SPACELINK NON-GEOSTATIONARY SATELLITE SYSTEM (S2982)
MODIFICATION TO AUTHORIZED SYSTEM

TECHNICAL ATTACHMENT
Technical Information to Supplement Schedule S

Contents

A.1 BACKGROUND, SCOPE AND PURPOSE

In June 2018, the Federal Communications Commission ("Commission" or "FCC") granted authorization to construct, deploy, and operate the SpaceLink Corporation's ("SpaceLink") non-geostationary orbit ("NGSO") satellite system ("SpaceLink System") to provide continuous, high-speed communications between other NGSO satellites and gateway earth stations, using frequencies in the inter-satellite service ("ISS") and the fixed-satellite service ("FSS").[1]

The instant modification reflects the current architecture contemplated for the SpaceLink System, which is optimized to provide superior performance and reliability for the Low Earth Orbit ("LEO") community and takes advantage of new optical technologies for inter-satellite communications.[2] Details of the proposed modifications are given in this document ("Technical Attachment") and in the associated Schedule S. The changes resulting from this modification will not present interference problems to or from any other licensed system, as explained below in Section A.8.

The Technical Attachment contains the information required for the proposed modification request by §25.117(d), §25.114(d), §25.146 and other sections of the FCC's Part 25 rules that cannot be captured by the Schedule S software. A complete and updated Schedule S is also being submitted

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1 *See In the Matter of Audacy Corporation Application for Authority to Launch and Operate a Non-Geostationary Medium Earth Orbit Satellite System in the Fixed and Inter-Satellite Services,* Order and Authorization, Call Sign S2982, IBFS File No. SAT-LOA-20161115-00117 (rel. June 6, 2018) ("*Original Authorization*"). Call Sign S2982 was transferred to SpaceLink Corporation's ultimate parent, Electro Optic Systems Ltd. in March 2020. *See In the Matter of Electro Optics Systems Ltd., Transfer of Control*, Grant of Authority SAT-T/C-20200124-00013, DA No. 20-240 (rel. March 26, 2020).

2 The use of optical inter-satellite links in the SpaceLink system is discussed further in the legal narrative of this modification request and is not further addressed in this technical narrative.

with this application, which aggregates all the technical information for the SpaceLink system to date, including this modification.

A.2 SUMMARY OF THE PROPOSED MODIFICATIONS

The proposed modifications affect the following:

A.2.1 The orbital characteristics of the SpaceLink System and the number of operational satellites.

The originally authorized SpaceLink System employed three satellites in circular Medium Earth Orbit ("MEO") at an altitude of 13,892 km with an orbit inclination of 25°.[3] Each of the three satellites had its own orbital plane, and these orbit planes were evenly spaced around the Earth.[4] The proposed modification is to change the orbit inclination from 25° to 0°, and to increase the number of operational satellites from three to four, all evenly spaced in a single equatorial orbital plane. There is no change to the orbit altitude or eccentricity.[5] Table A.2-1 below compares the orbital configuration of the currently authorized SpaceLink System against the instant proposed modified system.

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3 *See Audacy Application*, Schedule S.

4 *See Id.*

5 *See Id*.

Table A.2-1. Comparison of currently authorized and proposed modified system

Parameter	Current Authorization	Proposed Modification
Total number of satellites	3	4
Orbital planes	3	1
Satellites per plane	1	4
Altitude	13,892 km	13,892 km
Inclination	25°	0°

A.2.2 Increase of satellite EIRP density in some portions of the ISS bands.

SpaceLink also proposes to increase the maximum Effective Isotropic Radiated Power ("EIRP"), and hence EIRP density, of its inter-satellite beams in the 22.55-23.18 and 23.38-23.55 GHz bands while remaining within the Commission's Power Flux-Density ("PFD") limits. Each of SpaceLink's relay satellites will generate no more than two of these beams at any time using the same steerable high-gain parabolic reflectors as its feeder links. Increasing the EIRP density enables SpaceLink to deliver data to LEO user satellites that have less sensitive receivers and who would otherwise be unable to access SpaceLink's network. An increase in the EIRP density of these beams necessarily results in an increase in PFD levels incident on the Earth's surface. However, the updated PFD levels remain within the Commission's PFD limits, as defined in §25.208(c), and as demonstrated by the maximum PFD values given in the associated Schedule S. Table A.2-2 compares the current and proposed ISS link transmissions from the SpaceLink satellites in the specified frequency ranges.

Table A.2-2: Comparison of current and proposed ISS links operating in the 22.55-23.18 and 23.38-23.55 GHz band.

Parameter	Units	Current Authorization	Proposed Modification
Tx frequency range	GHz	22.55-23.18, 23.38-23.55	22.55-23.18, 23.38-23.55
Peak satellite antenna gain	dBi	43.5	43.0
Max. transmit EIRP density	dBW/Hz	-32.9	-18.7

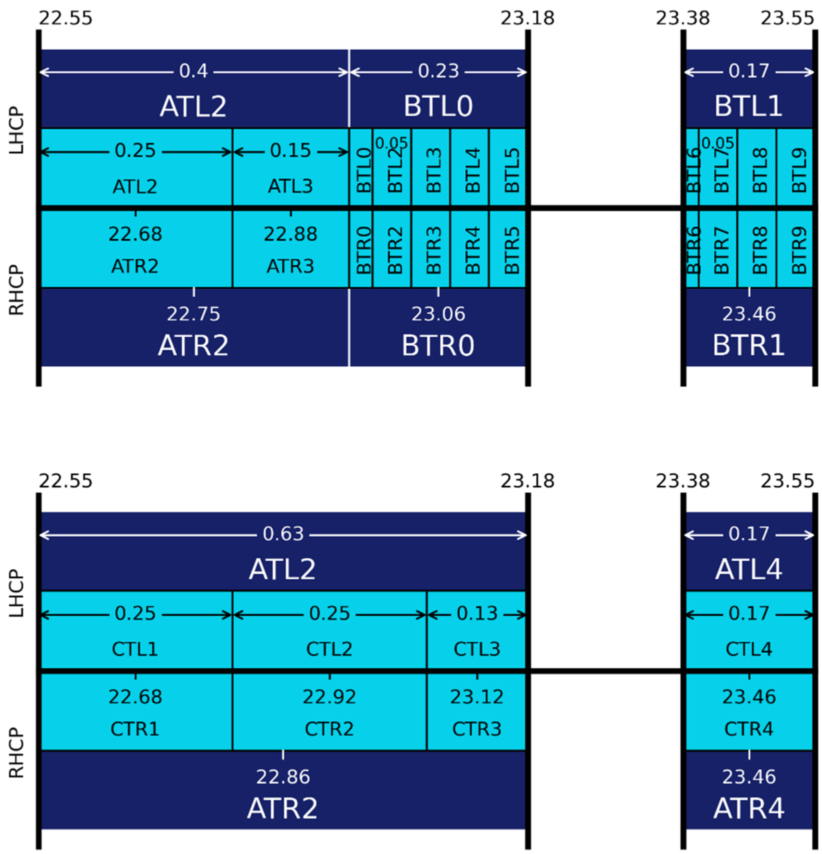
A.2.3 Addition of ISS frequency band.

SpaceLink requests receive-only use of the 25.25-27.5 GHz ISS band for reception by the SpaceLink System satellites of ISS transmissions from LEO user satellites. Use of this frequency band was not in the original application. All required technical details are provided in the associated Schedule S.

A.2.4 Changes to the channelization and beam arrangement of the ISS frequency bands to optimize the system performance.

SpaceLink proposes changes to its channel plan in the 22.55-23.18 GHz and 23.38-23.55 GHz ISS band, as far as transmissions from the SpaceLink satellites are concerned, as reflected in Figure A-1 below and in the associated Schedule S. This change has no impact on the frequencies used by the SpaceLink system and any related interference assessment, and results from differences between the original design of the SpaceLink satellites and their actual hardware implementation.

Figure A-1: Comparison of current (top) and proposed (bottom) ISS transmit beam channel plans in the 22.55-23.18 and 23.38-23.55 GHz band.
Beams are drawn in blue; channels in cyan.



A.2.5 Revised PFD levels.

The PFD levels reflected in the Schedule S associated with the original Audacy Application contained discrete inconsistencies identified during the preparation of the instant modification application. Although such inconsistencies did not impact the original architecture's compliance with all applicable PFD limits, they have been revised in the Schedule S associated with this application.

A.2.6 Reduction of downlink EIRP density levels and changes to the channelization for the V-band links

SpaceLink proposes to reduce the EIRP density of its V-band downlink beams (GTL1 and GTR1 in Schedule S) by 3 dB and standardize the channel plan to 9 × 500 MHz channels for both uplink and downlink. These changes are a result of the optimization of the service requirements and finalization of the hardware implementation of the SpaceLink spacecraft.

The reduction in satellite transmit EIRP density in the V-band downlink frequency band provides additional margin relative to the Commission's power flux-density limits. Updated PFD levels are provided in the associated Schedule S. Table A.2-3 shows the differences between the current and proposed downlink beam characteristics.

Table A.2-3: Comparison of current and proposed downlink beams.

Parameter	Units	Current Authorization	Proposed Modification
Beam ID	-	GTL1 / GTR1	GTL1 / GTR1
Tx frequency range	GHz	37.5 – 42.0	37.5 – 42.0
Peak satellite antenna gain	dBi	55.2	46.8
Max. transmit EIRP density	dBW/Hz	-30.9	-33.9
Max. transmit EIRP	dBW	65.6	62.6

Figures A-2 and A-3 compare the current and proposed downlink and uplink channel plans, respectively.

Figure A-2: Comparison of current (top) and proposed (bottom) channel plans for the V-Band downlink.
Beams are drawn in blue; channels in cyan.

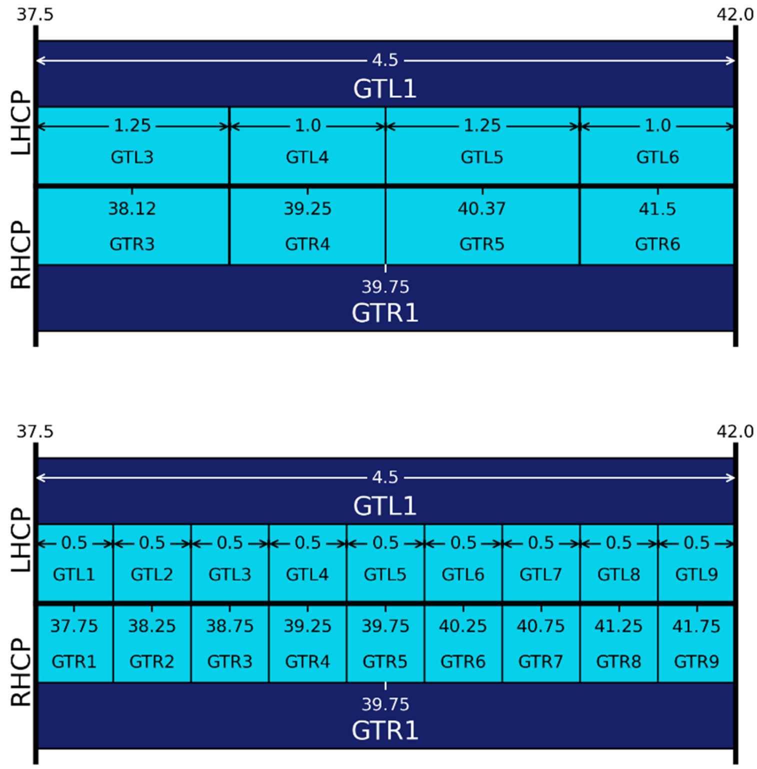
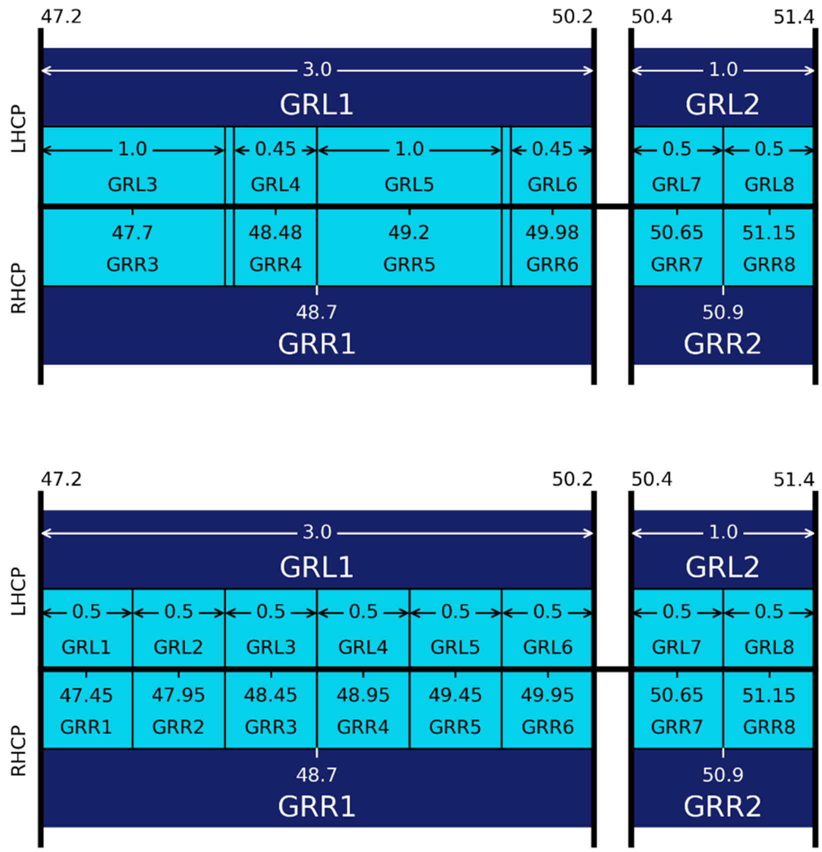


**Figure A-3: Comparison of current (top) and proposed (bottom) channel plans for the V-Band uplink.
Beams are drawn in blue; channels in cyan.**



A.2.7 Reduction in the potential Ka bandwidth used for off-nominal TT&C operations

In the Original Authorization, 500 MHz of Ka-band spectrum was potentially available for off-nominal Telemetry, Tracking, and Command ("TT&C"): 29.5-30.0 GHz for uplink and 19.7-20.2 GHz for downlink.[6] As a result of progress in the hardware implementation of the relay spacecraft,

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[6] Nominal TT&C operations will occur within the same V-band FSS feeder beams and channels as all other space-ground communications.

SpaceLink proposes to significantly reduce the bandwidth for off-nominal TT&C to only two 10 MHz bands, one at either end of the original frequency ranges, consistent with §25.202(g). These updated beams are defined in the associated Schedule S. These off-nominal TT&C beams will be used when the V-band uplink/downlink feeder beams are not usable, such as if a spacecraft should lose its correct orientation and during initial deployment from the launch vehicle. The use of these bands therefore represents a de minimis risk of interference to other uses of the Ka-band spectrum. The final selection of precise carrier frequencies within these 10 MHz bands will be made in coordination with other satellite operators.

Figures A-4 and A-5 compare the current and proposed off-nominal telemetry and command beam and channel plans, respectively.

Figure A-4: Comparison of current (top) and proposed (bottom) off-nominal telemetry channel plans.
Beams are drawn in blue; channels in cyan.

