees		Earth Station Gain	60.7	43.2	41.6	41.6	46.7	49.2			
Topocentric Separation	2.0	degrees		Upl. EIRP density	-4.6	-9.3	-10.2	-10.5	-4.4	-10.0			
				Sidelobe Characteristic	29	29	29	29	29	29			
				Off-axis Eirp density	-44.0	-31.2	-30.5	-30.9	-29.8	-37.9			
Uplink: SES-3 Carriers							Uplink C/I: SES-11 into SES-3 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	74.7	-0.9	6.0	57.2	29	-36.7	43.1	30.3	29.6	30.0	29.0	37.0
27M0G7W	27.000	74.7	0.4	6.0	57.2	29	-35.5	44.4	31.6	30.9	31.2	30.2	38.3
6M95G1W	7.000	63.6	-4.9	6.0	57.2	29	-40.7	39.1	26.3	25.7	26.0	25.0	33.1
5M00G1W	5.000	63.6	-3.4	6.0	57.2	29	-39.3	40.6	27.8	27.1	27.5	26.4	34.5
100KG1W	0.100	52.7	2.7	6.0	57.2	29	-33.2	46.7	33.9	33.2	33.6	32.5	40.6
1M60G1W	1.600	62.7	0.7	6.0	57.2	29	-35.2	44.6	31.8	31.2	31.5	30.5	38.6

Table 2B- 2: SES-11 into SES-3 Ku-Band Downlink C/I

Downlink C/I analysis SES-11 into SES-3				Downlink: SES-11 Carriers									
Frequency	11.95	GHz		Emission				36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W
				Bandwidth				30.00	3.617	0.037	1.68	0.91	6.01
SES-11 Orbital Position	104.95	W		Receive Earth Station (m)				1.20	4.50	3.20	1.80	1.80	4.50
SES-3 Orbital Position	103.0	W		Satellite EIRP				44.3	31.9	11.1	27.2	30.8	33.3
Geocentric Separation	1.9	degrees		Downlink EIRP density				-30.5	-33.7	-34.6	-35.0	-28.8	-34.5
Topocentric Separation	2.0	degrees		RX Earth Station Gain				41.7	53.1	50.2	45.2	45.2	53.1
				Sidelobe Characteristic				29	29	29	29	29	29
				Off-axis Gain				21.3	21.3	21.3	21.3	21.3	21.3
Downlink: SES-3 Carriers								Downlink C/I: SES-11 into SES-3 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
36M0G7W	49.5	36.00	-26.1	1.2	41.7	29	21.3	24.8	28.0	28.9	29.4	23.1	28.8
27M0G7W	48.3	27.000	-26.0	1.2	41.7	29	21.3	24.8	28.0	28.9	29.4	23.2	28.8
6M95G1W	38.4	7.000	-30.1	1.2	41.7	29	21.3	20.8	24.0	24.9	25.4	19.1	24.8
5M00G1W	36.9	5.000	-30.1	1.8	45.2	29	21.3	24.3	27.5	28.4	28.8	22.6	28.3
100KG1W	19.9	0.100	-30.1	1.8	45.2	29	21.3	24.3	27.5	28.4	28.8	22.6	28.3
1M60G1W	32.0	1.600	-30.0	1.8	45.2	29	21.3	24.3	27.5	28.4	28.9	22.6	28.3

