Panasonic Avionics Corporation
ESAA Blanket License Modification Application

Technical Appendix

SES

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Federal Communications Commission
International Bureau
445 12th Street, SW
Washington, D.C.
20554

8 July 2021

Subject: **Engineering Certification of SES**

To Whom It May Concern:

This letter certifies that SES is aware that Panasonic Avionics Corporation ("Panasonic") is planning to modify its earth stations aboard aircraft (“ESAA”) blanket license from the Federal Communication Commission (“FCC”), Call Sign E100089, to add SES-4 (22°W.L.), SES-9 (108.3° E.L.), and SES-10 (67°W.L.) satellites as authorized points of communication for its PPA and SPA ESAA terminals. SES understands that Panasonic will file the modification application pursuant to the FCC rules governing ESAA operations, including Section 25.228.

SES confirms and hereby certifies that the power density levels of the proposed operations are consistent with existing satellite coordination agreements with the satellites with +/-6 degrees of the SES satellite's orbit location, and acknowledges that the proposed operation of Panasonic's PPA and SPA ESAA terminals has the potential to create and receive harmful interference from adjacent satellite networks that may be unacceptable.

If the FCC authorizes the operation proposed by Panasonic, SES will include the power density levels specified by Panasonic, defined within the satellite coordination agreements, in all future satellite network coordination with operators of satellite that are adjacent to the satellite addressed by this letter.

Yours Sincerely,

Zach Rosenbaum

Digitally signed by Zach Rosenbaum
DN: DC=com, DC=ses, DC=gad, OU=INTERNALS, OU=User Resources, OU=Client Users, OU=NASA-US-WDC, CN=Zach Rosenbaum
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II. SES-4

Orbital Debris Mitigation

SES WORLD SKIES has reviewed orbit debris mitigation for all satellites in its fleet, including the SES-4 spacecraft. SES WORLD SKIES' policy is to incorporate these objectives, as appropriate, into its test plan, including a formal analysis of orbital debris risks associated with the TT&C, propulsion, and power generation and storage systems.

Spacecraft Hardware Design

SES WORLD SKIES has assessed and limited the amount of debris released in a planned manner during normal operations. SES-4 will not be a source of debris during drift or operating mode, as SES WORLD SKIES does not intend to release debris during the planned course of operations of the satellite.

SES WORLD SKIES has also assessed and limited the possibility of SES-4 becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control of the spacecraft and prevent post-mission disposal. Specifically, the SES-4 satellite has been designed and constructed in a manner that incorporates redundancy, shielding, separation of components, and other physical characteristics into the satellite's design. For example, omni-directional antennas are mounted on opposite sides of the spacecraft, and either will be sufficient to support orbit raising. The command receivers and decoders, telemetry encoders and transmitters, and the bus control electronics are fully redundant, physically separated, and located within a shielded area to minimize the probability of the spacecraft becoming a source of debris due to a collision.

Minimizing Accidental Explosions

SES WORLD SKIES has assessed and limited the probability of accidental explosion during and after completion of mission operations. The key areas reviewed for this purpose included leakage of propellant and mixing of fuel and oxidizer as well as battery pressure vessels. The basic propulsion design (including component and functional redundancy, and the placement of fuel tanks inside a central cylinder which provides a high level of shielding), propulsion subsystem component construction, preflight verification through both proof testing and analysis, and quality standards have been designed to ensure a very low risk of propellant leakage and fuel and oxidizer mixing that can result in subsequent explosions. During the mission, batteries and various critical areas of the propulsion subsystem will be continually monitored (for both pressure and temperature) to preclude conditions that could result in the remote possibility of explosion and subsequent generation of debris.

After SES-4 reaches its final disposal orbit, all on-board sources of stored energy will be depleted, all residual fuel will be depleted, all fuel line valves will be left "open," all batteries will be left in a permanent discharge state, and all pressurized systems will be vented. The solar cells will also be slewed away from the sun to minimize power generation.

Through this process, SES WORLD SKIES has assessed and limited the possibility of accidental explosions during and after completion of mission operations and will assure that all stored energy at the end of the satellite’s operation will be removed.

Safe Flight Profiles

SES WORLD SKIES has assessed and limited the probability of SES-4 becoming a source of debris by collisions with large debris or other operational space stations through detailed and conscientious mission planning. SES WORLD SKIES has reviewed the list of licensed systems and systems that are under consideration by the Commission for the nominal 22° W.L. orbital location where SES-4 will operate. In addition, in order to address non-U.S. licensed systems, SES WORLD SKIES has reviewed the list of satellite networks in the vicinity of 22° W.L. for which a request for coordination has been submitted to the ITU. Only those networks that are operating, or are planned to be operating, within ± 0.2° have been taken into account in this review.

SES WORLD SKIES has determined that no system is under consideration or has been licensed by the Commission, or is currently operating, at the nominal 22° W.L. location, except for the NSS-7 satellite. Also, with the exception of the filings made by SES WORLD SKIES, the company is not aware of any system with an overlapping station-keeping volume with SES-4, that is the subject of an ITU filing and that is either in orbit or progressing towards launch. SES WORLD SKIES therefore concludes that physical coordination of SES-4 with another operator will not be required at the present time.

With respect to the NSS-7 satellite, which is currently located at 22.0° W.L., that satellite will be moved to another location once SES-4 has arrived on station and traffic transfer is complete. At that time, SES-4 will assume the station-keeping box currently occupied by NSS-7. During the brief period in which communication traffic is being transferred from NSS-7 to SES-4, SES WORLD SKIES will take all the necessary steps, e.g., execute a "pass-in-the-night-maneuver" or temporarily offset the orbital location of

NSS-7 and/or SES-4 (with Commission authorization, where necessary), to minimize the risk of collision between the two spacecraft.