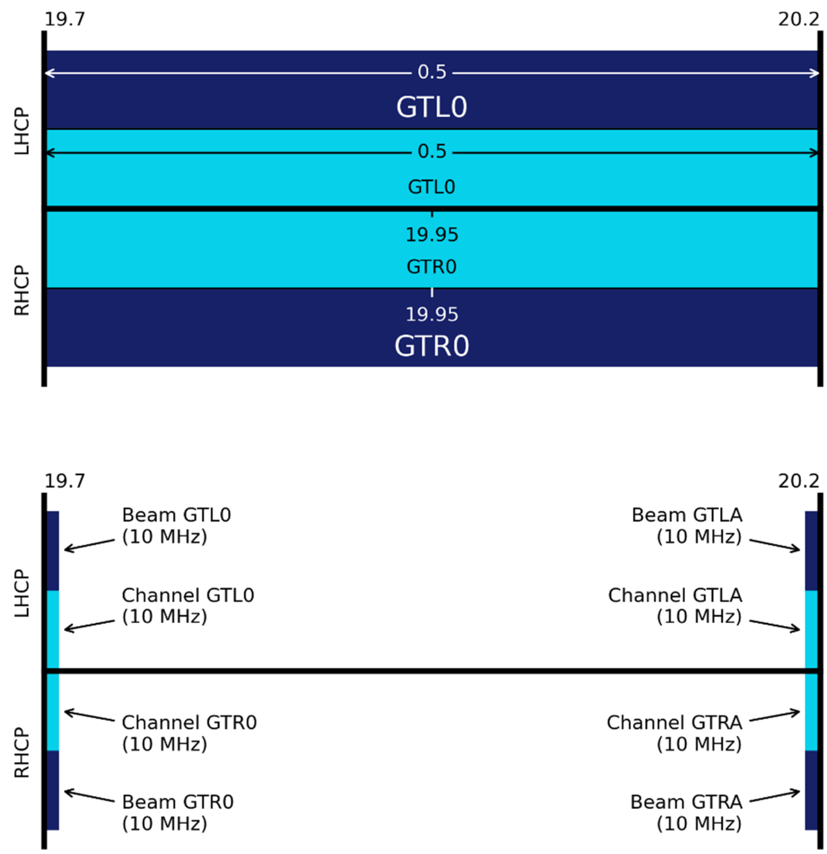
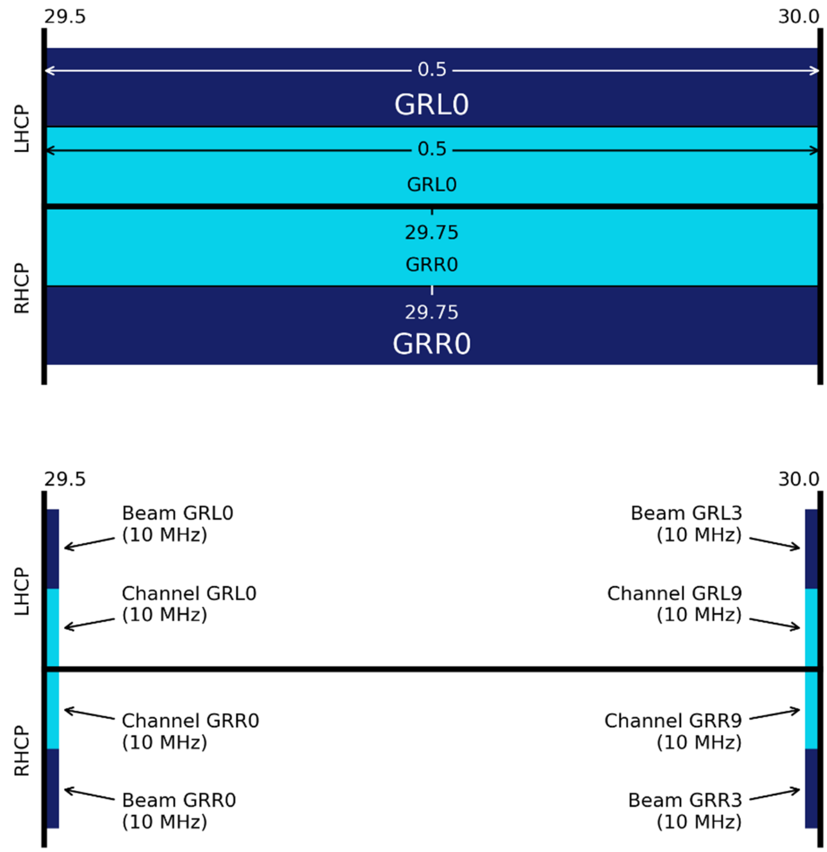


Figure A-5: Comparison of current (top) and proposed (bottom) off-nominal command channel plans.
Beams are drawn in blue; channels in cyan.



A.3 OVERALL DESCRIPTION OF SYSTEM FACILITIES, OPERATIONS AND SERVICES AND EXPLANATION OF HOW UPLINK FREQUENCY BANDS ARE CONNECTED TO DOWNLINK FREQUENCY BANDS (§25.114(d)(1))

Beyond the express changes described in Section A.2 above, the instant modification does not affect any information required by §25.114(d)(1) previously submitted to the Commission. The SpaceLink System will provide inter-satellite relay services as originally proposed and will operate under the US-filed USASAT-NGSO-2 and USASAT-NGSO-2A ITU systems.

The modified orbit inclination of 0° necessitates a different GSO protection strategy. Specifically, all SpaceLink gateway earth stations will now be located above a certain minimum latitude (19°) and will not transmit or receive below 15° elevation. These strategies provide a separation angle of at least 3.8° at all times between SpaceLink's satellites and both the geostationary and O3b orbits.[7] In fact, SpaceLink's V-band gateway earth stations will be located only between latitudes of 19° and 40° and will have a main reflector diameter of at least 9 meters.

The proposed changes to the orbital parameters and number of SpaceLink satellites permit more cost-effective launch strategies and more flexible satellite sparing scenarios, while improving the quality of service to user satellites.

A.4 PREDICTED SPACE STATION ANTENNA GAIN CONTOURS (§25.114(c)(4)(vi)(B))

There is no change to the predicted space station antenna gain contours from that previously submitted to the Commission.[8] The associated Schedule S carries forward this data from the previous submission for frequencies involved in the instant modification application.

A.5 TT&C AND PAYLOAD CONTROL CHARACTERISTICS (§25.202(g))

There is no change to the TT&C and payload control characteristics from that previously submitted to the Commission.[9]

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7 *See infra* Section A.8.1. The authorized SpaceLink System uses a 25° inclined orbit, which reduces potential in-line interference event geometries with respect to co-frequency GSO satellite networks for the gateway locations being considered at that time.

8 *See Audacy Application*, Schedule S.

9 *See Audacy Application,* Narrative Exhibit at 1, 2 and 22 (describing TT&C operations and frequencies).

A.6 CESSATION OF EMISSIONS (§25.207)

There is no change concerning cessation of emissions from that previously submitted to the Commission.[10]

A.7 COMPLIANCE WITH PFD LIMITS (§25.146(a)(1))

The proposed modification reduces the maximum satellite downlink EIRP density levels in the 37.5-42 GHz band and maintains the same orbit altitude, thus the previously provided demonstrations of compliance with the FCC and ITU PFD limits are still applicable.[11] The maximum satellite EIRP density in the 22.55-23.18 and 23.38-23.55 GHz ISS bands has been increased but the resulting PFD levels remain within the Commission's clear-sky PFD limits, as shown in the associated Schedule S.

In the Audacy Application, a waiver was requested for a small (approximately 2 dB) exceedance of the PFD limit of §25.208(r)(1) in the 37.5-40.0 GHz band at elevation angles in the 5° to 10° range, but this waiver was denied by the Commission.[12] In the proposed modified SpaceLink System, compliance with the §25.208(r)(1) PFD limit in the 37.5-40.0 GHz band is ensured because the satellite beam in question will not be pointed toward any Earth location where the elevation to the SpaceLink satellite is less than 15°. Previously, this minimum elevation angle was

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10 *See Id.,* at 16 and 36 (memorializing the capabilities of the network operations center to mute transmissions from both SpaceLink relay spacecraft and gateway ground stations).

11 *See Id.,* at 8-11 (providing PFD limits for SpaceLink NGSO system); *see also, Original Authorization* at 21 (clarifying that SpaceLink must comply with PFD limits established in Sections 25.114(c)(8) and 25.208(r) of the Commission's rules concerning the 37.5-40.0 GHz band).

12 *See Original Authorization,* Ordering Clause 56 (clarifying that SpaceLink must comply with PFD limits established in Sections 25.114(c)(8) and 25.208(r) of the Commission's rules concerning the 37.5-40.0 GHz band).

5°. The steep roll-off of the satellite beam, when operating at a 15° elevation point on the Earth, provides greater than 15 dB of attenuation towards the 10° elevation contour, which more than compensates for the original small PFD exceedance. Therefore, SpaceLink is no longer seeking a waiver of §25.208(r)(1).

A.8 INTERFERENCE ANALYSES

SpaceLink has adopted two important modifications to the operation of its system:

1) **Increased minimum elevation angle (MEA) for the gateway earth stations**. The MEA for the gateway earth stations in the system approved in the Original Authorization was 5°. SpaceLink will use a higher MEA value of 15°.

2) **New minimum latitude for SpaceLink gateway earth stations**. The minimum latitude for any corresponding V-band gateway earth station in the SpaceLink System is now 19°. Previously there was no such minimum latitude.

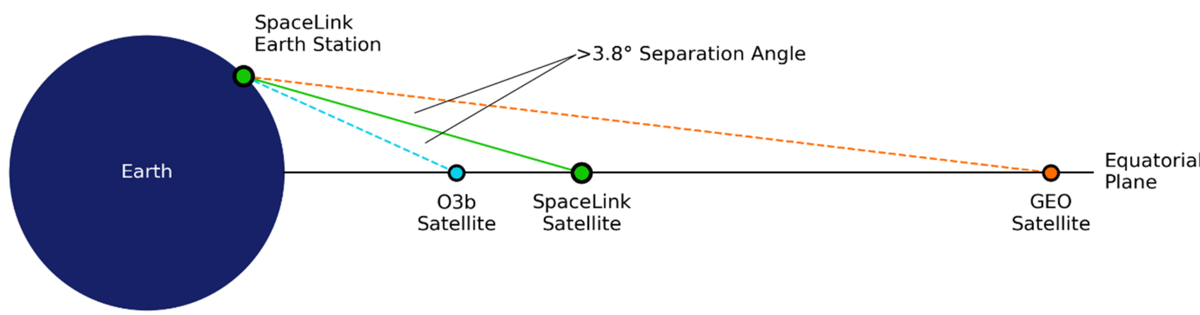
The two above factors contribute to the enhanced ability of the modified SpaceLink System to share spectrum with both GSO and NGSO satellite systems.

The following sub-sections relate to each of the frequency sharing scenarios that exist between the SpaceLink System and other co-frequency users of the spectrum.

A.8.1 Interference Protection for GSO Satellite Networks (§25.146)

The SpaceLink System shares Ka-Band and V-band FSS spectrum with GSO satellite networks. With all the SpaceLink satellites in equatorial orbits (*i.e.*, 0° orbit inclination) the approach to protecting GSO satellite networks in these bands from unacceptable interference from the SpaceLink space-to-Earth and Earth-to-space links will be different from the Original Authorization. By now locating the corresponding SpaceLink earth stations at a certain minimum latitude, the inherent angular separation from any GSO link will provide the required interference isolation. This is shown qualitatively in Figure A.8-1 below.

Figure A.8-1: Inherent angular separation geometry of the SpaceLink orbit relative to the GSO orbit



The minimum operational latitude of the SpaceLink earth stations (19°) will ensure the required interference protection for GSO networks by this mechanism as it results in the minimum angular separation from the geostationary orbit being greater than 3.8°. SpaceLink hereby certifies, consistent with the requirements of §25.146(a)(2), that it will comply with the applicable equivalent power flux-density levels, and other required protection criteria, in Article 22, Section II, and Resolution 76 of the ITU Radio Regulations (both incorporated by reference, §25.108), thereby providing the necessary interference protection to GSO networks. This includes compliance with RR 22.5L and 22.5M which relate to GSO protection in V band.

A.8.2 Interference with Respect to Other NGSO Satellite Systems

SpaceLink will ensure that the proposed modification to the SpaceLink System will not cause any additional interference to, or require additional interference protection from, any other non-GSO satellite system in the shared V-band frequencies (uplink and downlink).

Several key features of the proposed modification support the fact that there is no increase in interference:

- The altitude of the proposed SpaceLink System satellites has not been altered from the value of 13,892 km for the existing authorization.

- There are no geographic locations on the Earth that have additional visibility of SpaceLink satellites resulting from the change in SpaceLink's orbit inclination from 25° to 0°.

- The maximum EIRP density from the proposed SpaceLink satellites, and hence the maximum PFD at the Earth's surface, in both Ka and V FSS bands, has not been increased from the values in the existing authorization, and in V band has actually been reduced by 3 dB.[13]

Representative analyses of the I/N (Interference-to-Noise ratio) statistics for some representative victim NGSO systems have been performed which further confirm that there is no perceptible increase in interference to other NGSO FSS systems. SpaceLink has analyzed four example NGSO systems with a wide range of orbital configurations and numbers of satellites:

- The very large SpaceX constellation consisting of 7,518 satellites at altitudes of between 335.9 km and 345.6 km, and with orbit inclinations ranging from 42° to 53°, as described in the SpaceX V-band NGSO application to the FCC (so-called "VLEO" component). That application also referred to an additional 4,425 satellites in LEO orbits (1,110 to 1,325 km altitude), which was the SpaceX NGSO system being proposed for Ku and Ka band at the time the V-band application was made. However, SpaceX has subsequently modified its legacy LEO system to much lower orbits, and it seems unlikely that it would use the old legacy orbit altitudes for V-band. It is therefore not clear at present what configuration the SpaceX V-band NGSO system will use, but the VLEO component alone makes for a representative very large NGSO system for purpose of the interference analysis. If SpaceX were to modify its V-band system and add additional satellites at orbit altitudes below 1,110 km in the future, it is unlikely to materially change the interference results reported here.

- The relatively small proposed V-band O3b MEO constellation (so-called "O3bN" orbits) consisting of 12 satellites in an equatorial (0° inclination) orbital plane with an altitude of 8,062 km.

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13 Neither has the maximum EIRP density of the corresponding earth stations been increased, although this parameter is addressed by the Commission only for the earth station licensing applications.

- The mid-sized proposed V-band Telesat NGSO system consisting of a total of 117 satellites in two types of orbits. The first orbit is at an altitude of 1,000 km with an inclination of 99.5°, with 72 satellites in six orbital planes. The second orbit is at an altitude of 1,248 km with an inclination of 37.4°, with 45 satellites in five orbital planes.

- The Viasat V-band MEO constellation (so-called "VIASAT-NGSO"), as modified in its September 2018 Amendment and granted by the Commission in April 2020, consisting of a total of 20 satellites spread across four 87° inclined and evenly spaced planes with an altitude of 8,200 km. We note that Viasat has a subsequent modification pending before the Commission for 288 satellites in eight orbital planes at 1,300 km and 45° inclination. However, this modification has not been acted on by the Commission and is similar to a portion of the Telesat constellation, which has been analyzed. We therefore chose not to analyze the pending Viasat modification as the results would be very similar to the Telesat results.

The starting point for the interference analyses is the determination of the reference interference levels that would exist prior to the SpaceLink modification. This takes the form of a cumulative distribution function (CDF) of the interference levels, expressed as an interference-to-noise (I/N) ratio, for varying percentages of time. The CDF of the I/N is derived from a time-domain simulation of the two NGSO systems over sufficient time, and with sufficiently small timesteps, to give stable results. The corresponding interference levels after the modification are then calculated in the same way and compared to the reference situation before the modification.