Table 2B- 3: SES-3 into SES-11 Ku-band Uplink C/I

Uplink C/I analysis SES-3 into SES-11				Uplink: SES-11 Carriers							
Frequency	14.250	GHz		Emission	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W	
				Bandwidth (MHz)	30.000	3.617	0.037	1.675	0.910	6.006	
				Uplink EIRP	70.2	56.3	35.5	51.7	55.2	57.8	
				Uplink Power	9.5	13.1	-6.1	10.1	8.5	8.6	
SES-11 Orbital Position	104.95	W		Uplink Power density	-65.3	-52.5	-51.8	-52.1	-51.1	-59.2	
SES-3 Orbital Position	103.0	W		Uplink Earth Station (m)	9.0	1.2	1.0	1.00	1.8	2.40	
Geocentric Separation	1.9	degrees		Earth Station Gain	60.7	43.2	41.6	41.6	46.7	49.2	
Topocentric Separation	2.0	degrees		Upl. EIRP density	-4.6	-9.3	-10.2	-10.5	-4.4	-10.0	
				Sidelobe Characteristic	29.0	29.0	29.0	29.0	29.0	29.0	
				Off-axis Eirp density	-44.0	-31.2	-30.5	-30.9	-29.8	-37.9	
Uplink: SES-3 Carriers				Uplink C/I: SES-3 into SES-11 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
36M0G7W	36.00	74.7	-0.9	6.00	57.2	29	-36.7	32.2	27.5	26.6	26.2
27M0G7W	27.00	74.7	0.4	6.00	57.2	29	-35.5	30.9	26.2	25.3	25.0
6M95G1W	7.000	63.6	-4.9	6.00	57.2	29	-40.7	36.2	31.5	30.6	30.2
5M00G1W	5.000	63.6	-3.4	6.00	57.2	29	-39.3	34.7	30.0	29.1	28.7
100KG1W	0.100	52.7	2.7	6.00	57.2	29	-33.2	28.6	23.9	23.0	22.6
1M60G1W	1.600	62.7	0.7	6.00	57.2	29	-35.2	30.7	25.9	25.0	24.7

Table 2B- 4: SES-3 into SES-11 Ku-Band Downlink C/I

Downlink C/I analysis SES-3 into SES-11				Downlink: SES-11 Carriers							
Frequency	11.95	GHz		Emission	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W	
				Bandwidth	30.00	3.617	0.037	1.68	0.91	6.01	
SES-11 Orbital Position	104.95	W		Receive Earth Station (m)	1.20	4.50	3.20	1.80	1.80	4.50	
SES-3 Orbital Position	103.0	W		Satellite EIRP	44.3	31.9	11.1	27.2	30.8	33.3	
Geocentric Separation	1.9	degrees		Downlink EIRP density	-30.5	-33.7	-34.6	-35.0	-28.8	-34.5	
Topocentric Separation	2.0	degrees		RX Earth Station Gain	41.7	53.1	50.2	45.2	45.2	53.1	
				Sidelobe Characteristic	29	29	29	29	29	29	
				Off-axis Gain	21.3	21.3	21.3	21.3	21.3	21.3	
Downlink: SES-3 Carriers				Downlink C/I: SES-3 into SES-11 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
36M0G7W	49.5	36.00	-26.1	1.2	41.7	29	21.3	16.0	24.2	20.4	14.9
27M0G7W	48.3	27.000	-26.0	1.2	41.7	29	21.3	15.9	24.2	20.3	14.9
6M95G1W	38.4	7.000	-30.1	1.2	41.7	29	21.3	20.0	28.2	24.4	18.9
5M00G1W	36.9	5.000	-30.1	1.8	45.2	29	21.3	20.0	28.3	24.4	18.9
100KG1W	19.9	0.100	-30.1	1.8	45.2	29	21.3	20.0	28.3	24.4	19.0
1M60G1W	32.0	1.600	-30.0	1.8	45.2	29	21.3	19.9	28.2	24.4	18.9

Table 2B- 5: SES-11 into Hypothetical satellite at 106.95° W.L. Ku-Band Uplink C/I