Post-Mission Disposal

Consistent with the requirements of Section 25.283(a) of the Commission's rules, at the end of the operational life of the satellite, SES WORLD SKIES will maneuver SES-4 into a disposal orbit with an altitude no less than that calculated using the IADC formula:

36,021 km + (1000·CR·A/m).

The calculated value of CRA/m in this instance is based on the following parameters:

CR = Solar Pressure Radiation Coefficient = 1.20

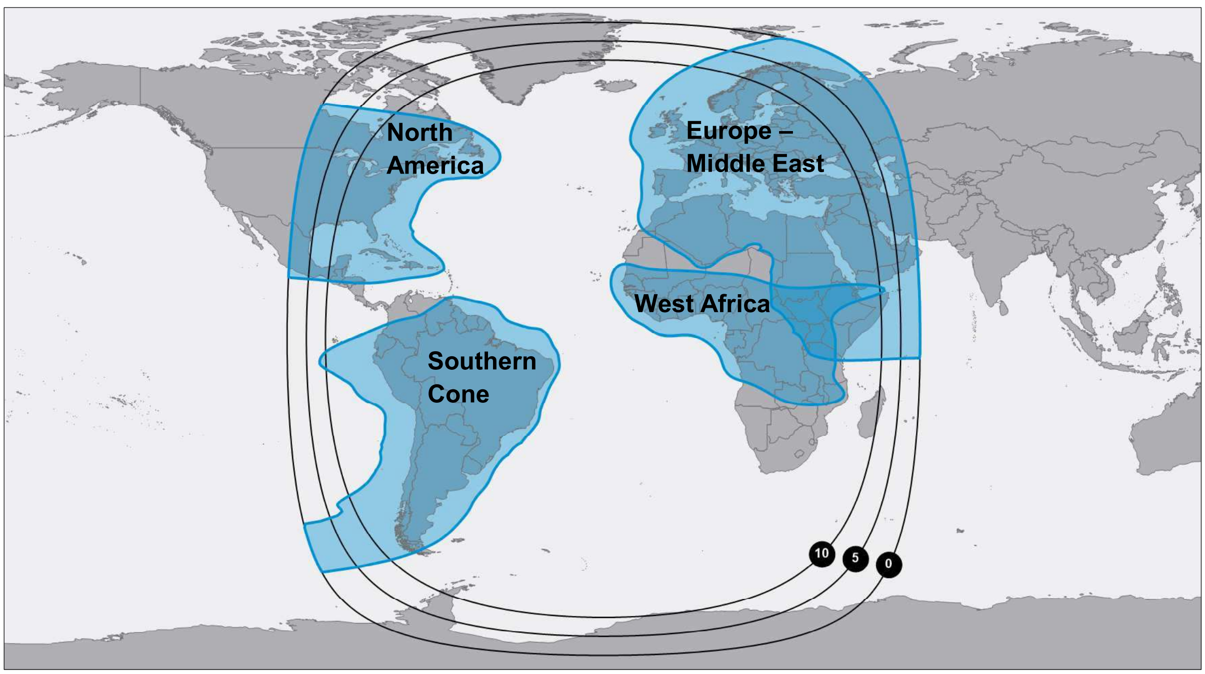
A = Total Solar Pressure Area = 115 m2

M = Dry Mass of Satellite = 3073.3 kg

Using these values in the IADC formula results in a minimum de-orbit altitude of 36066 km, or approximately 280 km above geosynchronous altitude. To provide adequate margin, the nominal disposal orbit will be increased above this calculated value to a value of 300 km. Approximately 31.6 kg of propellant will be allocated and reserved for final orbit raising maneuvers to this altitude. This value was determined through a detailed Proton/M-Breeze M propellant budget analysis. In addition, SES WORLD SKIES has assessed fuel gauging uncertainty and this budgeted propellant provides an adequate margin of fuel reserve to ensure that the disposal orbit will be achieved despite such uncertainty.