The key FCC criterion relevant to a proposed modification of an NGSO system is that it should not present significant additional interference problems to other NGSO systems in the same processing round.[14] Therefore, the methodology used here is to first assess whether the interference

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14 *See In the Matter of Space Exploration Holdings, Inc.*, Order and Authorization and Order on Reconsideration, FCC 21-48, at ¶ 1 (rel. April 27, 2021) ("*SpaceX 2021 Recon Order*"), reaffirming the Commission's longstanding policy of acting favourably on NGSO modification applications that do "*not create significant interference problems"* (emphasis added).

levels in the resulting CDF of the I/N are any greater than those prior to the modification and, if they are, what the real-world impact of any increases would be.

The downlink interference is simulated from the transmitting SpaceLink satellites into the other NGSO systems' receiving earth stations, using the latitude of the victim earth station as a variable in the analysis. Analyses are performed for two latitude values, one corresponding to the minimum stated latitude for the SpaceLink gateway earth station (19°), and the other to the maximum stated latitude (40°).

Two example tracking strategies are analyzed for the victim earth station: one where it always tracks the highest-elevation satellite in its own system and the other where, for each timestep of the simulation, the victim earth station is randomly pointed towards any satellite within its system that is visible to it. These two scenarios bookend the range of operational tracking possibilities.

In the downlink interference analysis, all SpaceLink System satellites with elevation angles greater than 15° as viewed from the victim earth station are assumed to be simultaneously radiating their peak EIRP density towards the victim earth station, thereby representing the worst-case situation of collocated earth stations and satellite beam pointing directions. The aggregate interference from these SpaceLink satellites into this victim earth station is then computed over time as the simulation proceeds. The aggregate I/N values for each sample time are collected and the results are shown as a CDF of these I/N values, comparing the interference before the modification with that after the modification. The solid lines on the CDF are the results for the original SpaceLink System and the dotted lines are the same results after the proposed SpaceLink modification. The different colored lines represent the results into different types of victim earth stations which represent the range of earth station gain values for the other NGSO system.

The uplink interference is simulated from a single transmitting SpaceLink earth station into the other NGSO system's receiving satellites. The I/N is calculated for a continuous link emanating from the collocated victim earth station, regardless of which victim satellite that link is carried by, which depends on the tracking strategy. The same two potential tracking strategies are analyzed (highest elevation and random) as for the downlink analysis. The SpaceLink earth station is assumed to be transmitting only at an elevation angle greater than 15°. In the case of the uplink, the tracking strategy relates to the direction in which the earth station antennas are pointing at each timestep of the analysis. The satellites in the other NGSO system that are being used to carry the link are assumed to always be pointing their receive beam towards the interfering SpaceLink transmitting earth station, which is itself collocated with the victim earth station.

The interference levels on the victim link are then calculated over time as the simulation proceeds. The aggregate I/N values for each sample time are collected and the results are shown as a CDF of these I/N values, comparing the interference before the modification with that after the modification. Two earth station latitude cases are considered (19° and 40°) as for the downlink analysis. The solid lines on the CDF are the results for the original SpaceLink System and the dotted lines are the same results after the proposed SpaceLink modification. The different colored lines represent the results for the two sizes of SpaceLink earth station antenna - 9 meters and 13 meters.

Figures A.8-2 to A.8-5 below show the interference results for the first example victim satellite system, the SpaceX VLEO system, using the "highest elevation" tracking strategy.[15] The SpaceX system is assumed to be operating with a minimum GSO avoidance angle of 18°.[16]

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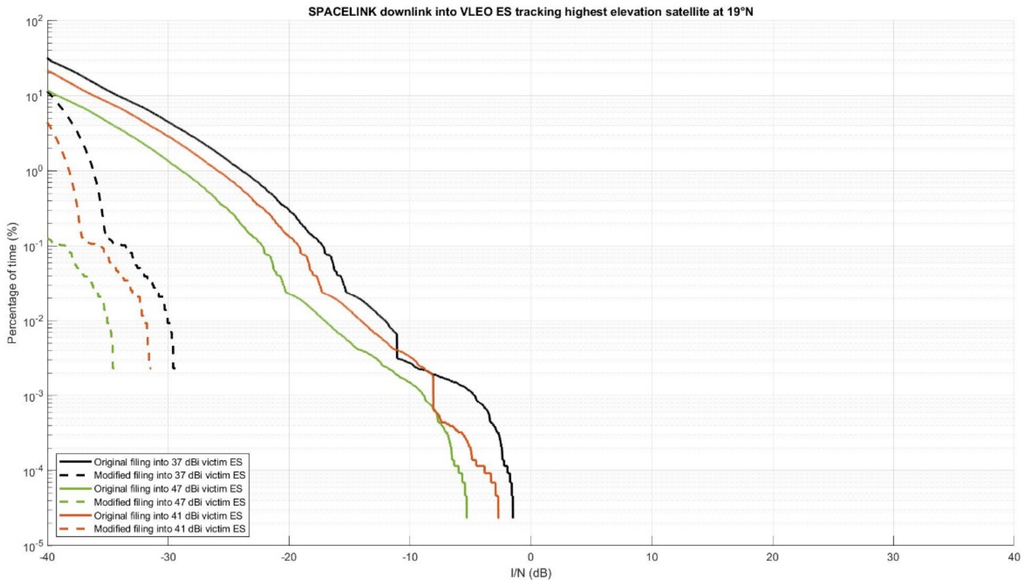
15 *See Application of Space Exploration Holdings, LLC for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, Application, IBFS File No. SAT-LOA-20170301-00027, at Technical Attachment 22-23 (filed Aug. 25, 2017) ("*SpaceX V-band Application*").

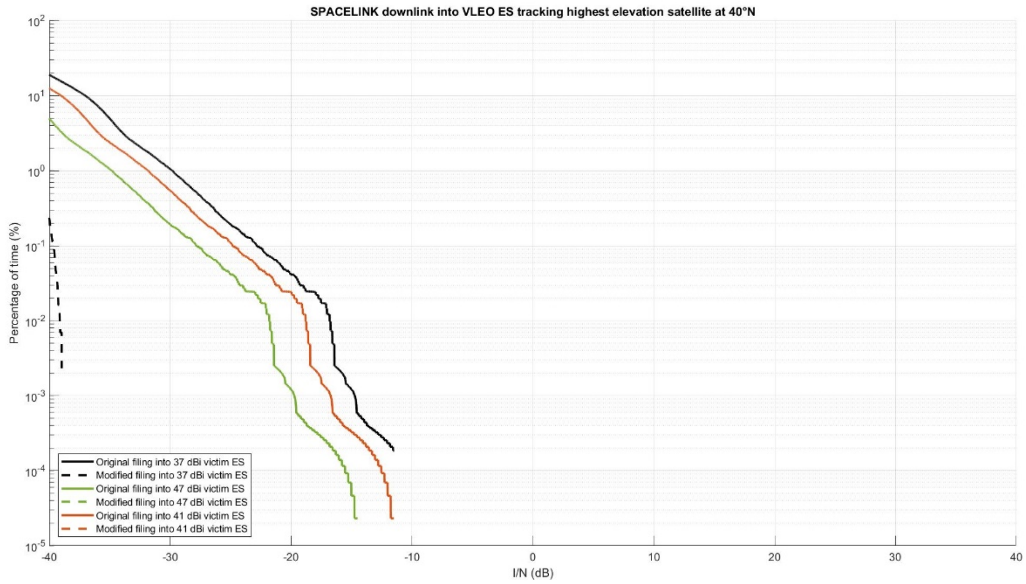
16 In the absence of a known GSO avoidance angle for the SpaceX V-band NGSO system, the value of 18° was taken as a representative value based on the known GSO avoidance angle of the SpaceX Ku/Ka-band NGSO system.

Figure A.8-2: I/N statistics for downlink interference into the SpaceX NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 19° latitude)



In all cases in Figure A.8-2 the interference after the modification is reduced compared to the original system. The absence of short-term inline or near-inline interference events after the modification is accounted for by the GSO avoidance strategy of the SpaceX system which simultaneously protects from inline events with the equatorial SpaceLink System.

**Figure A.8-3: I/N statistics for downlink interference into the SpaceX NGSO system
("Highest elevation" tracking strategy)
(Test earth stations located at 40° latitude)**



The results in Figure A.8-3 (40° latitude ES) are similar to those in Figure A.8-2 (19° latitude ES), but the levels are generally lower because of the assumed highest elevation tracking strategy which provides more interference isolation from SpaceLink's equatorial orbit at higher latitudes.

**Figure A.8-4: I/N statistics for uplink interference into the SpaceX NGSO system
("Highest elevation" tracking strategy)
(Test earth stations located at 19° latitude)**

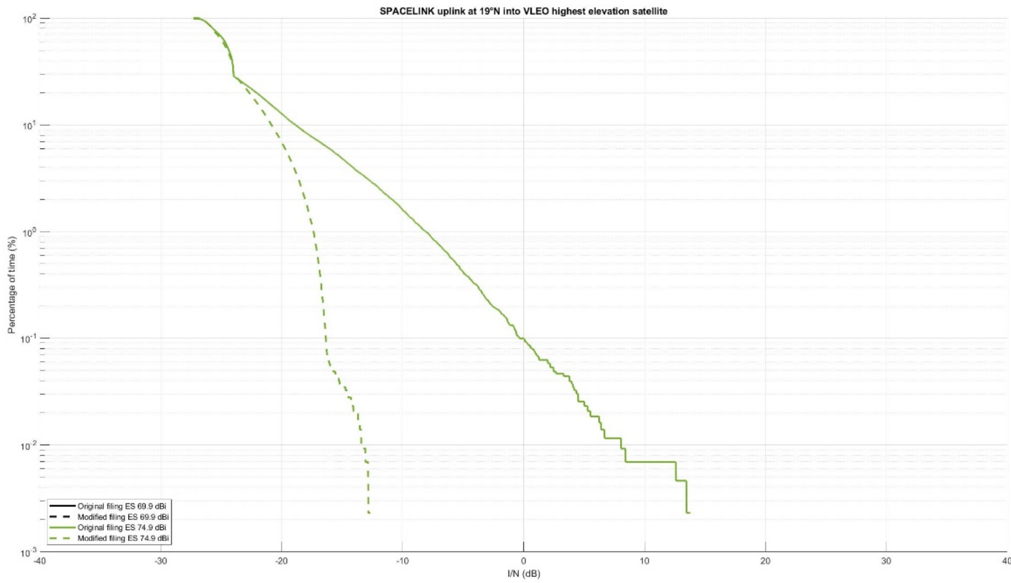
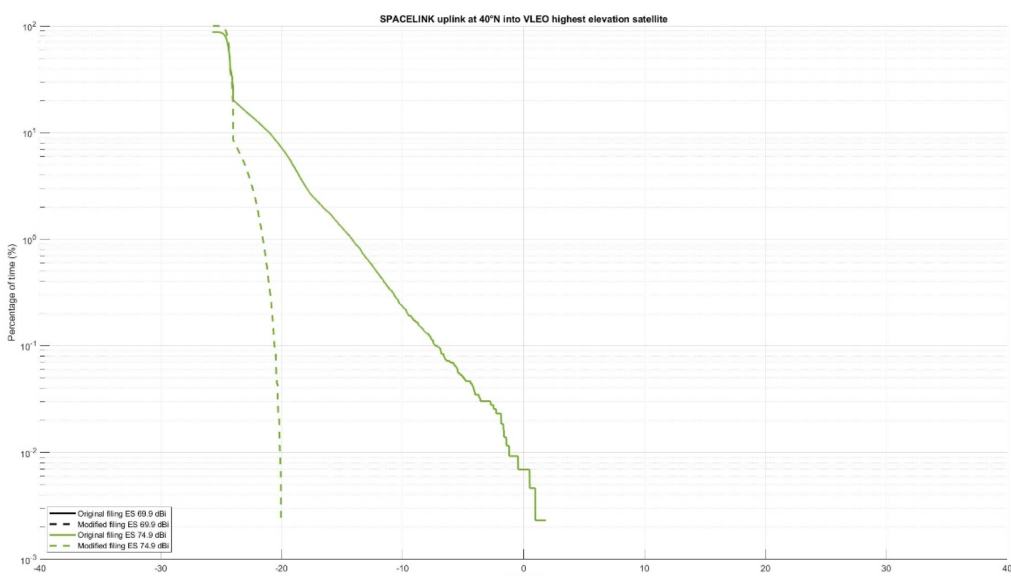


**Figure A.8-5: I/N statistics for uplink interference into the SpaceX NGSO system
("Highest elevation" tracking strategy)
(Test earth stations located at 40° latitude)**



Similar results are seen for the uplink interference in Figures A.8-4 and A.8-5, and for the same reasons as explained above for the downlink. The only very minor exception where the interference after the modification is higher than that of the original system occurs in Figure A.8-5 at the very long-term end of the curves corresponding to I/N levels below -24 dB. This represents a C/(N+I) degradation no greater than 0.017 dB, which is insignificant.

Note that the results in Figures A.8-4 and A.8-5 above seemingly show only one set of curves, despite the analysis being for two earth station sizes. This is because the only interference that occurs is related to the far-out sidelobes of the earth stations which are the same for both sizes of earth station antenna. Therefore, the results for all earth station sizes are identical and overlaid so only one set is visible in the diagram. This effect occurs in several of the interference results shown in this section below.

The next set of results below (Figures A.8-6 to A.8-9) are also for the SpaceX system but using the random satellite tracking strategy for the analysis. All other assumptions are identical to the earlier analyses.

Figure A.8-6: I/N statistics for downlink interference into the SpaceX NGSO system ("Random" tracking strategy) (Test earth stations located at 19° latitude)

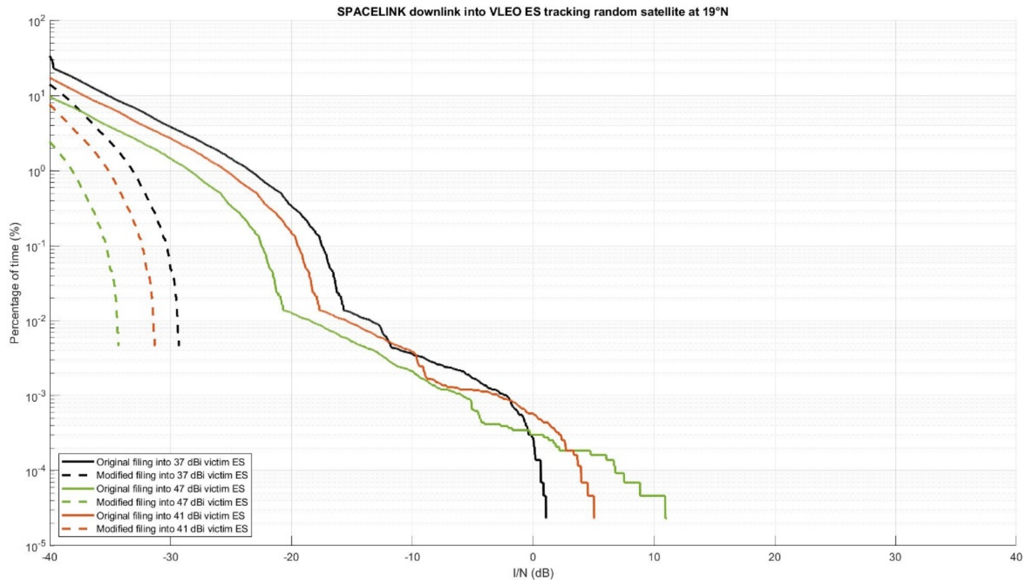


Figure A.8-7: I/N statistics for downlink interference into the SpaceX NGSO system ("Random" tracking strategy) (Test earth stations located at 40° latitude)