Uplink C/I analysis SES-11 into Hypothetical				Uplink: SES-11 Carriers							
Frequency	14.250	GHz		Emission	36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W	
				Bandwidth (MHz)	30.000	3.617	0.04	1.68	0.91	6.01	
				Uplink EIRP	70.2	56.3	35.5	51.7	55.2	57.8	
				Uplink Power	9.5	13.1	-6.1	10.1	8.5	8.6	
SES-11 Orbital Position	104.95	W		Uplink Power density	-65.3	-52.5	-51.8	-52.1	-51.1	-59.2	
Hypothetical Orbital Position	106.95	W		Uplink Earth Station (m)	9.0	1.2	1.0	1.00	1.8	2.4	
Geocentric Separation	1.9	degrees		Earth Station Gain	60.7	43.2	41.6	41.6	46.7	49.2	
Topocentric Separation	2.1	degrees		Upl. EIRP density	-4.6	-9.3	-10.2	-10.5	-4.4	-10.0	
				Sidelobe Characteristic	29	29	29	29	29	29	
				Off-axis Eirp density	-44.3	-31.5	-30.8	-31.1	-30.1	-38.2	
Uplink: Hypothetical Carriers				Uplink C/I: SES-11 into Hypothetical 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
36M0G7W	30.00	70.2	-4.6	9.0	60.7	29	-44.3	39.7	26.9	26.2	26.6
5M00G1W	3.617	56.3	-9.3	1.2	43.2	29	-31.5	35.0	22.2	21.5	21.9
100KG1D	0.037	35.5	-10.2	1.0	41.6	29	-30.8	34.1	21.3	20.6	21.0
1M40G1D	1.675	51.7	-10.5	1.0	41.6	29	-31.1	33.7	20.9	20.3	20.6
2M00G7W	0.910	55.2	-4.4	1.8	46.7	29	-30.1	39.9	27.1	26.4	26.8
8M00G7W	6.006	57.8	-10.0	2.4	49.2	29	-38.2	34.3	21.5	20.8	21.2

Table 2B- 6: SES-11 into Hypothetical satellite at 106.95° W.L. Ku-Band Downlink C/I

Downlink C/I analysis				Downlink: SES-11 into Hypothetical				Downlink: SES-11 Carriers						
Frequency	11.95	GHz						36M0G7W	5M00G1W	100KG1D	1M40G1D	2M00G7W	8M00G7W	
SES-11 Orbital Position Hypothetical Orbital Position Geocentric Separation Topocentric Separation	104.95	W						Emission Bandwidth	30.00	3.617	0.037	1.68	0.91	6.01
	106.95	W						Receive Earth Station (m)	1.20	4.50	3.20	1.80	1.80	4.50
								Satellite EIRP	44.3	31.9	11.1	27.2	30.8	33.3
	1.9	degrees						Downlink EIRP density	-30.5	-33.7	-34.6	-35.0	-28.8	-34.5
	2.1	degrees						RX Earth Station Gain	41.7	53.1	50.2	45.2	45.2	53.1
								Sidelobe Characteristic	29	29	29	29	29	29
								Off-axis Gain	21.0	21.0	21.0	21.0	21.0	21.0
Downlink: Hypothetical Carriers								Downlink C/I: SES-11 into Hypothetical 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	
36M0G7W	44.3	30.00	-30.5	1.2	41.7	29	21.0	20.7	23.9	24.8	25.2	19.0	24.7	
5M00G1W	31.9	3.617	-33.7	4.5	53.1	29	21.0	28.9	32.1	33.0	33.5	27.3	32.9	
100KG1D	11.1	0.037	-34.6	3.2	50.2	29	21.0	25.1	28.3	29.2	29.6	23.4	29.1	
1M40G1D	27.2	1.675	-35.0	1.8	45.2	29	21.0	19.6	22.8	23.7	24.2	17.9	23.6	
2M00G7W	30.8	0.910	-28.8	1.8	45.2	29	21.0	25.9	29.1	30.0	30.4	24.2	29.9	
8M00G7W	33.3	6.006	-34.5	4.5	53.1	29	21.0	28.1	31.3	32.2	32.7	26.4	32.1	

Engineering Declaration

DECLARATION OF Giadira V. León

I, Giadira V. León, 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/ Giadira V. León

Manager, Spectrum Management
and Development Americas
SES Americom, Inc.

Dated: 12 May 2016