II.2. SES-4 Coverage Map

Aggregate Ku-Band Service Area Coverage



II.3. SES-4 Link Budgets

Forward Link Budget

eXConnect Terminal		
Antenna Type	DPA	
Lat	-40.2	deg
Lon	-61.7	deg
EIRP max	46.1	dBW
G/T	10.1	dB/K
Satellite		
Name	SES4	
Longitude	-22.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2X	
Modulation	8PSK	
Bits per symbol	3	
Spread Factor	1	
Coding Rate	0.56	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	1.50	bps/Hz
Data Rate	8.86E+07	bps
Information Rate (Data + Overhead)	9.84E+07	bps
Symbol Rate	5.91E+07	Hz
Chip Rate (Noise Bandwidth)	5.91E+07	Hz
Occupied Bandwidth	6.20E+07	Hz
Power Equivalent Bandwidth	6.20E+07	Hz
C/N Threshold	4.5	dB
Uplink		
Frequency	14.221	GHz
Back off	0.1	dB
EIRP Spectral Density	38.2	dBW/4kHz
Slant Range	38952	km
Space Loss, Ls	207.3	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	2.9	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	1.0	dB/K
Thermal Noise, C/No	99.3	dBHz
C/(No+Io)	98.8	dBHz
Satellite		
Flux Density	-85.8	dBW/m2
SFD @ Hub	-83.4	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	0.4	dB
Downlink		
Frequency	11.921	GHz
Transponder Sat. EIRP @ Beam Peak	52.2	dBW
Transponder Sat. EIRP @ Terminal	52.0	dBW
DL PSD Limit	12.0	dBW/4kHz
DL PSD @ Beam Peak	10.1	dBW/4kHz
Carrier EIRP @ Beam Peak	51.8	dBW
Carrier EIRP @ Terminal	51.6	dBW
Slant Range	38763	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	84.0	dBHz
C/(No+Io)	84.0	dBHz
End to End		
End to End C/(No+Io)	83.8	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	4.6	dB
Link Margin	0.1	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	DPA	
Lat	-40.2	deg
Lon	-61.7	deg
EIRP max	46.1	dBW
G/T	10.1	dB/K
Satellite		
Name	SES4	
Longitude	-22.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	MxDMA	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	6	
Coding Rate	0.35	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	0.11	bps/Hz
Data Rate	2.10E+06	bps
Information Rate (Data + Overhead)	2.33E+06	bps
Symbol Rate	3.33E+06	Hz
Chip Rate (Noise Bandwidth)	2.00E+07	Hz
Occupied Bandwidth	2.10E+07	Hz
Power Equivalent Bandwidth	1.10E+05	Hz
C/N Threshold	-8.7	dB
Uplink		
Frequency	14.221	GHz
Back off	0.0	dB
EIRP Spectral Density	9.1	dBW/4kHz
Slant Range	38763	km
Space Loss, Ls	207.3	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
Transponder G/T @ Terminal	2.0	dB/K
Thermal Noise, C/No	68.8	dBHz
C/(No+Io)	68.3	dBHz
Satellite		
Flux Density	-117.3	dBW/m2
SFD @ Terminal	-84.4	dBW/m2
Small Signal Gain (IBO/OBO)	3.0	dB
OBO	29.9	dB
Downlink		
Frequency	11.921	GHz
Transponder Sat. EIRP @ Beam Peak	52.2	dBW
Transponder Sat. EIRP @ Hub	48.0	dBW
DL PSD Limit	12.0	dBW/4kHz
DL PSD @ Beam Peak	-14.7	dBW/4kHz
Carrier EIRP @ Beam Peak	22.3	dBW
Carrier EIRP @ Hub	18.1	dBW
Slant Range	38952	km
Space Loss, Ls	205.8	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	3.6	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	74.8	dBHz
C/(No+Io)	69.5904	dBHz
End to End		
End to End C/(No+Io)	65.9	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	-8.6	dB
Link Margin	0.0	dB

Forward Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	-40.2	deg
Lon	-61.7	deg
EIRP max	44.0	dBW
G/T	11.5	dB/K
Satellite		
Name	SES4	
Longitude	-22.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2X	
Modulation	16APSK	
Bits per symbol	4	
Spread Factor	1	
Coding Rate	0.50	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	1.80	bps/Hz
Data Rate	1.06E+08	bps
Information Rate (Data + Overhead)	1.18E+08	bps
Symbol Rate	5.91E+07	Hz
Chip Rate (Noise Bandwidth)	5.91E+07	Hz
Occupied Bandwidth	6.20E+07	Hz
Power Equivalent Bandwidth	6.20E+07	Hz
C/N Threshold	5.7	dB
Uplink		
Frequency	14.221	GHz
Back off	0.1	dB
EIRP Spectral Density	38.2	dBW/4kHz
Slant Range	38952	km
Space Loss, Ls	207.3	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	2.9	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	1.0	dB/K
Thermal Noise, C/No	99.3	dBHz
C/(No+Io)	98.8	dBHz
Satellite		
Flux Density	-85.8	dBW/m2
SFD @ Hub	-83.4	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	0.4	dB
Downlink		
Frequency	11.921	GHz
Transponder Sat. EIRP @ Beam Peak	52.2	dBW
Transponder Sat. EIRP @ Terminal	52.0	dBW
DL PSD Limit	12.0	dBW/4kHz
DL PSD @ Beam Peak	10.1	dBW/4kHz
Carrier EIRP @ Beam Peak	51.8	dBW
Carrier EIRP @ Terminal	51.6	dBW
Slant Range	38763	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	85.3	dBHz
C/(No+Io)	85.3	dBHz
End to End		
End to End C/(No+Io)	85.1	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	5.9	dB
Link Margin	0.2	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	-40.2	deg
Lon	-61.7	deg
EIRP max	44.0	dBW
G/T	11.5	dB/K
Satellite		
Name	SES4	
Longitude	-22.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	MxDMA	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	7	
Coding Rate	0.35	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	0.09	bps/Hz
Data Rate	1.30E+06	bps
Information Rate (Data + Overhead)	1.44E+06	bps
Symbol Rate	2.06E+06	Hz
Chip Rate (Noise Bandwidth)	1.44E+07	Hz
Occupied Bandwidth	1.51E+07	Hz
Power Equivalent Bandwidth	6.74E+04	Hz
C/N Threshold	-9.3	dB
Uplink		
Frequency	14.221	GHz
Back off	0.0	dB
EIRP Spectral Density	8.4	dBW/4kHz
Slant Range	38763	km
Space Loss, Ls	207.3	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
Transponder G/T @ Terminal	2.0	dB/K
Thermal Noise, C/No	66.7	dBHz
C/(No+Io)	66.2	dBHz
Satellite		
Flux Density	-119.4	dBW/m2
SFD @ Terminal	-84.4	dBW/m2
Small Signal Gain (IBO/OBO)	3.0	dB
OBO	32.0	dB
Downlink		
Frequency	11.921	GHz
Transponder Sat. EIRP @ Beam Peak	52.2	dBW
Transponder Sat. EIRP @ Hub	48.0	dBW
DL PSD Limit	12.0	dBW/4kHz
DL PSD @ Beam Peak	-15.4	dBW/4kHz
Carrier EIRP @ Beam Peak	20.2	dBW
Carrier EIRP @ Hub	16.0	dBW
Slant Range	38952	km
Space Loss, Ls	205.8	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	3.6	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	72.7	dBHz
C/(No+Io)	67.4825	dBHz
End to End		
End to End C/(No+Io)	63.8	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	-9.3	dB
Link Margin	0.0	dB