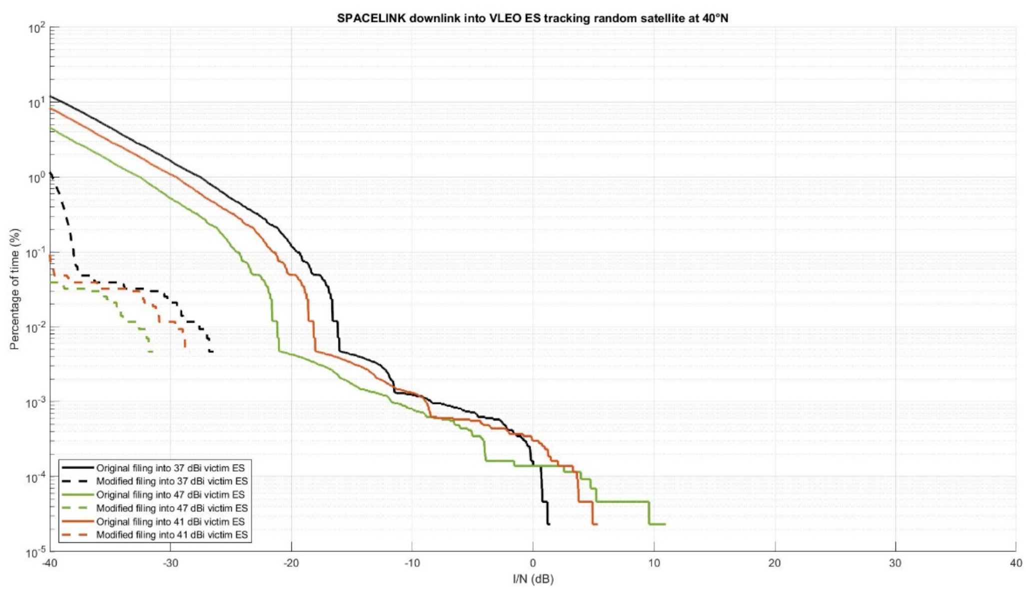


Figure A.8-8: I/N statistics for uplink interference into the SpaceX NGSO system ("Random" tracking strategy) (Test earth stations located at 19° latitude)

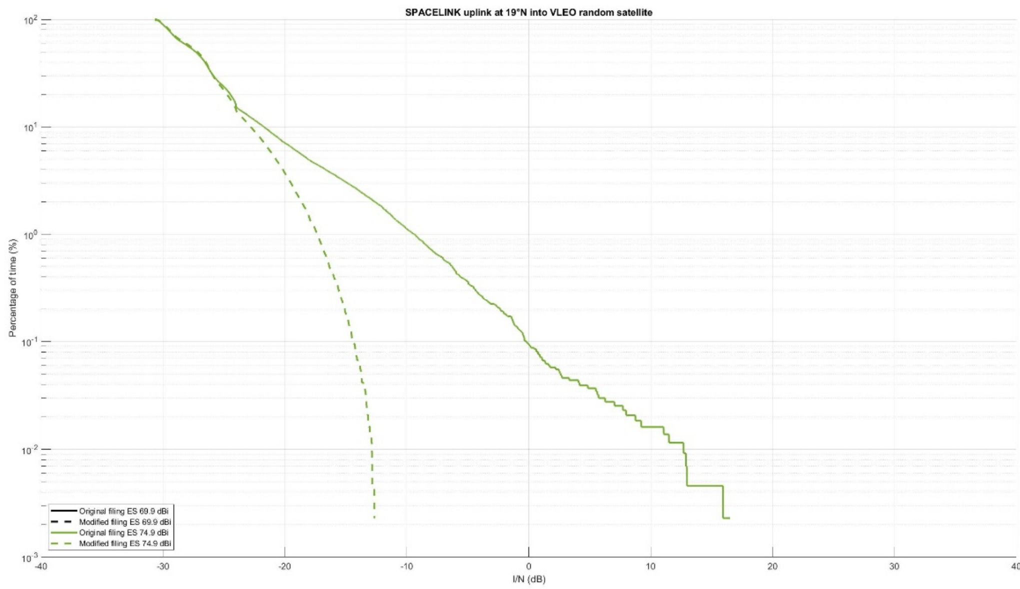
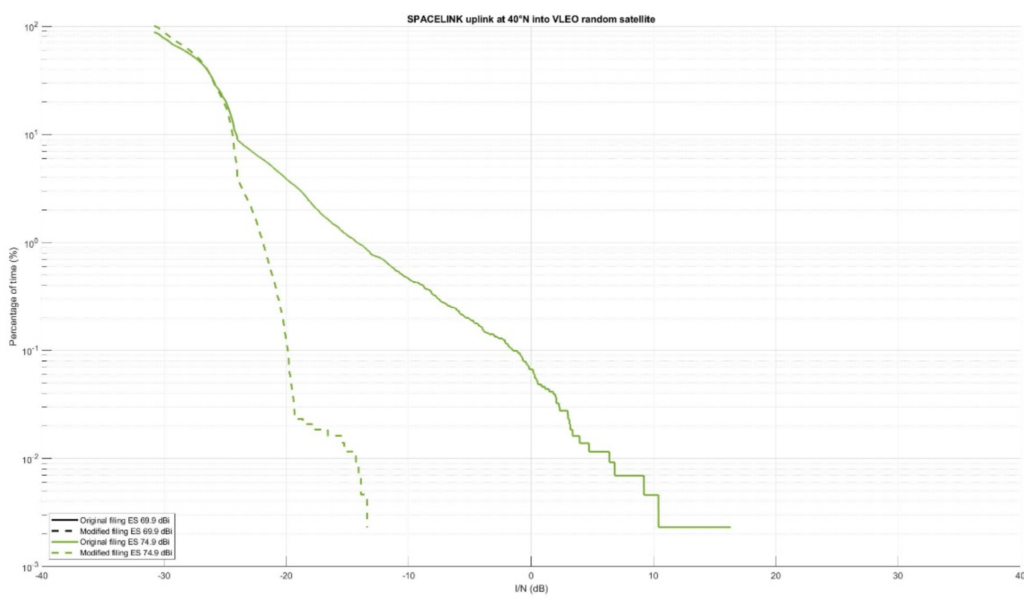


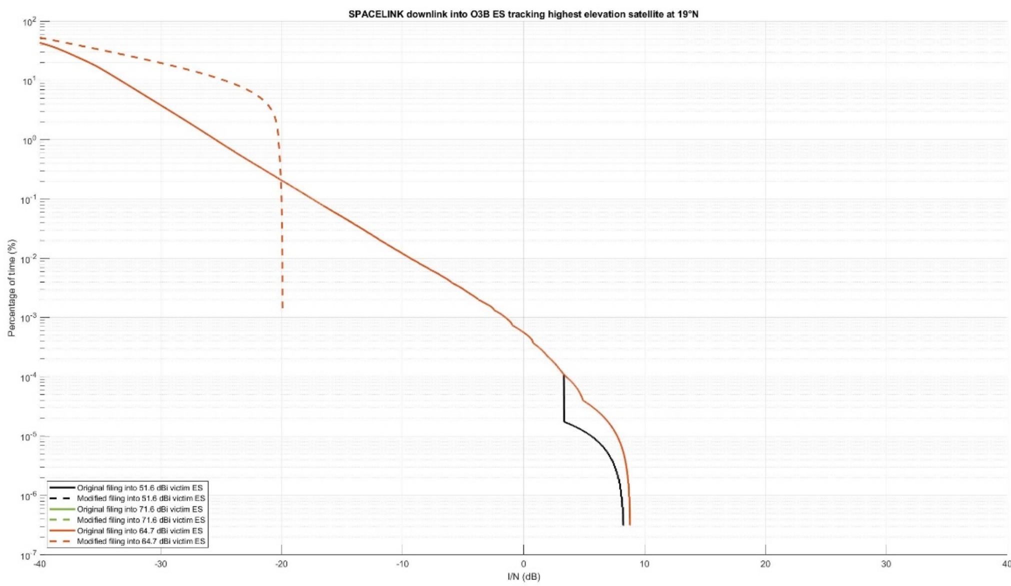
Figure A.8-9: I/N statistics for uplink interference into the SpaceX NGSO system (“Random” tracking strategy) (Test earth stations located at 40° latitude)



The differences in the CDF curves in Figures A.8-6 to A.8-9 above, compared to Figures A.8-2 to A.8-5, are accounted for by the different assumed tracking strategy for the SpaceX system. Nevertheless, in all cases, regardless of tracking strategy, the conclusions are the same: the proposed SpaceLink modification either does not increase the levels of interference into the SpaceX system or the levels of additional interference are imperceptibly low.

Figures A.8-10 to A.8-13 below shows the interference results for the O3b satellite system using the "highest elevation" tracking strategy.[17] The O3b system is assumed to be operating with a minimum GSO avoidance angle of 2°.[18]

Figure A.8-10: I/N statistics for downlink interference into the O3b NGSO system ("Highest elevation" tracking strategy) (Test earth stations located at 19° latitude)



The result in Figure A.8-10 above results from the change in the inclination of the SpaceLink orbit which is now generally more aligned with the O3b orbit, particularly at lower latitudes. From this

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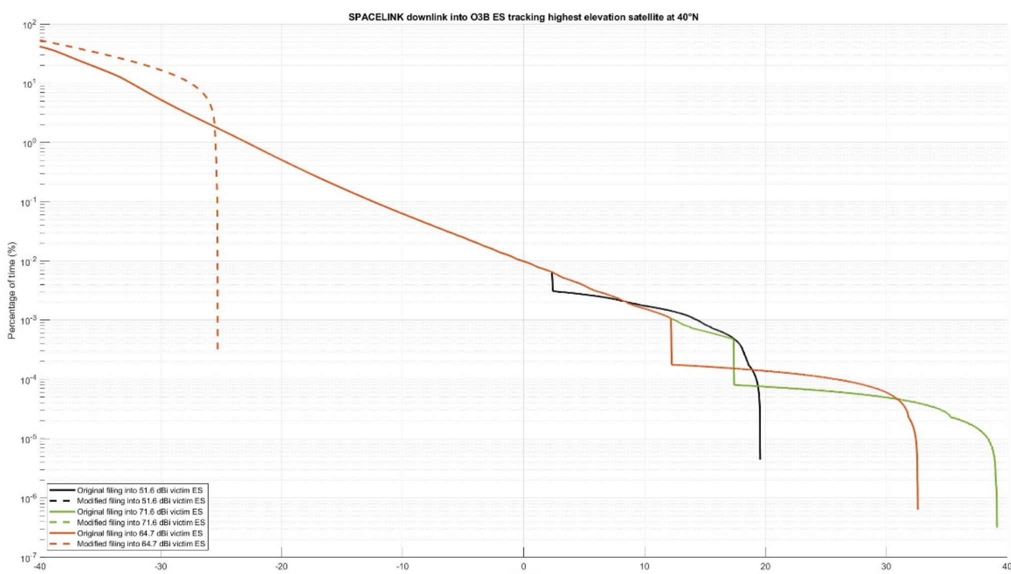
17 *See In the Matter of O3b Limited Amendment to Application to Modify U.S. Market Access Grant for the O3b Medium Earth Orbit Satellite System*, Amendment, IBFS File No. SAT-AMD-20170301-00026, Legal and Technical Narrative at 10 (filed Aug. 25, 2017) ("*O3b V-band Application*").

18 This value of GSO avoidance angle for O3b was obtained from the ITU WP4A Liaison Statement to WP7C concerning FSS characteristics in Q/V band (July 2021).

minimum latitude (19°) the worst-case interference is reduced by the SpaceLink modification, but the lower-level, long-term interference level increases due to the orbit alignment. The interference occurs only into the far-out sidelobes of the O3b receiving earth station antenna (where gain does not vary with antenna size), explaining why there is only one set of results generally visible in Figure A.8-10 – the results for all three sizes of O3b receiving earth station antenna are identical and overlaid except at the short-term end of the CDF. Because of this interference mechanism, the absolute level of the interference is very low, corresponding to I/N levels below -20 dB and a C/(N+I) degradation no greater than 0.04 dB, which is insignificant. For reference, an I/N value of -12.2 dB is equivalent to a ΔT/T value of 6%, a commonly used metric for requiring coordination.

Figure A.8-11: I/N statistics for downlink interference into the O3b NGSO system ("Highest elevation" tracking strategy) (Test earth stations located at 40° latitude)



The results in Figure A.8-11 (40° latitude ES) are similar in overall shape to those in Figure A.8-10 (19° latitude ES), but the impact of the SpaceLink modification is a much greater reduction in the worst-case interference into the O3b system due to the higher latitude and thus, increased angular separation between the equatorial orbits. After the modification, the absolute level of the interference corresponds to I/N levels below -25 dB and a C/(N+I) degradation no greater than 0.01 dB, which is insignificant.

Figure A.8-12: I/N statistics for uplink interference into the O3b NGSO system ("Highest elevation" tracking strategy) (Test earth stations located at 19° latitude)

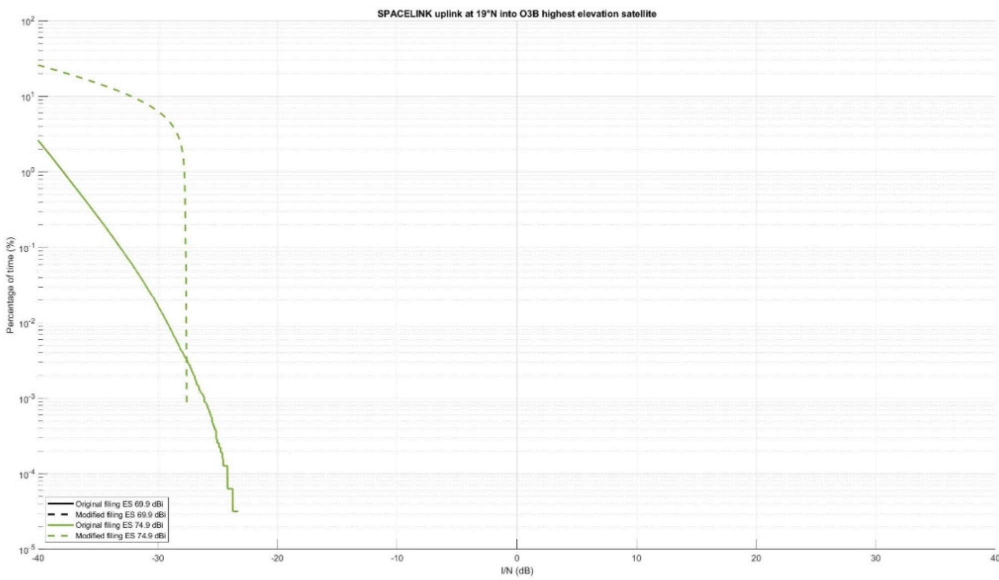
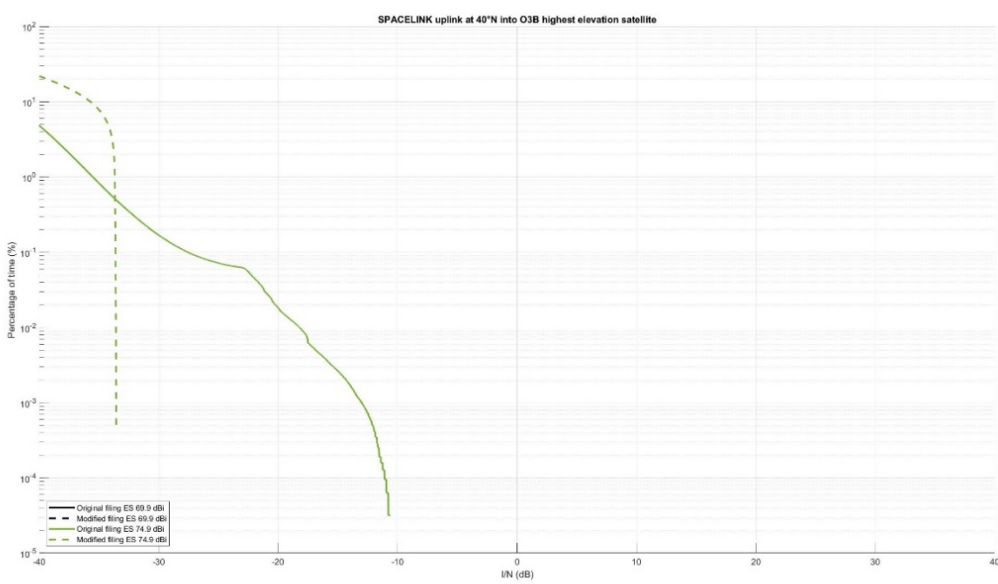


Figure A.8-13: I/N statistics for uplink interference into the O3b NGSO system ("Highest elevation" tracking strategy) (Test earth stations located at 40° latitude)



The uplink results in Figures A.8-12 and A.8-13 above show a similar effect to the downlink interference results of Figures A.8-10 and A.8-11, and for the same reasons explained above, although in this case the interference arises only from the far-out sidelobes of the SpaceLink transmitting earth station. The results show that after the proposed SpaceLink modification the I/N levels are below -28 dB for the 19° latitude case and -34 dB for 40° latitude. This corresponds to C/(N+I) degradations no greater than 0.007 dB and 0.002 dB, respectively, which are insignificant.