III. SES-9

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

Spacecraft Hardware Design

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

SES has also assessed and limited the probability of the space station becoming a source of orbital debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. The design of SES's recent spacecraft locates all sources of stored energy within the body of the structure, which provides protection from small orbital debris. SES requires that spacecraft manufacturers assess the probability of micrometeorite damage that can cause any loss of functionality. This probability is then factored into the ultimate spacecraft probability of success. Any significant probability of damage would need to be mitigated in order for the spacecraft design to meet SES's required probability of success of the mission. SES has taken the following steps to limit the effects of such collisions: (1) critical spacecraft components are located inside the protective body of the spacecraft and properly shielded; and (2) all spacecraft subsystems have redundant components to ensure no single-point failures. The spacecraft will not use any subsystems for end-of-life disposal that are not used for normal operations.

Minimizing Accidental Explosions

SES has assessed and limited the probability of accidental explosions during and after completion of mission operations. As part of the Safety Package, an extensive analysis is completed by the spacecraft manufacturer, reviewing each potential hazard relating to accidental explosions and analyzing each subsystem for potential hazards. Also, the spacecraft manufacturer generates a Failure Mode Effects and Criticality Analysis for the spacecraft to identify all potential mission failures. The risk of accidental explosion is included as part of this analysis. This analysis indicates failure modes, possible causes, methods of detection, and compensating features of the spacecraft design.

The design of the SES-9 spacecraft is such that the risk of explosion is minimized both during and after mission operations. In designing and building the spacecraft, the manufacturer took steps to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. For stationkeeping and momentum control SES-9 uses a Xenon Ion Propulsion System (XIPS) with a single xenon inert gas. Because xenon is inert it requires less end of life care than chemical propellant fuels. All propulsion subsystem pressure vessels, which have high margins of safety at launch, have even higher margins in orbit, since use of xenon during transfer orbit decreases the propulsion system pressure. Burst tests were performed on all pressure vessels during qualification testing to demonstrate a margin of safety against burst. The xenon tank has a specified proof pressure of 4375 psia and burst pressure of 5250 psia although qualification testing has been demonstrated up to 7800 psia, well above the specified burst pressure. In addition, the xenon tank is designed to leak before burst. On-orbit, all pressures, including those of the batteries, are monitored by telemetry.

At the end of operational life, after the satellite has reached its final disposal orbit, all on-board sources of stored energy will be depleted or secured, the batteries will be discharged, and the xenon propellant will be vented per the Satellite Manufacturer's procedure and guidelines to a value below 5% of the tank rated proof pressure of 4375 psia. For the maximum xenon loading of 320 kg, the projected pressure and mass of residual Xenon that could remain in the tank at mission end of life is as follows, well below the specified proof and burst pressures:

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

Safe Flight Profiles

SES has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Specifically, SES has assessed the possibility of collision with satellites located at, or reasonably expected to be located at, the nominal 108.3° E.L. orbital location. Regarding avoidance of collisions with controlled objects, in general, if a geosynchronous satellite is controlled within its specified longitude and latitude station-keeping limits, collision with another controlled object (excluding where the satellite is collocated with another object) is the direct result of that object entering the allocated space.

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

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

SES uses the Space Data Center ("SDC") system from the Space Data Association to monitor the risk of close approach of its satellites with other objects. Any close encounters (separation of less than 10 km) are flagged and investigated in more detail. If required, avoidance maneuvers are performed to eliminate the possibility of collisions. During any relocation, the moving spacecraft is maneuvered such that it is at least 30 km away from the synchronous radius at all times. In most cases, much larger deviation from the synchronous radius is used. In addition, the SDC system is used to ensure no close encounter occurs during the move. When de-orbit of a spacecraft is required, the initial phase is treated as a satellite move, and the same precautions are used to ensure collision avoidance.