The next set of results below (Figures A.8-14 to A.8-17) are also for the O3b system but using the random tracking strategy for the analysis. All other assumptions are identical to the earlier analyses.

Figure A.8-14: I/N statistics for downlink interference into the O3b NGSO system (“Random” tracking strategy) (Test earth stations located at 19° latitude)

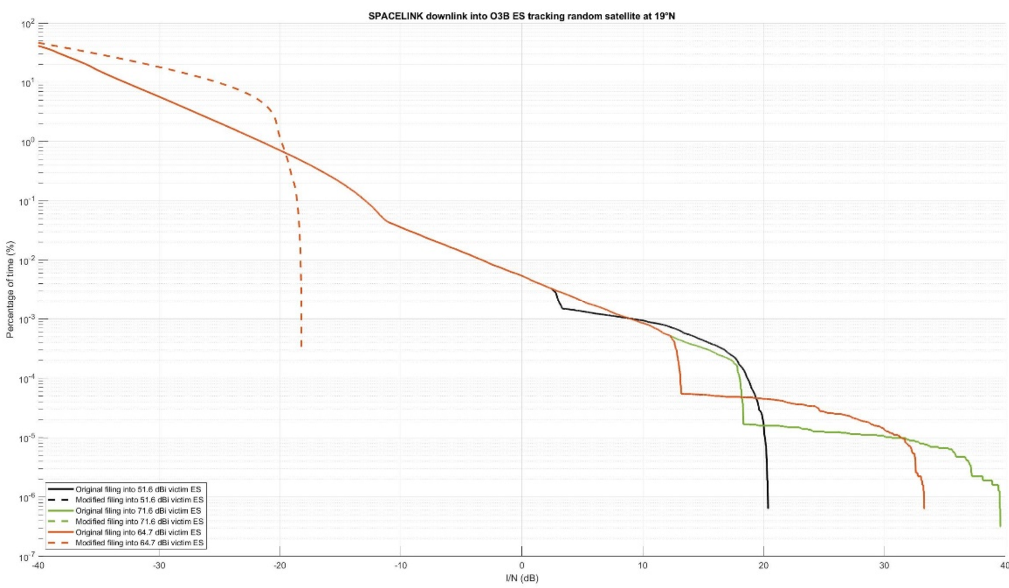


Figure A.8-15: I/N statistics for downlink interference into the O3b NGSO system ("Random" tracking strategy) (Test earth stations located at 40° latitude)

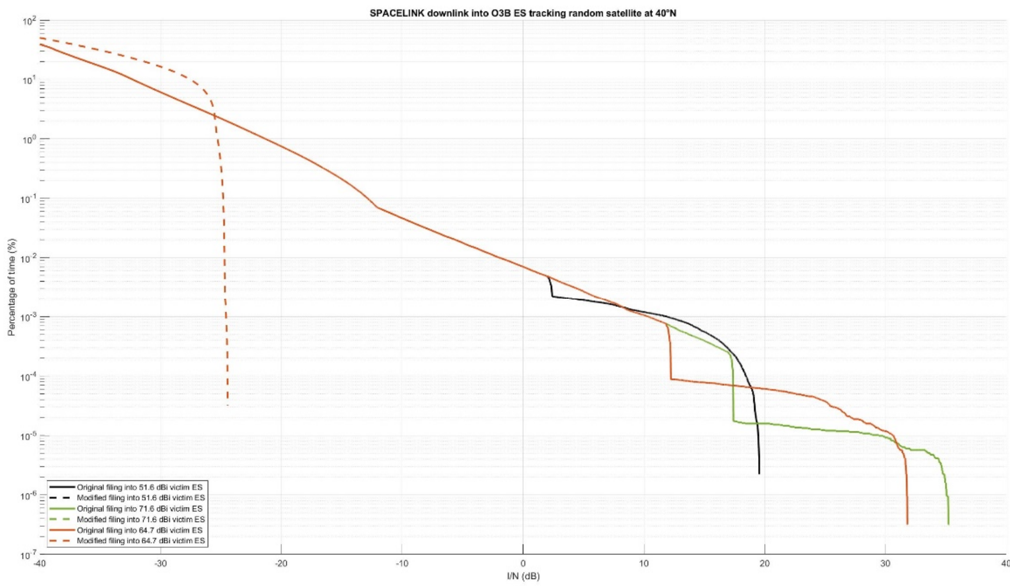


Figure A.8-16: I/N statistics for uplink interference into the O3b NGSO system ("Random" tracking strategy) (Test earth stations located at 19° latitude)

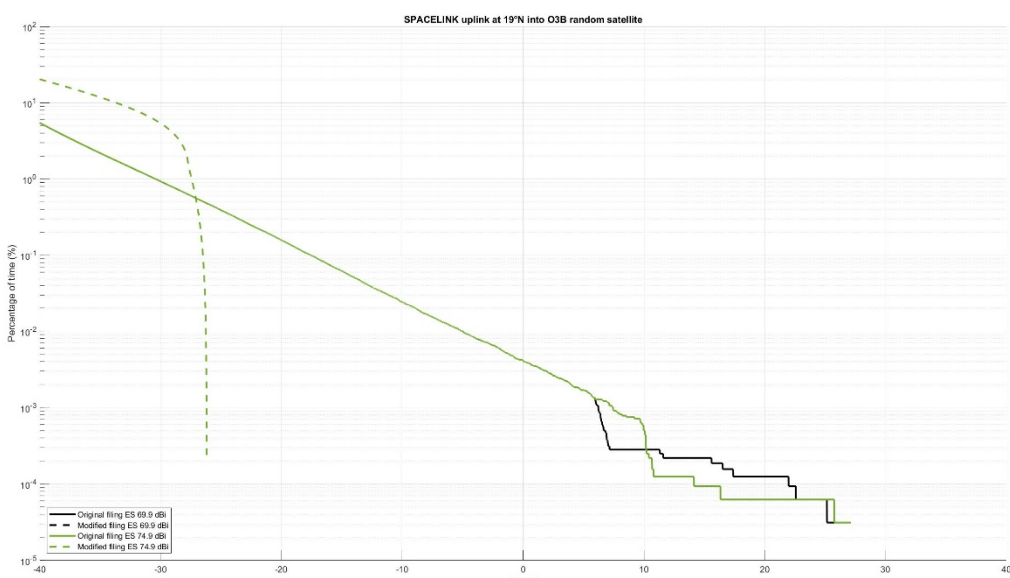
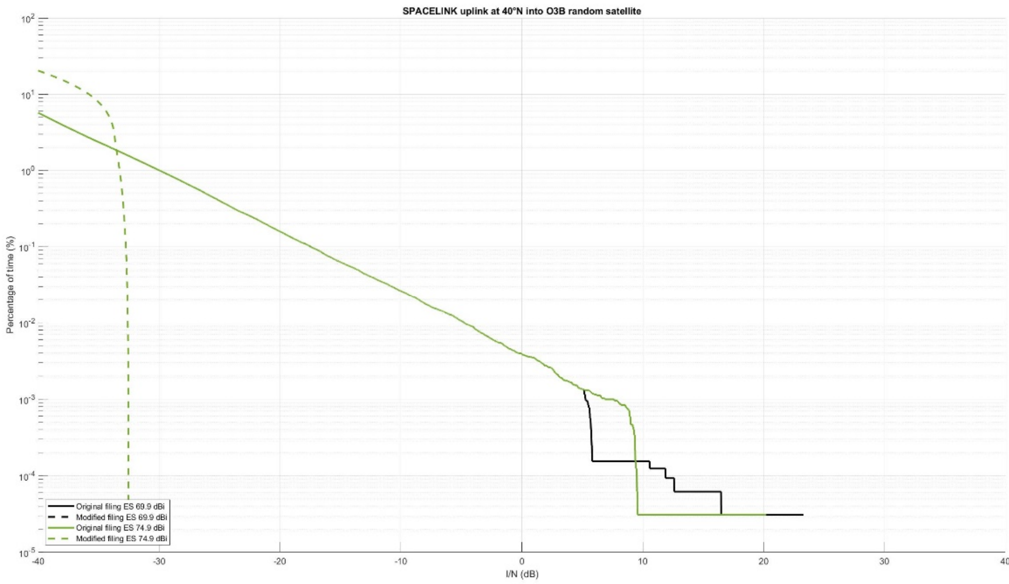


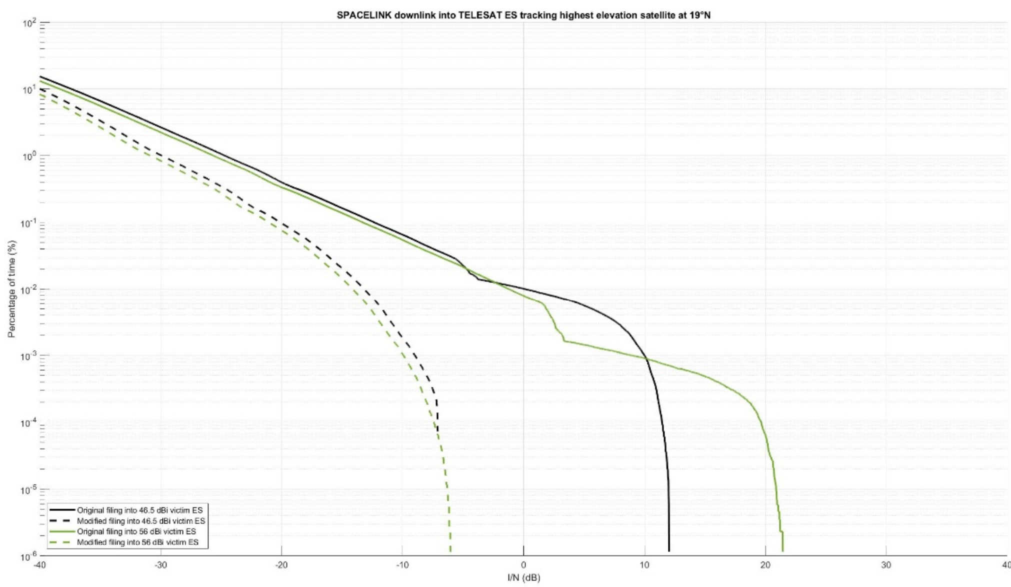
Figure A.8-17: I/N statistics for uplink interference into the O3b NGSO system
(“Random” tracking strategy)
(Test earth stations located at 40° latitude)



The differences in the CDF curves in Figures A.8-14 to A.8-17 above, compared to Figures A.8-10 to A.8-13, are accounted for by the different assumed tracking strategy for the O3b system. The results after the modification are almost the same for this tracking strategy, but those before the modification are significantly worse as they involve inline and near-inline interference events due to the 25° inclination of the original SpaceLink orbit. Therefore, the improvements in the worst-case interference resulting from the SpaceLink modification are much greater with this assumed tracking strategy. The only exception occurs at the long-term end of the CDFs where the absolute interference levels are so low as to be imperceptible, as explained above. The conclusion is therefore that the proposed SpaceLink modification does not increase the levels of interference into the O3b system or, where it does, the levels of interference are imperceptibly low.

Figures A.8-18 to A.8-21 below shows the interference results for the third example victim satellite system, Telesat, using the "highest elevation" tracking strategy.[19] The Telesat system is assumed to be operating with a minimum GSO avoidance angle of 6°.[20]

Figure A.8-18: I/N statistics for downlink interference into the Telesat NGSO system ("Highest elevation" tracking strategy) (Test earth stations located at 19° latitude)

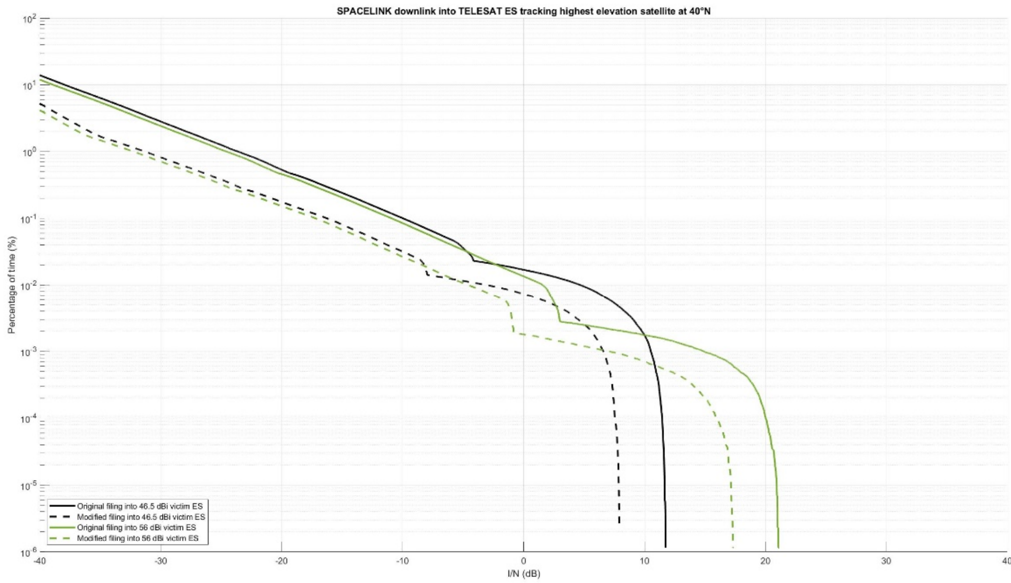


In all cases in Figure A.8-18 the interference after the modification is reduced compared to the original system. The absence of short-term inline or near-inline interference events after the modification results from the Telesat system's GSO avoidance strategy, which also protects from inline events with the equatorial SpaceLink System.

19 *See Telesat Canada Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation*, Petition for Declaratory Ruling, IBFS File No. SAT-LOI-20161115-00108, Legal and Technical Narrative at 13-14 (filed Nov. 15, 2016) ("*Telesat Ka-band PDR*"), which addresses Telesat's tracking strategy for NGSO operations in the V-band as well.