Post Mission Disposal Plan

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

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

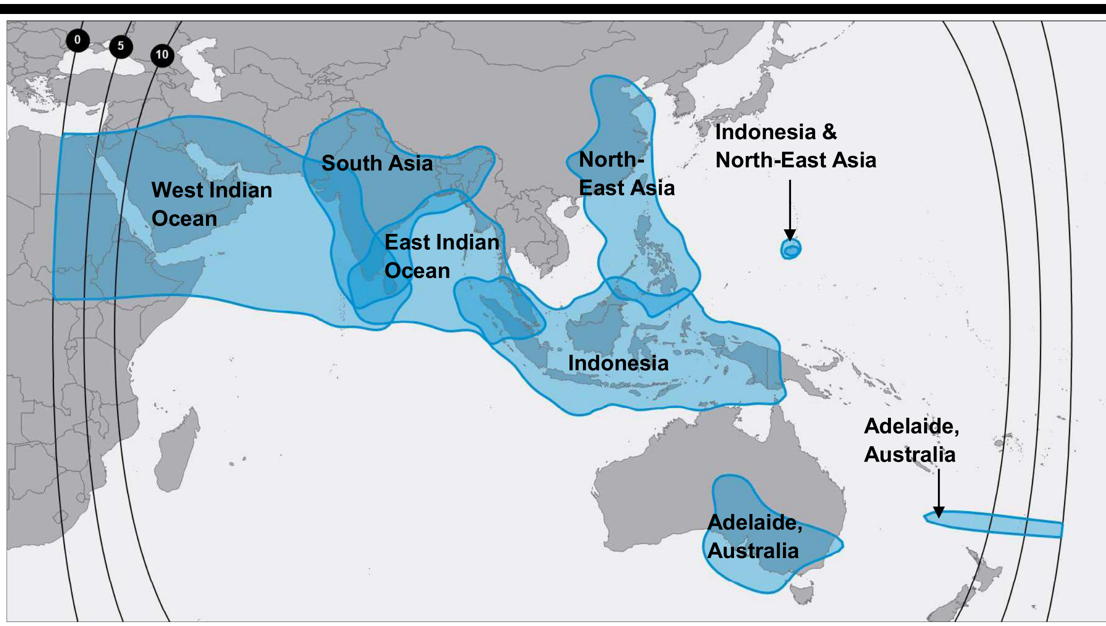
Therefore the Minimum Disposal Orbit Perigee Altitude:

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

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

III.2. SES-9 Coverage Map

Aggregate Ku-Band Service Area Coverage



III.3. SES-9 Link Budgets

Forward Link Budget

eXConnect Terminal		
Antenna Type	DPA	
Lat	9.9	deg
Lon	77.9	deg
EIRP max	47.1	dBW
G/T	11.2	dB/K
Satellite		
Name	SES-9	
Longitude	108.3	deg
Hub Earth Station		
Site	New Delhi	
Lat	28.637	deg
Lon	77.2	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2X	
Modulation	16APSK	
Bits per symbol	4	
Spread Factor	1	
Coding Rate	0.53	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	1.92	bps/Hz
Data Rate	9.87E+07	bps
Information Rate (Data + Overhead)	1.10E+08	bps
Symbol Rate	5.14E+07	Hz
Chip Rate (Noise Bandwidth)	5.14E+07	Hz
Occupied Bandwidth	5.40E+07	Hz
Power Equivalent Bandwidth	5.40E+07	Hz
C/N Threshold	6.4	dB
Uplink		
Frequency	14.210	GHz
Back off	16.6	dB
EIRP Spectral Density	22.3	dBW/4kHz
Slant Range	37612	km
Space Loss, Ls	207.0	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	4.4	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	9.5	dB/K
Thermal Noise, C/No	90.1	dBHz
C/(No+Io)	89.6	dBHz
Satellite		
Flux Density	-103.5	dBW/m2
SFD @ Hub	-103.5	dBW/m2
Small Signal Gain (IBO/OBO)	0.0	dB
OBO	0.0	dB
Downlink		
Frequency	12.462	GHz
Transponder Sat. EIRP @ Beam Peak	56.0	dBW
Transponder Sat. EIRP @ Terminal	55.0	dBW
DL PSD Limit	17.0	dBW/4kHz
DL PSD @ Beam Peak	14.9	dBW/4kHz
Carrier EIRP @ Beam Peak	56.0	dBW
Carrier EIRP @ Terminal	55.0	dBW
Slant Range	36907	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	88.5	dBHz
C/(No+Io)	86.9	dBHz
End to End		
End to End C/(No+Io)	85.0	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	6.4	dB
Link Margin	0.0	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	DPA	
Lat	9.9	deg
Lon	77.9	deg
EIRP max	47.1	dBW
G/T	11.2	dB/K
Satellite		
Name	SES-9	
Longitude	108.3	deg
Hub Earth Station		
Site	New Delhi	
Lat	28.637	deg
Lon	77.2	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	MxDMA	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	1	
Coding Rate	0.35	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	0.63	bps/Hz
Data Rate	1.26E+07	bps
Information Rate (Data + Overhead)	1.40E+07	bps
Symbol Rate	2.00E+07	Hz
Chip Rate (Noise Bandwidth)	2.00E+07	Hz
Occupied Bandwidth	2.10E+07	Hz
Power Equivalent Bandwidth	7.05E+06	Hz
C/N Threshold	-0.3	dB
Uplink		
Frequency	14.150	GHz
Back off	0.0	dB
EIRP Spectral Density	10.2	dBW/4kHz
Slant Range	36907	km
Space Loss, Ls	206.8	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
Transponder G/T @ Terminal	7.0	dB/K
Thermal Noise, C/No	75.3	dBHz
C/(No+Io)	74.8	dBHz
Satellite		
Flux Density	-115.8	dBW/m2
SFD @ Terminal	-101.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	12.8	dB
Downlink		
Frequency	12.402	GHz
Transponder Sat. EIRP @ Beam Peak	55.0	dBW
Transponder Sat. EIRP @ Hub	55.0	dBW
DL PSD Limit	17.0	dBW/4kHz
DL PSD @ Beam Peak	5.2	dBW/4kHz
Carrier EIRP @ Beam Peak	42.2	dBW
Carrier EIRP @ Hub	42.2	dBW
Slant Range	37612	km
Space Loss, Ls	205.8	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	5.6	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	96.8	dBHz
C/(No+Io)	93.7370	dBHz
End to End		
End to End C/(No+Io)	74.7	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	0.2	dB
Link Margin	0.5	dB

Forward Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	9.9	deg
Lon	77.9	deg
EIRP max	44.0	dBW
G/T	11.5	dB/K
Satellite		
Name	SES-9	
Longitude	108.3	deg
Hub Earth Station		
Site	New Delhi	
Lat	28.637	deg
Lon	77.2	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2X	
Modulation	16APSK	
Bits per symbol	4	
Spread Factor	1	
Coding Rate	0.53	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	1.92	bps/Hz
Data Rate	9.87E+07	bps
Information Rate (Data + Overhead)	1.10E+08	bps
Symbol Rate	5.14E+07	Hz
Chip Rate (Noise Bandwidth)	5.14E+07	Hz
Occupied Bandwidth	5.40E+07	Hz
Power Equivalent Bandwidth	5.40E+07	Hz
C/N Threshold	6.4	dB
Uplink		
Frequency	14.210	GHz
Back off	16.6	dB
EIRP Spectral Density	22.3	dBW/4kHz
Slant Range	37612	km
Space Loss, Ls	207.0	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	4.4	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	9.5	dB/K
Thermal Noise, C/No	90.1	dBHz
C/(No+Io)	89.6	dBHz
Satellite		
Flux Density	-103.5	dBW/m2
SFD @ Hub	-103.5	dBW/m2
Small Signal Gain (IBO/OBO)	0.0	dB
OBO	0.0	dB
Downlink		
Frequency	12.462	GHz
Transponder Sat. EIRP @ Beam Peak	56.0	dBW
Transponder Sat. EIRP @ Terminal	55.0	dBW
DL PSD Limit	17.0	dBW/4kHz
DL PSD @ Beam Peak	14.9	dBW/4kHz
Carrier EIRP @ Beam Peak	56.0	dBW
Carrier EIRP @ Terminal	55.0	dBW
Slant Range	36907	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	88.8	dBHz
C/(No+Io)	86.9	dBHz
End to End		
End to End C/(No+Io)	85.0	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	6.4	dB
Link Margin	0.0	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	9.9	deg
Lon	77.9	deg
EIRP max	44.0	dBW
G/T	11.5	dB/K
Satellite		
Name	SES-9	
Longitude	108.3	deg
Hub Earth Station		
Site	New Delhi	
Lat	28.637	deg
Lon	77.2	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	MxDMA	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	2	
Coding Rate	0.40	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	0.36	bps/Hz
Data Rate	7.20E+06	bps
Information Rate (Data + Overhead)	8.00E+06	bps
Symbol Rate	1.00E+07	Hz
Chip Rate (Noise Bandwidth)	2.00E+07	Hz
Occupied Bandwidth	2.10E+07	Hz
Power Equivalent Bandwidth	3.40E+06	Hz
C/N Threshold	-3.1	dB
Uplink		
Frequency	14.150	GHz
Back off	0.0	dB
EIRP Spectral Density	7.0	dBW/4kHz
Slant Range	36907	km
Space Loss, Ls	206.8	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
Transponder G/T @ Terminal	7.0	dB/K
Thermal Noise, C/No	72.1	dBHz
C/(No+Io)	71.6	dBHz
Satellite		
Flux Density	-119.0	dBW/m2
SFD @ Terminal	-101.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	16.0	dB
Downlink		
Frequency	12.402	GHz
Transponder Sat. EIRP @ Beam Peak	55.0	dBW
Transponder Sat. EIRP @ Hub	55.0	dBW
DL PSD Limit	17.0	dBW/4kHz
DL PSD @ Beam Peak	2.0	dBW/4kHz
Carrier EIRP @ Beam Peak	39.0	dBW
Carrier EIRP @ Hub	39.0	dBW
Slant Range	37612	km
Space Loss, Ls	205.8	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	5.6	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	93.7	dBHz
C/(No+Io)	90.5657	dBHz
End to End		
End to End C/(No+Io)	71.6	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	-3.0	dB
Link Margin	0.1	dB

IV. SES-10

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

1. *Spacecraft Hardware design.* SES has assessed and limited the amount of debris that will be released in a planned manner during normal operations of SES-10. 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.

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 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-10 spacecraft is such that the risk of explosion is minimized both during and after mission operations. In designing and building the spacecraft, the manufacturer took steps to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. Burst tests are performed on all pressure vessels during qualification testing to demonstrate a margin of safety against burst. Bipropellant mixing is prevented by the use of valves that prevent backwards flow in propellant and pressurization lines. All pressures, including those of the batteries, will be monitored by telemetry. At the end of operational life, after the satellite has reached its final disposal orbit, all on-board sources of stored energy will be depleted or secured, excess propellant remaining in the chemical propulsion tanks will be vented, excess pressurant remaining in the helium tanks will be vented, and the batteries will be discharged.

Safe Flight Profiles. SES has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Specifically, SES has assessed the possibility of collision with satellites located at, or reasonably expected to be located at, 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-10 will be positioned at 67° W.L. In considering current and planned satellites that may have a station-keeping volume that overlaps the SES-10 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 67° 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-10 satellite, have been taken into account in the analysis.

Based on these reviews, the satellites operating nominally at 67° W.L. are AMC-3 and AMC-4, which are also controlled and operated by SES. There are no pending applications before the Commission requesting authorization to use an orbital location within ±0.15° of 67° W.L., and within this sub-arc, there are no ITU networks other than those at 67° W.L., all of which were submitted on behalf of SES. Based on the preceding, it is concluded that physical coordination of the SES-10 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-10 will be temporarily co-located with AMC-3 and AMC-4 as traffic is transferred to SES-10. After traffic transfer is complete, the AMC-3 and AMC-4 satellites will be relocated to another orbital location such that there will be no station-keeping volume overlap with SES-10.[3] During the period of collocation, 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

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

(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.