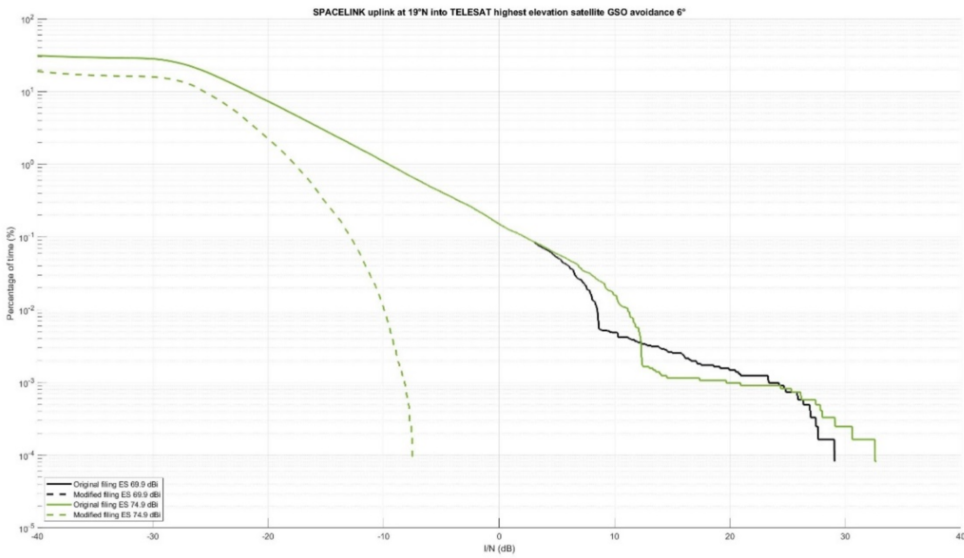
20 SpaceLink is not aware of Telesat providing a definitive GSO avoidance angle for its V-band NGSO system, and so we have used a typical value of 6°.

Figure A.8-19: I/N statistics for downlink interference into the Telesat NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 40° latitude)



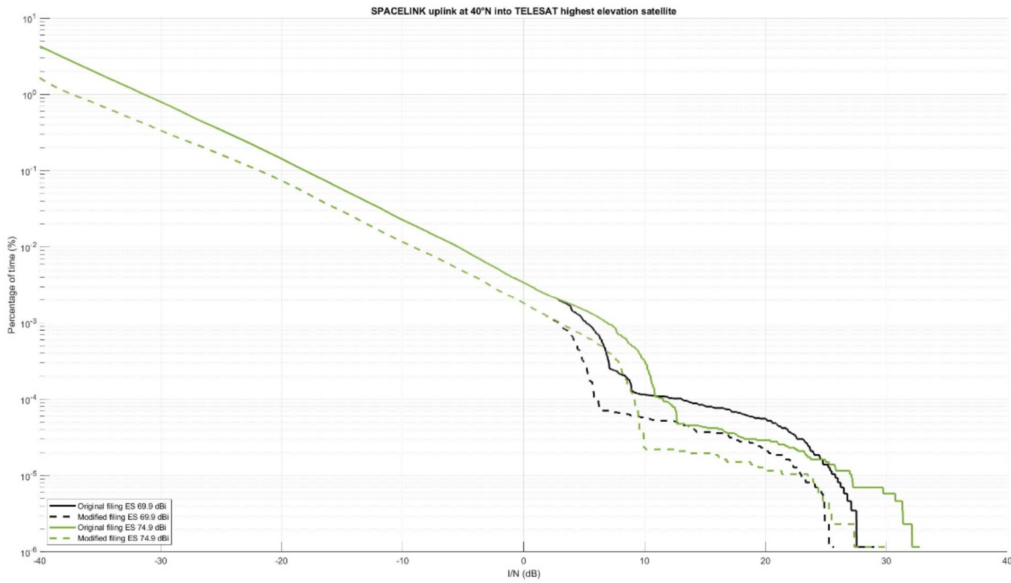
The results in Figure A.8-19 also show the interference after the modification is reduced compared to the original SpaceLink System.

Figure A.8-20: I/N statistics for uplink interference into the Telesat NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 19° latitude)



In Figure A.8-20 the data for both SpaceLink earth station antenna sizes after the modification is overlaid and appears as a single curve. These results show that the interference after the modification is reduced compared to the original system. The absence of short-term inline or near-inline uplink interference events after the modification is again accounted for by the Telesat system’s GSO avoidance strategy, which simultaneously protects from inline events with the SpaceLink System.

Figure A.8-21: I/N statistics for uplink interference into the Telesat NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 40° latitude)



The results in Figure A.8-21 also show the interference after the modification is reduced compared to the original system.

The next set of results below (Figures A.8-22 to A.8-25) are also for the Telesat system but using the random tracking strategy for the analysis. All other assumptions are identical to the earlier analyses.

Figure A.8-22: I/N statistics for downlink interference into the Telesat NGSO system ("Random" tracking strategy) (Test earth stations located at 19° latitude)

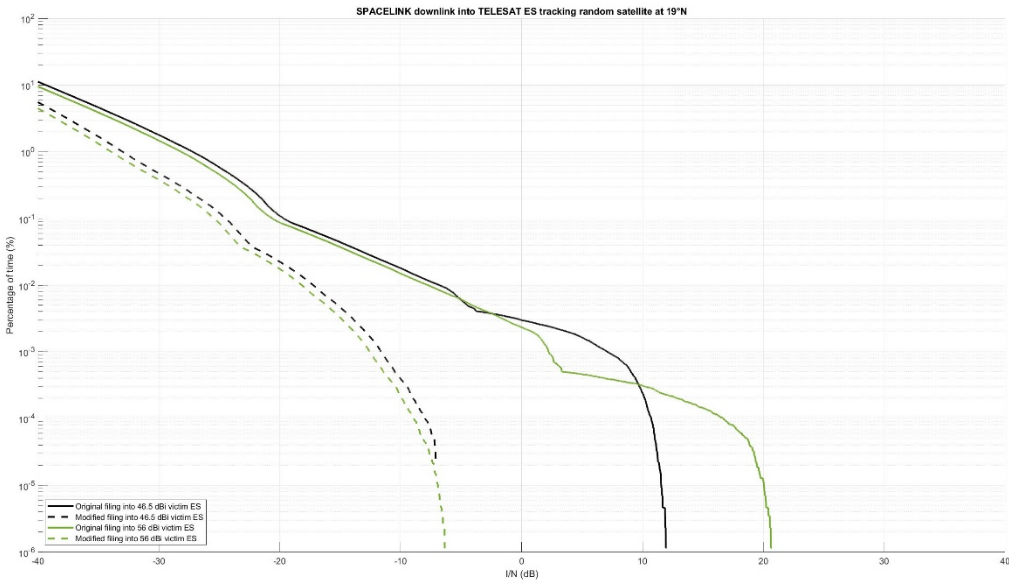


Figure A.8-23: I/N statistics for downlink interference into the Telesat NGSO system ("Random" tracking strategy) (Test earth stations located at 40° latitude)

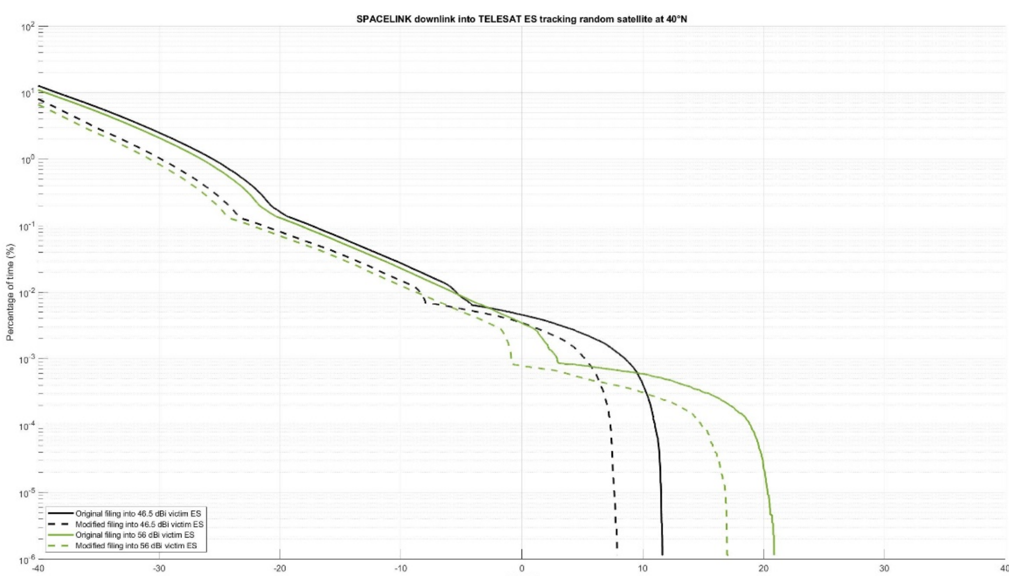


Figure A.8-24: I/N statistics for uplink interference into the Telesat NGSO system ("Random" tracking strategy) (Test earth stations located at 19° latitude)

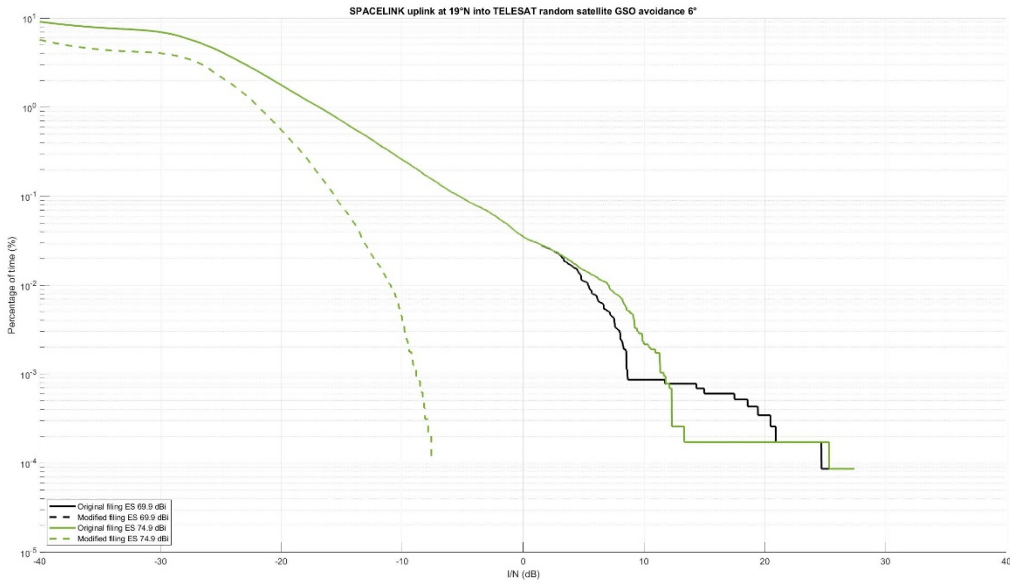
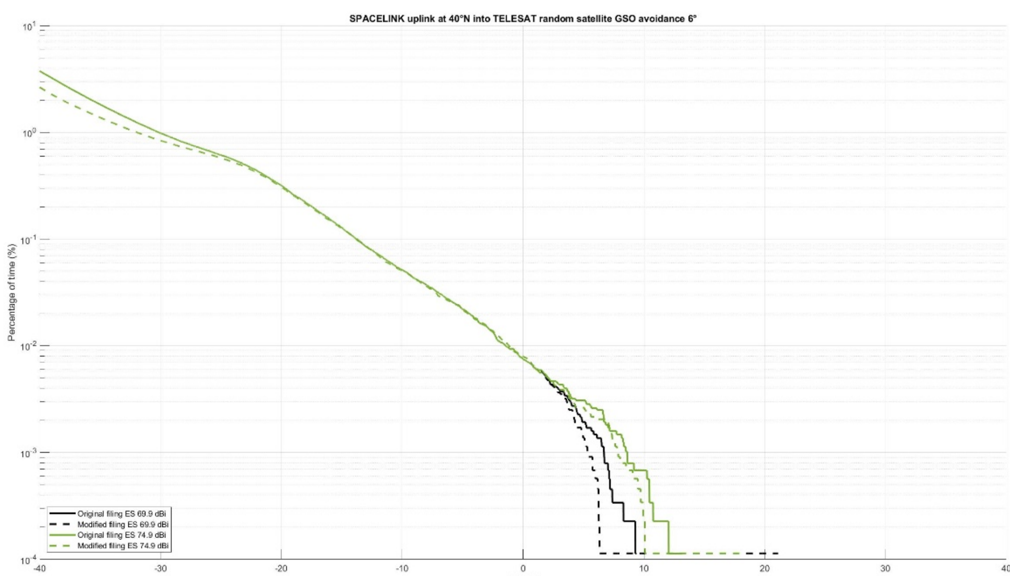


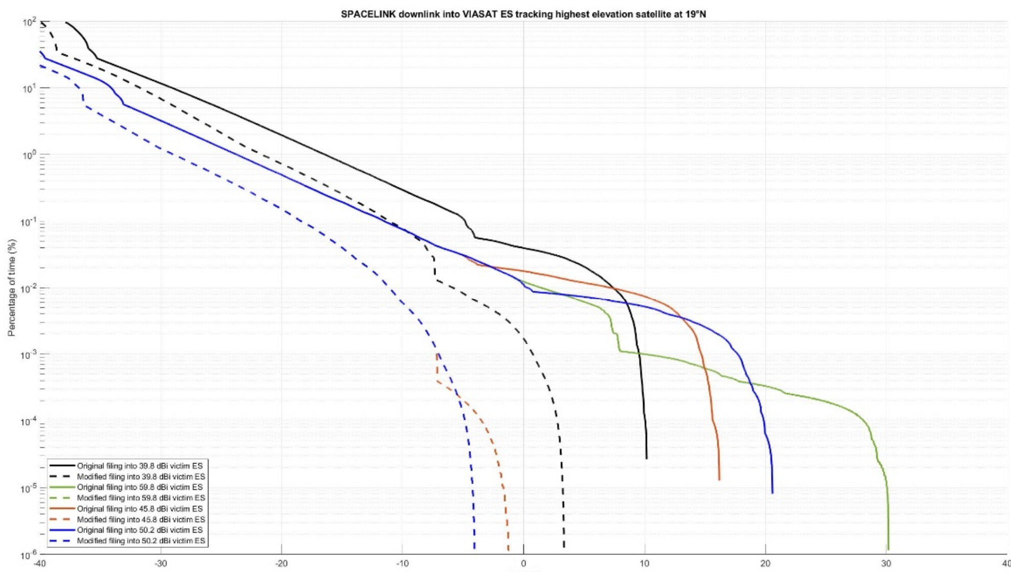
Figure A.8-25: I/N statistics for uplink interference into the Telesat NGSO system ("Random" tracking strategy) (Test earth stations located at 40° latitude)



Similar results are seen in the CDF curves in Figures A.8-22 to A.8-25 above compared to Figures A.8-18 to A.8-21 with no increase in interference resulting from the modification assuming a random tracking strategy. The overall conclusion is therefore that the proposed SpaceLink modification does not increase the levels of interference into the Telesat NGSO system.

Figures A.8-26 to A.8-29 below show the interference results for the fourth example victim satellite system, VIASAT-NGSO, using the "highest elevation" tracking strategy. The Viasat system is assumed to be operating with a minimum GSO avoidance angle of 6°.[21]

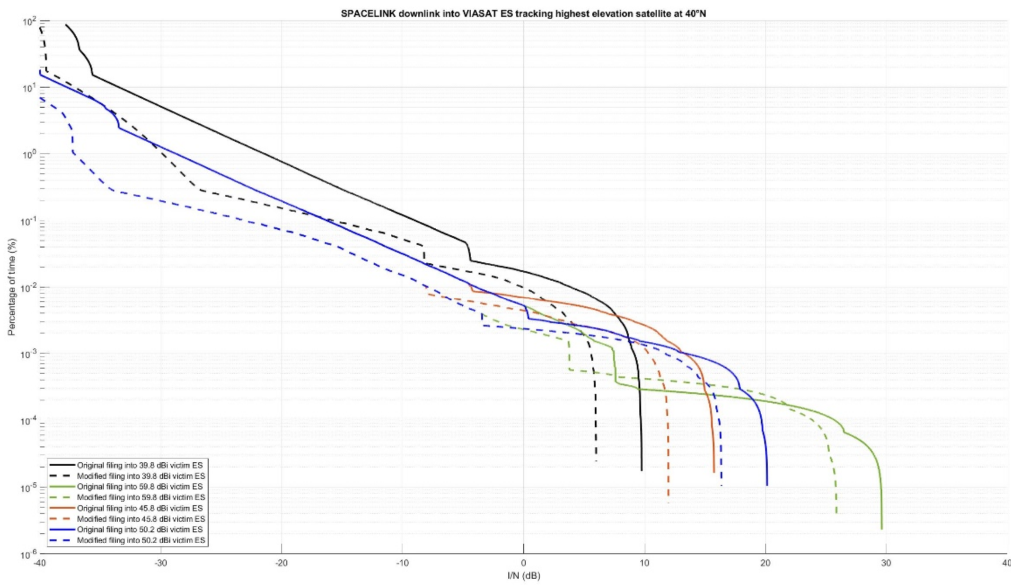
Figure A.8-26: I/N statistics for downlink interference into the VIASAT-NGSO system ("Highest elevation" tracking strategy) (Test earth stations located at 19° latitude)



[21] SpaceLink is not aware of Viasat providing a definitive GSO avoidance angle for its V-band NGSO system, and so we have used a typical value of 6°.