3. *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-10 to a disposal orbit with a minimum perigee of 260 km above the normal GSO operational orbit. This proposed disposal orbit altitude results from application of the IADC formula based on the following calculation:

   Total Solar Pressure Area "A" = 61.2 m^2

   "M" = Dry Mass of Satellite = 2440 kg

   "CR" = Solar Pressure Radiation Coefficient = 1.00

   Therefore the Minimum Disposal Orbit Perigee Altitude:

   = 36,021 km + 1000 x CR x A / m

   = 36,021 km + 1000 x 1.00 x 61.2 / 2440

   = 36,046 km

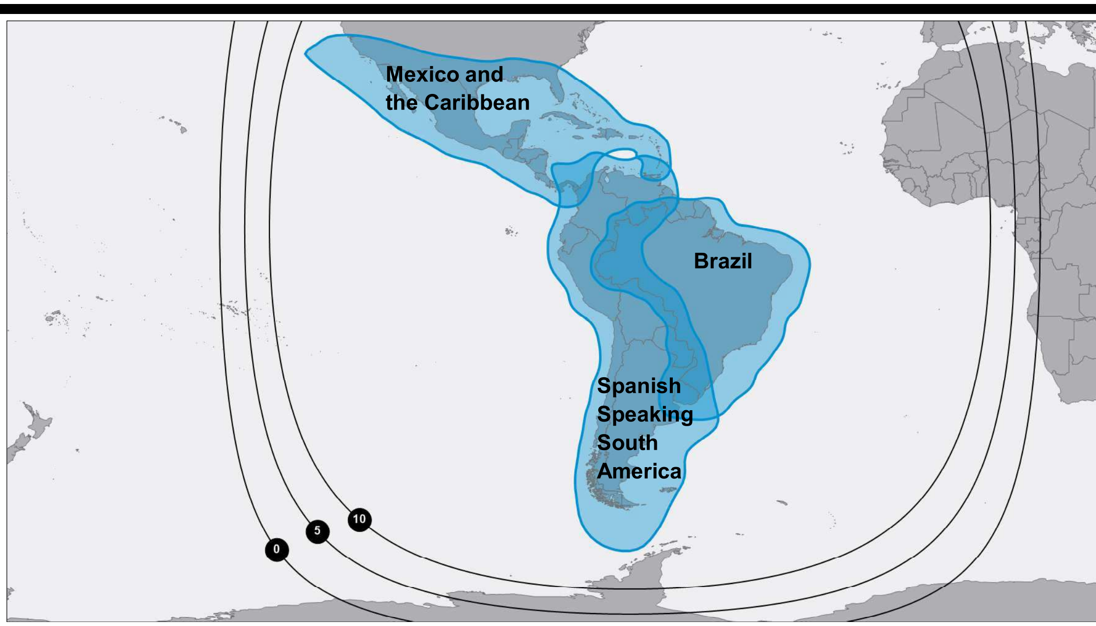
   = 260 km above GSO (35,786 km)

SES intends to reserve 30 kg of propellant in order to account for post-mission disposal of SES-10. SES has assessed fuel-gauging uncertainty and has provided an adequate margin of fuel reserve to address the assessed uncertainty.

IV.2. SES-10 Coverage Map

SES

Aggregate Ku-Band Service Area Coverage (FSS)



IV.3. SES-10 Link Budgets

Forward Link Budget

eXConnect Terminal		
Antenna Type	DPA	
Lat	17.9	deg
Lon	-99.3	deg
EIRP max	47.0	dBW
G/T	11.0	dB/K
Satellite		
Name	SES10	
Longitude	-67.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2X	
Modulation	16APSK	
Bits per symbol	4	
Spread Factor	1	
Coding Rate	0.56	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	2.00	bps/Hz
Data Rate	1.03E+08	bps
Information Rate (Data + Overhead)	1.14E+08	bps
Symbol Rate	5.14E+07	Hz
Chip Rate (Noise Bandwidth)	5.14E+07	Hz
Occupied Bandwidth	5.40E+07	Hz
Power Equivalent Bandwidth	5.40E+07	Hz
C/N Threshold	6.6	dB
Uplink		
Frequency	14.300	GHz
Back off	3.1	dB
EIRP Spectral Density	35.9	dBW/4kHz
Slant Range	36071	km
Space Loss, Ls	206.7	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	1.8	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	2.0	dB/K
Thermal Noise, C/No	99.0	dBHz
C/(No+Io)	98.5	dBHz
Satellite		
Flux Density	-87.0	dBW/m2
SFD @ Hub	-84.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	1.0	dB
Downlink		
Frequency	12.000	GHz
Transponder Sat. EIRP @ Beam Peak	53.3	dBW
Transponder Sat. EIRP @ Terminal	53.0	dBW
DL PSD Limit	14.0	dBW/4kHz
DL PSD @ Beam Peak	11.2	dBW/4kHz
Carrier EIRP @ Beam Peak	52.3	dBW
Carrier EIRP @ Terminal	52.0	dBW
Slant Range	37232	km
Space Loss, Ls	205.5	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	85.5	dBHz
C/(No+Io)	85.5	dBHz
End to End		
End to End C/(No+Io)	85.3	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	6.7	dB
Link Margin	0.0	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	DPA	
Lat	17.9	deg
Lon	-99.3	deg
EIRP max	47.0	dBW
G/T	11.0	dB/K
Satellite		
Name	SES10	
Longitude	-67.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	MxDMA	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	2	
Coding Rate	0.50	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	0.45	bps/Hz
Data Rate	9.00E+06	bps
Information Rate (Data + Overhead)	1.00E+07	bps
Symbol Rate	1.00E+07	Hz
Chip Rate (Noise Bandwidth)	2.00E+07	Hz
Occupied Bandwidth	2.10E+07	Hz
Power Equivalent Bandwidth	3.32E+06	Hz
C/N Threshold	-1.7	dB
Uplink		
Frequency	14.140	GHz
Back off	0.0	dB
EIRP Spectral Density	10.0	dBW/4kHz
Slant Range	37232	km
Space Loss, Ls	206.9	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
Transponder G/T @ Terminal	6.0	dB/K
Thermal Noise, C/No	74.0	dBHz
C/(No+Io)	73.5	dBHz
Satellite		
Flux Density	-116.1	dBW/m2
SFD @ Terminal	-98.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	16.1	dB
Downlink		
Frequency	11.840	GHz
Transponder Sat. EIRP @ Beam Peak	49.0	dBW
Transponder Sat. EIRP @ Hub	49.0	dBW
DL PSD Limit	14.0	dBW/4kHz
DL PSD @ Beam Peak	-4.1	dBW/4kHz
Carrier EIRP @ Beam Peak	32.9	dBW
Carrier EIRP @ Hub	32.9	dBW
Slant Range	36071	km
Space Loss, Ls	205.1	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	2.1	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	91.8	dBHz
C/(No+Io)	85.0529	dBHz
End to End		
End to End C/(No+Io)	73.2	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	-1.3	dB
Link Margin	0.5	dB