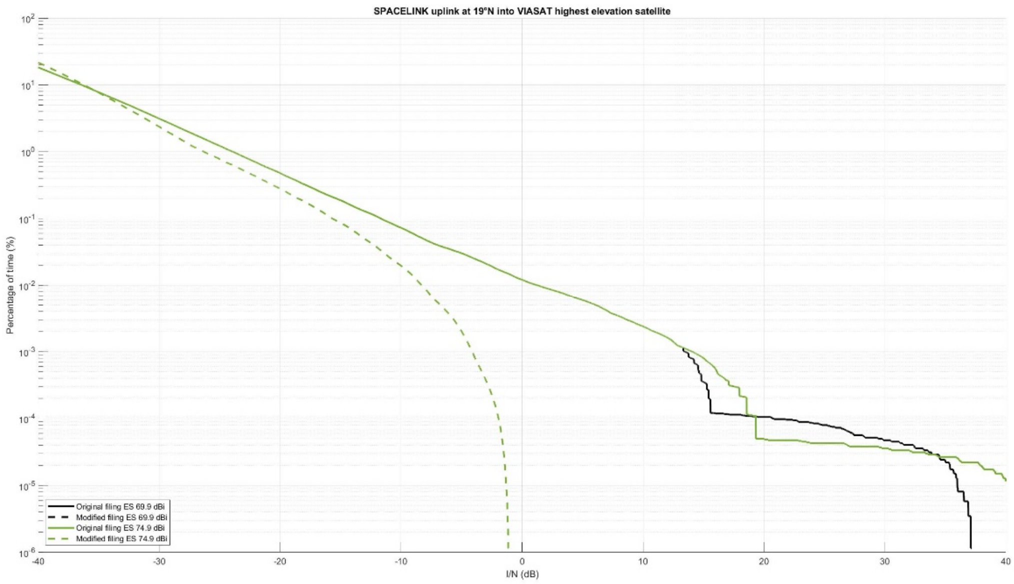
In all cases in Figure A.8-26 the interference after the modification is reduced compared to the original system. The absence of short-term inline or near-inline interference events after the modification results from the assumed Viasat system's GSO avoidance strategy, which simultaneously protects from inline events with the equatorial SpaceLink System.

Figure A.8-27: I/N statistics for downlink interference into the VIASAT-NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 40° latitude)



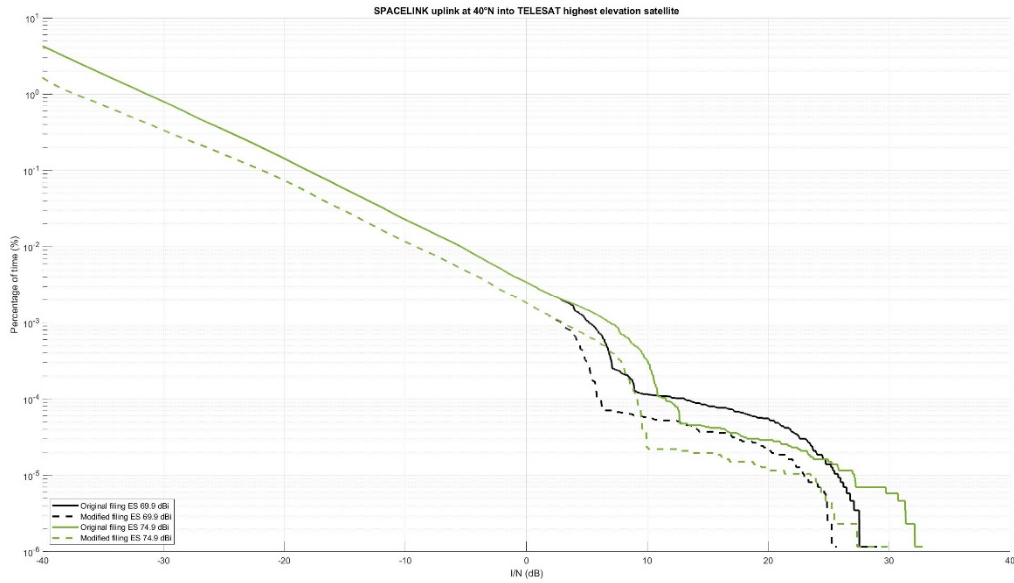
The results in Figure A.8-27 show the significant reduction in the very short-term interference associated with inline interference events which results from the decrease in the SpaceLink System's maximum downlink EIRP density. This leaves only a very minor exceedance after the modification for the largest Viasat receiving earth station size in a limited portion of the CDF. Such effects are insignificant in terms of the degradation of even this worst-case Viasat link taken overall.

Figure A.8-28: I/N statistics for uplink interference into the VIASAT-NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 19° latitude)



In Figure A.8-28 the data for both SpaceLink earth station antenna sizes after the modification is overlaid and appears as a single curve, as explained in some of the other results presented above. These results show that the interference after the modification is reduced compared to the original system. The absence of short-term inline or near-inline uplink interference events after the modification is again accounted for by the Viasat system’s assumed GSO avoidance strategy, which simultaneously protects from inline events with the SpaceLink System.

Figure A.8-29: I/N statistics for uplink interference into the VIASAT-NGSO system (“Highest elevation” tracking strategy) (Test earth stations located at 40° latitude)



The results in Figure A.8-21 also show the interference after the modification is reduced compared to the original system.

The final set of results below (Figures A.8-30 to A.8-33) are also for the VIASAT-NGSO system but using the random tracking strategy for the analysis. All other assumptions are identical to the earlier analyses.

Figure A.8-30: I/N statistics for downlink interference into the VIASAT-NGSO system (“Random” tracking strategy) (Test earth stations located at 19° latitude)

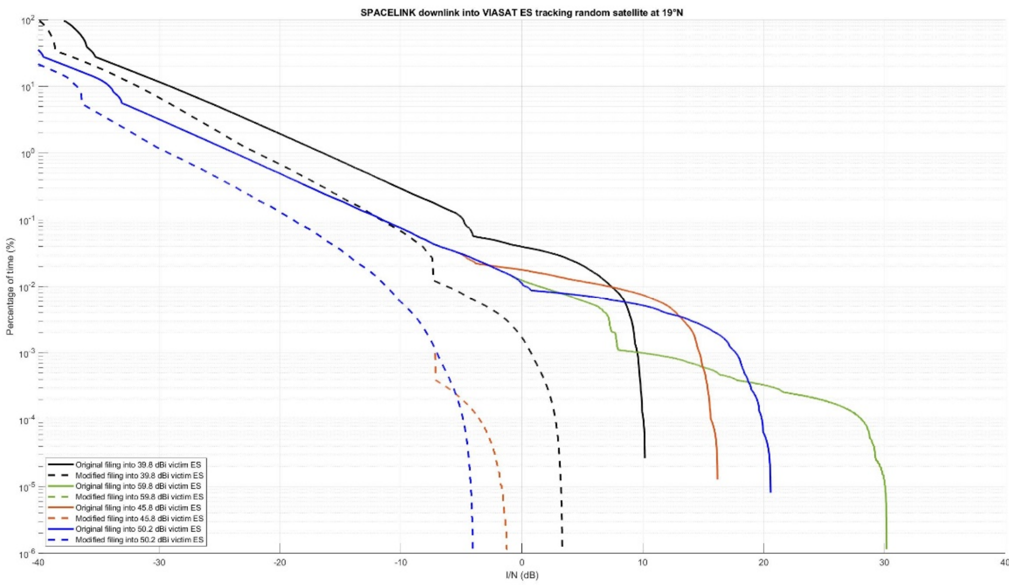


Figure A.8-31: I/N statistics for downlink interference into the VIASAT-NGSO system (“Random” tracking strategy) (Test earth stations located at 40° latitude)

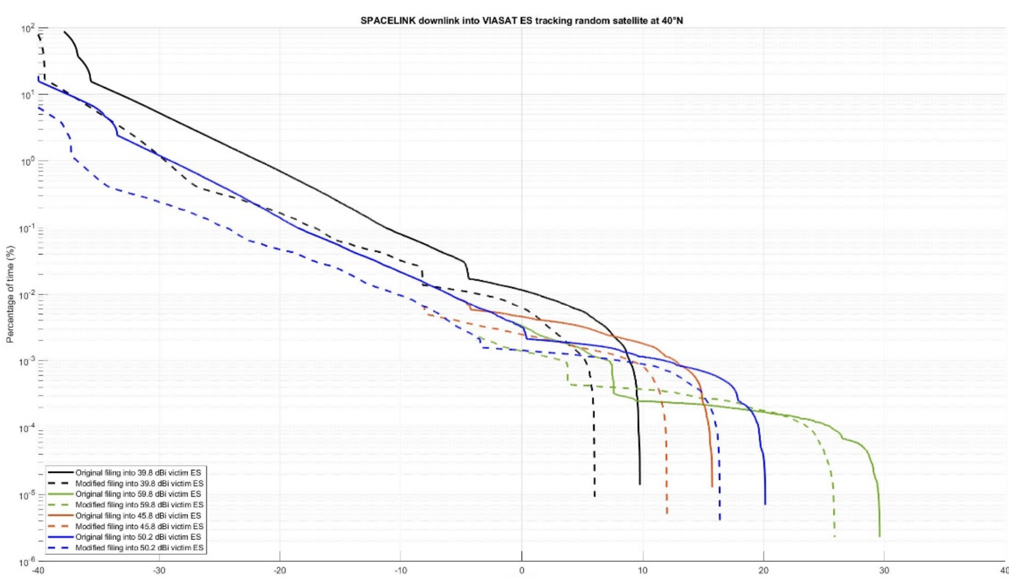


Figure A.8-32: I/N statistics for uplink interference into the VIASAT-NGSO system ("Random" tracking strategy) (Test earth stations located at 19° latitude)

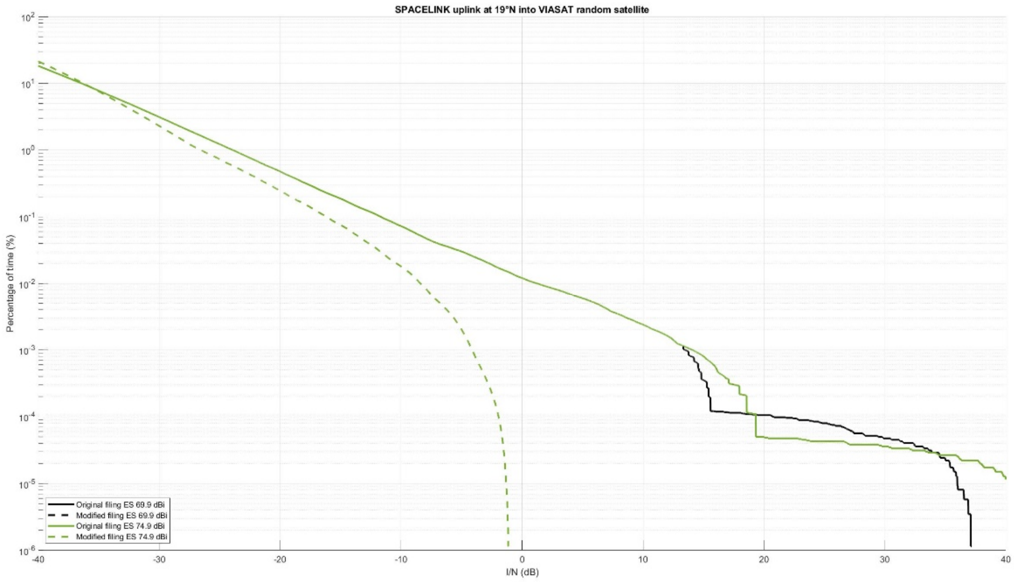
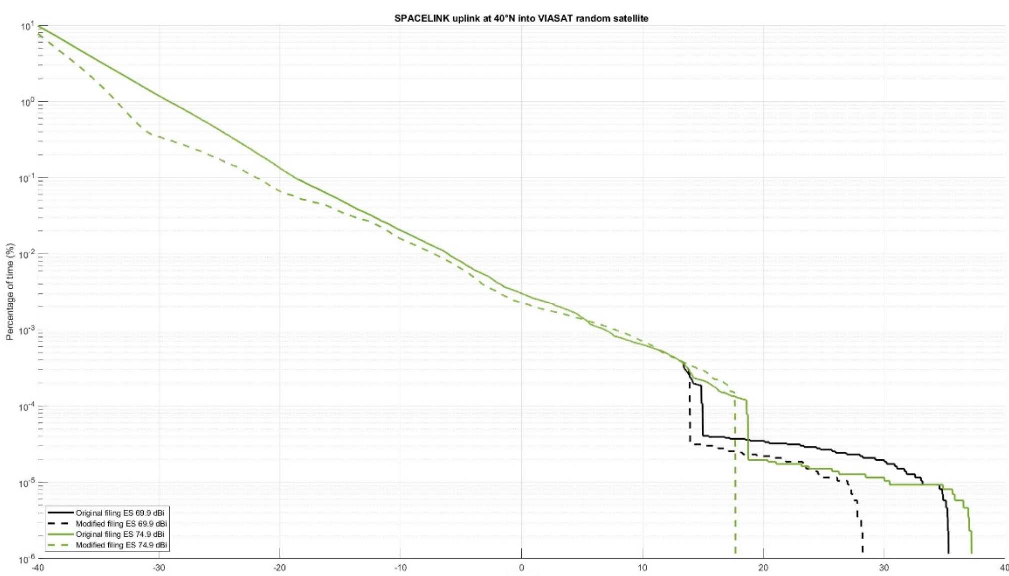


Figure A.8-33: I/N statistics for uplink interference into the VIASAT-NGSO system ("Random" tracking strategy) (Test earth stations located at 40° latitude)



Similar results are seen in the CDF curves in Figures A.8-30 to A.8-33 above compared to Figures A.8-26 to A.8-29 with no significant increase in interference resulting from the modification assuming a random tracking strategy. The overall conclusion is therefore that the proposed SpaceLink modification does not increase the levels of interference into the Viasat NGSO system.

A.8.3 Interference with Respect to the Radio Astronomy Service

SpaceLink will enter into coordination discussions with the National Science Foundation (NSF) and the responsible entities for the various Radio Astronomy Service ("RAS") sites concerning the protection of the RAS sites in the USA and worldwide which operate in frequency bands that could potentially be affected by the transmissions from the SpaceLink satellites and associated earth stations.

A.9 COORDINATION WITH THE US GOVERNMENT SATELLITE NETWORKS (Footnote US334 in the FCC Table of Frequency Allocations)

SpaceLink will coordinate with the US government satellite networks, as required by US334, concerning the SpaceLink downlink transmissions in the Ka band.

A.10 ORBITAL DEBRIS (§25.114(d)(14))

SpaceLink applauds the FCC's desire to promulgate rules that reduce the risk of intentional or unintentional events that release orbital debris. SpaceLink is acutely aware that clean, sustainable LEO and MEO orbits are a prerequisite for our success as well as that of our downstream customers. Accordingly, and as described below, SpaceLink satellites have been engineered to satisfy all recently adopted FCC orbital debris requirements.

SpaceLink also reaffirms that the SpaceLink System will markedly improve our downstream customers' ability to minimize events that may result in the unintentional release of orbital debris from their LEO spacecraft. Specifically, the SpaceLink System will enable our downstream LEO customers to enjoy real-time situational awareness in space, as well as the ability to take immediate corrective action to the extent that a potential onboard malfunction or risk of on-orbit collision threatens the customer's mission. Whereas a LEO spacecraft that conducts TT&C communications only when directly over a designated ground station must frequently wait to transmit telemetry data or receive commands, SpaceLink customers that enjoy continuous and uninterrupted real-time TT&C communications with their spacecraft through the SpaceLink System will enjoy enhanced situational awareness, the ability to instantaneously perform diagnostic queries, and the ability to command spacecraft to adjust onboard parameters or take evasive maneuvers in emergency situations without unnecessary delay.

A.10.1 Space station architecture and design

SpaceLink System relay satellites have been designed to prevent the release of debris during normal operations. More specifically, the SpaceLink System satellites will not employ any separate deployment devices distinct from the launch vehicle.

A.10.2 Assessment of debris probability resulting from collision with small debris/meteoroids

SpaceLink employed Version 3.1.2 of the National Aeronautics and Space Administration's ("NASA") Debris Assessment Software ("NASA-DAS") to analyze the probability of collision between its relay satellites and small debris or meteoroids that might shorten the mission of a relay satellite and prevent retirement in a storage orbit. The analysis included critical spacecraft systems (*e.g.,* fuel tank and star trackers), as well as protective outer layers (*e.g.,* aluminum honeycomb sandwich panels, payload enclosures, and multi-layer insulation). The probability for each of SpaceLink's satellites was calculated to be 8.8×10^{-3}, below the Commission's threshold value of 1.0×10^{-2}.

Further, even in a worst case where a relay satellite becomes completely incapacitated due to a collision with debris or a meteoroid, the SpaceLink System's orbit by itself meets the criteria for a stable storage orbit, and is far enough removed from the nearest operational systems (22,000 km from GEO, 12,000 km from LEO, 6,300 km from the Global Positioning System ("GPS"), and 5,800 km from O3b) that it would not present a risk to other systems.

A.10.3 Assessment of debris probability resulting from accidental explosion

SpaceLink has designed its spacecraft consistent with industry best practices to limit the probability of an accidental explosion during or after the completion of mission operations. All SpaceLink System satellites will be completely passivated at the end of their mission to eliminate the possibility of accidental explosion or fuel droplet release. Specifically, all reaction wheels will be de-spun, the thermal control system will be deactivated, the batteries will be depleted and left in a permanent discharge state, the pressurized station-keeping fuel tanks will be vented to remove all propellant, and the propulsion subsystem will be fully depressurized with fuel line valves left permanently open.

A.10.4 Assessment of debris probability resulting from collision with large debris

SpaceLink has assessed the risk of collision with other operational space stations and found it to be negligible. SpaceLink's orbit is far removed from existing systems (22,000 km from GEO, 12,000 km from LEO, 6,300 km from GPS, 5,800 km from O3b), which ensures that SpaceLink System satellites will not become sources of debris by collision with other existing or planned space stations.

A.10.5 NGSO operator demonstration that probability of collision with >10 cm objects assessed

SpaceLink has used NASA-DAS to analyze the probability of collision between its satellites and other large objects (10 cm or larger in diameter). Using the orbital parameters described in the associated Schedule S and an end-of-life area-to-mass ratio and mass of 0.02 m^2/kg and 775 kg respectively, DAS calculated a collision probability for each satellite of 2.4×10^{-5} (1 in over 40,000), well below the Commission's threshold probability of 1.0×10^{-3}. The collision probability of the associated launch vehicle upper stage (end-of-life area-to-mass ratio and mass of 0.01 m^2/kg and 200 kg respectively) is calculated to be 3.1×10^{-6}.

A.10.6 Assessment of space station orbits that present a collision risk

No characteristic of the SpaceLink System satellites' orbits presents a collision risk. In fact, SpaceLink's orbits have been expressly designed to eliminate any collision risk. There are no planned or operational satellites in SpaceLink's proposed orbits, and the nearest operational systems and densely populated orbits are many thousands of kilometers higher or lower in altitude vis-à-vis the SpaceLink System: 22,000 km from GEO, 12,000 km from LEO, 6,300 km from GPS, 5,800 km from O3b.

A.10.7 Statement disclosing station-keeping accuracy

The design of SpaceLink System satellites includes a propulsion system and three-axis attitude control for station-keeping and maneuvers. The orbit altitude and inclination will be maintained within 5 km and 0.1° respectively. The SpaceLink System's proposed equatorial orbit does not have an ascending node to maintain, however SpaceLink will maintain equidistant relative spacing of the satellites in the orbit.

A.10.8 Certification that operator will take all possible steps to mitigate potential collision risks

SpaceLink certifies that upon receipt of a space situational awareness conjunction warning, it will take all possible steps to assess and mitigate the risk of collision, including sharing satellite ephemerides and performing evasive maneuvers using the satellite's propulsion subsystem if necessary.

A.10.9 Assessment of space station trackability

The smallest dimension of the SpaceLink satellites will be at least 1.1 meters, excluding solar arrays, making them readily trackable by existing ground-based sensors.

A.10.10 Confirmation of registration and information sharing with 18th Space Control Squadron or successor entity

SpaceLink confirms that prior to deployment it will register SpaceLink System satellites with the 18th Space Control Squadron or an appropriate successor entity responsible for tracking space objects.

Similarly, SpaceLink will share information regarding the SpaceLink System satellites' initial deployment, ephemeris, and planned maneuvers with all appropriate situational awareness entities, both private and governmental, including the 18th Space Control Squadron or its designated successor entity, throughout the satellites' operational mission.

A.10.11 Disclosure of proximity operations

At no point in the SpaceLink System satellites' missions does SpaceLink plan any proximity operations.

A.10.12 Statement disclosing altitude selected for disposal orbit

Similar to orbits employed by geostationary or GPS satellites, the SpaceLink System satellites' proposed orbit at a 13,892 km altitude is too high for atmospheric re-entry to be a realistic disposal plan. SpaceLink System satellites would have to carry an unrealistic mass of fuel to perform the required orbit-lowering maneuvers from such an altitude.[22] Accordingly, SpaceLink proposes the use of a storage orbit. SpaceLink's 8-hour (13,892 km) orbit is already many thousands of kilometers in altitude from the nearest operational space systems (22,000 km from GEO, 12,000

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22 SpaceLink appreciates that the disposal of its customers' LEO spacecraft will in most circumstances involve atmospheric re-entry. Accordingly, SpaceLink is committed to proactively working with its downstream LEO customers as they develop disposal plans for their own spacecraft that minimize the possibility of surface impacts, and that strive to satisfy any future regulations concerning the atmospheric re-entry of commercial satellites. Among other efforts, SpaceLink is working to motivate customers electing to communicate with the SpaceLink System using an optical connection to incorporate subcomponents employing Design-for-Demise ("D4D") principles that prevent more durable subcomponents *(e.g.*, lenses, mirrors, and optical barrels) from re-entering the atmosphere and reaching the ground. SpaceLink is also developing a pre-engineered optical package for LEO customers that prefer to insert a "plug-and-play" communications payload into their spacecraft. Preliminary design efforts concerning this pre-engineered optical communications payload incorporate D4D principles and avoid the use of silica- or silicate-based lenses with high melting points.

km from LEO, 6,300 km from GPS, 5,800 km from O3b), so the system's nominal orbit by itself meets the criteria of a storage orbit. However, to protect other SpaceLink System satellites as well as any future users of the 8-hour orbit that are not yet planned, SpaceLink will raise the orbital altitude of its satellites by at least 100 km at the end of their respective missions, and will reserve at least 11 m/s Δv of propellant for this purpose. This proposed storage orbit remains thousands of kilometers in altitude removed from other operational space stations and poses no risk of collisions to any third party.

A.10.13 Statement evaluating probability of successful space station disposal

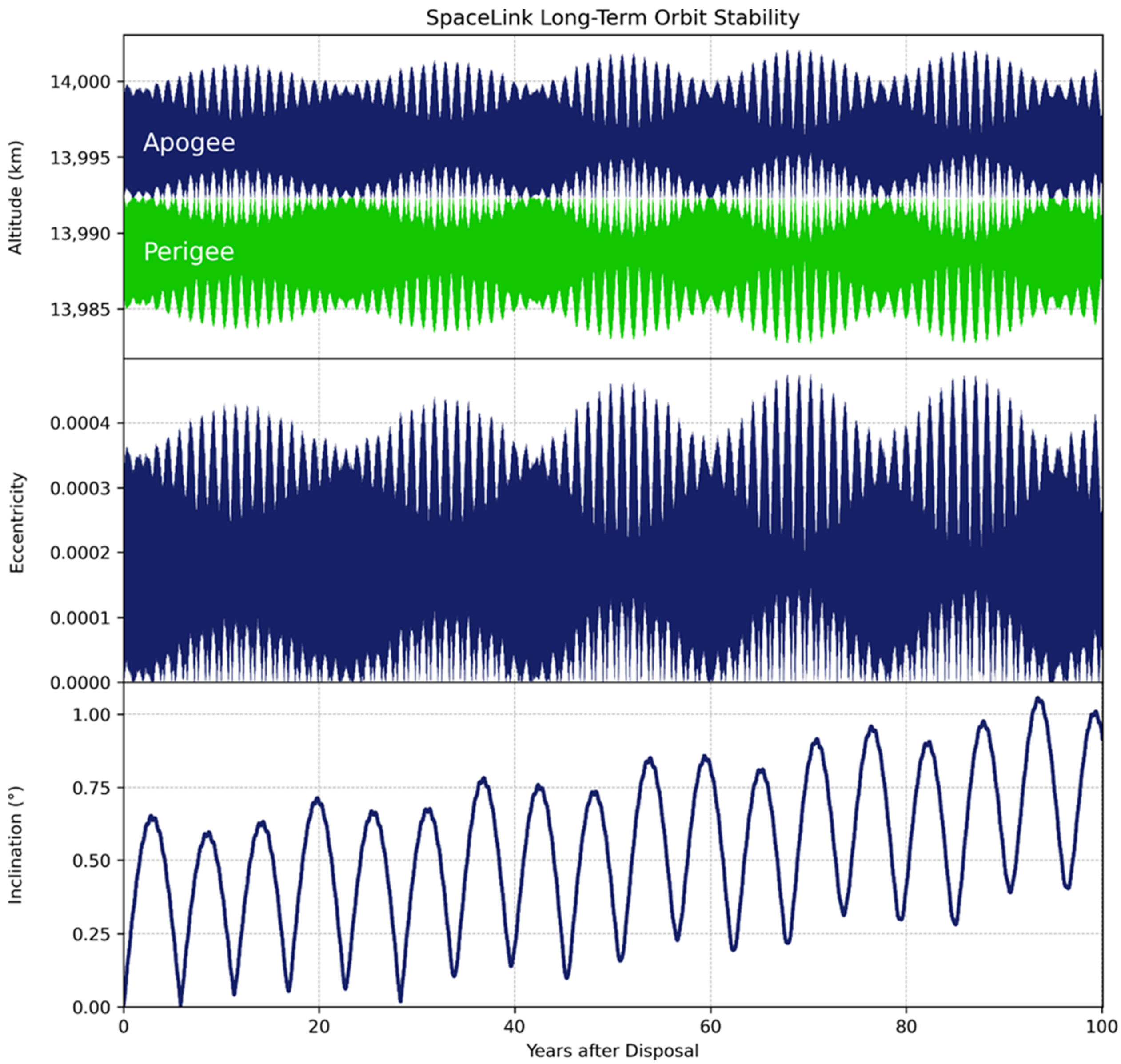
Given that the SpaceLink System satellites' operational orbit qualifies as a storage orbit without the need to undertake any further maneuvers following mission completion, SpaceLink assesses the probability of successful space station disposal at 100 percent. Nevertheless, SpaceLink has high confidence in the reliability of all four proposed satellites to undertake a final orbit-raising maneuver into a preferred storage orbit that is at least 100 km in altitude above the system's nominal operational orbit. All components of the spacecraft bus and propulsion subsystem necessary to perform the proposed disposal maneuvers have extensive flight heritage, and SpaceLink will have been operating the propulsion subsystem for a decade prior to ending each satellite's mission and performing the disposal orbit-raising maneuver.[23] Again, even in the worst case where a failure renders a SpaceLink satellite unable to perform the disposal orbit-raising maneuver, its operational orbit is itself an effective storage orbit, being thousands of kilometers removed in altitude from the nearest operational space systems (22,000 km from GEO, 12,000 km

[23] SpaceLink is evaluating the integration of an exterior physical interface to enable a space-based maintenance or recovery vehicle to rendezvous with and service SpaceLink System satellites. Given the gestational state of space-based commercial maintenance/recovery vehicles, and the lack of a definitive industry standard for a physical interface to facilitate the docking or tethering together of satellites, it is unclear at this juncture if SpaceLink will have adequate time to incorporate this feature into its initial spacecraft. Time permitting, such a feature will further enhance SpaceLink's ability to recover satellites that may have experienced a problem with their propulsion system or that may otherwise be non-responsive or disabled. SpaceLink will inform the FCC if such a feature is incorporated.

from LEO, 6,300 km from GPS, 5,800 km from O3b) including the other satellites in SpaceLink's system.

SpaceLink has analyzed the long-term stability of its proposed storage orbit using an industry-standard, high-precision propagator. This analysis included the EGM2008 Earth gravitational model up to order and degree 21, the gravitational effects of the Sun and Moon, solar radiation pressure with Earth and Moon eclipses, and atmospheric drag. The results of this analysis are shown in Figure A.10-1 and demonstrate that the storage orbits are extremely stable: 100 years after placement in the storage orbits, the satellites' inclination will not exceed 1.1°, and their altitudes of perigee and apogee will not have deviated from the intended storage orbit by more than 10 km. SpaceLink is confident that its proposed disposal solution will not present a hazard to GEO, GPS, O3b, LEO, or future users of SpaceLink's 8-hour orbit.

Figure A.10-1: The orbital parameters of SpaceLink's storage orbit over 100 years.



A.11 ADDITIONAL INFORMATION CONCERNING DATA IN THE ASSOCIATED SCHEDULE S (§25.114(c))

The associated Schedule S information for the modified SpaceLink system was prepared using the FCC's online Schedule S software.[24] The data provided in the Schedule S is consistent with the latest available FCC instructions.[25]

The following notes are provided related to the data provided in the accompanying Schedule S for the SpaceLink system:

1. Circular polarization is used for all satellite transmitting and receiving beams and therefore there is no polarization alignment angle. However, the Schedule S online software defaults to a value of 45° for the polarization angle when circular polarization is selected, and this value cannot be changed, so it should be ignored.

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24 Schedule S software is available at https://enterprisefiling.fcc.gov/schedules/.

25 *See* SPECIFIC INSTRUCTIONS FOR SCHEDULE S, April 2016, available at https://enterprisefiling.fcc.gov/schedules//resources/Instructions%20for%20Schedule%20S%20vApr2016.pdf .

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application and that it is complete and accurate to the best of my knowledge and belief.

/s/ Richard Barnett

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