Forward Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	17.9	deg
Lon	-99.3	deg
EIRP max	44.0	dBW
G/T	11.5	dB/K
Satellite		
Name	SES10	
Longitude	-67.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2X	
Modulation	16APSK	
Bits per symbol	4	
Spread Factor	1	
Coding Rate	0.56	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	2.00	bps/Hz
Data Rate	1.03E+08	bps
Information Rate (Data + Overhead)	1.14E+08	bps
Symbol Rate	5.14E+07	Hz
Chip Rate (Noise Bandwidth)	5.14E+07	Hz
Occupied Bandwidth	5.40E+07	Hz
Power Equivalent Bandwidth	5.40E+07	Hz
C/N Threshold	6.6	dB
Uplink		
Frequency	14.300	GHz
Back off	3.1	dB
EIRP Spectral Density	35.9	dBW/4kHz
Slant Range	36071	km
Space Loss, Ls	206.7	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	1.8	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	2.0	dB/K
Thermal Noise, C/No	99.0	dBHz
C/(No+Io)	98.5	dBHz
Satellite		
Flux Density	-87.0	dBW/m2
SFD @ Hub	-84.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	1.0	dB
Downlink		
Frequency	12.000	GHz
Transponder Sat. EIRP @ Beam Peak	53.3	dBW
Transponder Sat. EIRP @ Terminal	53.0	dBW
DL PSD Limit	14.0	dBW/4kHz
DL PSD @ Beam Peak	11.2	dBW/4kHz
Carrier EIRP @ Beam Peak	52.3	dBW
Carrier EIRP @ Terminal	52.0	dBW
Slant Range	37232	km
Space Loss, Ls	205.5	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	86.0	dBHz
C/(No+Io)	86.0	dBHz
End to End		
End to End C/(No+Io)	85.7	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	7.1	dB
Link Margin	0.5	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	17.9	deg
Lon	-99.3	deg
EIRP max	44.0	dBW
G/T	11.5	dB/K
Satellite		
Name	SES10	
Longitude	-67.0	deg
Hub Earth Station		
Site	Peru	
Lat	-12.092	deg
Lon	-77.027	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	MxDMA	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	3	
Coding Rate	0.40	
Overhead Rate	0.90	
Channel Spacing	1.05	
Spectral Efficiency (Rate/Noise BW)	0.24	bps/Hz
Data Rate	4.80E+06	bps
Information Rate (Data + Overhead)	5.33E+06	bps
Symbol Rate	6.67E+06	Hz
Chip Rate (Noise Bandwidth)	2.00E+07	Hz
Occupied Bandwidth	2.10E+07	Hz
Power Equivalent Bandwidth	1.67E+06	Hz
C/N Threshold	-4.9	dB
Uplink		
Frequency	14.140	GHz
Back off	0.0	dB
EIRP Spectral Density	7.0	dBW/4kHz
Slant Range	37232	km
Space Loss, Ls	206.9	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.5	dB
Transponder G/T @ Terminal	6.0	dB/K
Thermal Noise, C/No	71.1	dBHz
C/(No+Io)	70.6	dBHz
Satellite		
Flux Density	-119.1	dBW/m2
SFD @ Terminal	-98.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	19.1	dB
Downlink		
Frequency	11.840	GHz
Transponder Sat. EIRP @ Beam Peak	49.0	dBW
Transponder Sat. EIRP @ Hub	49.0	dBW
DL PSD Limit	14.0	dBW/4kHz
DL PSD @ Beam Peak	-7.1	dBW/4kHz
Carrier EIRP @ Beam Peak	29.9	dBW
Carrier EIRP @ Hub	29.9	dBW
Slant Range	36071	km
Space Loss, Ls	205.1	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	2.1	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	88.9	dBHz
C/(No+Io)	82.0740	dBHz
End to End		
End to End C/(No+Io)	70.3	dBHz
Implementation Loss	1.5	dB
End to End C/N w/ Imp Loss	-4.3	dB
Link Margin	0.6	dB