**Annex**

**Coexistence Study**

SpaceX has summarized results of a recent simulation campaign conducted to assess the worst-case aggregated interference incurred by Amazon LEO system due to either new installation or upgrade of a Starlink gateway (GW) site that consists of forty (40) 1.85-meter diameter, i.e., V4, antennas. The analysis includes an interference assessment to both, an Amazon LEO Gateway (GW) (downlink and uplink, respectively) and separately, an Amazon LEO user terminal (UT) (downlink and uplink, respectively). The simulations conservatively assume that both Amazon LEO ground station (GW or UT) and the Starlink GW site are collocated at Bude, England (51.5080N, -0.0952 E) and operate in the same frequency band (co-frequency).

**Orbital Configurations**

Orbital configuration for Amazon LEO system consisting of 3236 satellites is shown in Table A- 1 and were obtained from [1].

*Table A- 1 Amazon LEO Orbital Parameters*

| | | | |
|---|---|---|---|
| Orbital Altitude (km) | 590 | 610 | 630 |
| Inclination (deg) | 33° | 42° | 51.9° |
| Orbital Planes | 28 | 36 | 34 |
| Satellites per Plane | 28 | 36 | 34 |

For Starlink, SpaceX has conservatively simulated interference from its Gen2 system comprising of 29,988 satellites based on the representative orbital configurations tabulated in **Table A- 2**.

*Table A- 2 SpaceX Gen2 Constellation's Representative Orbital Configuration*

| Altitude (km) | Inclination | Planes | Satellites per plane | Satellites |
|---|---|---|---|---|
| **480** | 53° | 56 | 90 | 5040 |
| **485** | 43° | 56 | 120 | 6720 |
| **475** | 32° | 28 | 60 | 1680 |
| **340** | 53° | 72 | 50 | 3600 |
| **345** | 48° | 72 | 50 | 3600 |
| **355** | 43° | 72 | 50 | 3600 |
| **350** | 38° | 72 | 50 | 3600 |
| **365** | 32° | 18 | 58 | 1044 |
| **360** | 96.9° | 30 | 32 | 960 |
| **604** | 148° | 12 | 12 | 144 |
| **614** | 115.7° | 18 | 0 | 0 |
| **Total Satellites** | | 29,988 | | |

**Simulation Setup**

To demonstrate the interference that Starlink GW system could cause, SpaceX designed its simulation steps to allow use of dual interference metrics as suggested by OFCOM non-GSO satellite earth stations licensing guideline 2.10—increase in unavailability for short-term interference and degradation of time-averaged spectral efficiency for long-term interference.

Regarding the simulation methodology, SpaceX performed each of the time-domain simulations at one second time-steps and 5 days' worth of simulation. At each time step, both the C/N and carrier-to-noise plus interference, C/ (N+I), values are calculated, for both Amazon LEO downlink and uplink for each type of its earth station, where the Starlink's GW system is the interference source. For the C/N and C/(N+I)

values calculated at a time step, SpaceX incorporates all atmospheric attenuation characteristics (see Recommendation ITU-R P.618 and references therein) that both systems may experience, including degradation due to atmospheric gases, rain, cloud cover, and scintillation. Each calculated C/N and C/(N+I) value at a time step is recorded in an array, where these paired values are accumulated over the simulation duration. These arrays for Amazon LEO downlink and uplink operations were then sorted and processed into cumulative distribution functions (CDFs, which allow for calculation of short-term and long-term interference of the four cases described further below.

For each case, four figures of merit are provided to show the impact of interference from Starlink's proposed new or updated GW system into Amazon LEO's service. The first two are the baseline availability percentages and availability percentages with Starlink's GW in operations at objective C/N of 0 dB as well as the graphical figure from which these values were derived, which demonstrate how interference impacts Amazon LEO's C/N. The third is the reduction in availability due to Starlink's GW, which is the difference between Amazon LEO's baseline availability percentages and availability percentages with Starlink's GW at this objective C/N. Finally, the fourth is the degradation of Amazon LEO's time-averaged spectral efficiency, showing Amazon LEO's throughput loss due to Starlink's GW.

**Assumptions**

SpaceX assumes that both the Starlink and Amazon LEO systems maintain constant power flux density and Effective Isotropic Radiated Power ("EIRP") for downlink and uplink transmissions, respectively. SpaceX also assumes complete bandwidth overlap and a single receive polarization to enable analysis on a per-Hertz basis without the potential for discrimination. The interference simulations use a random pointing strategy as a proxy for simulating satellite selection for Amazon LEO systems. For Starlink, a topology-based empirical distribution is used for satellite selection simulation.

**Parameters and Results**

Table A- 3 to Table A- 10 specify the parameters and summarize the outcome of the simulation studies summaries for each scenario. The parameters for each case are specified just before that case summary.

**[CONFIDENTIAL ✂]**

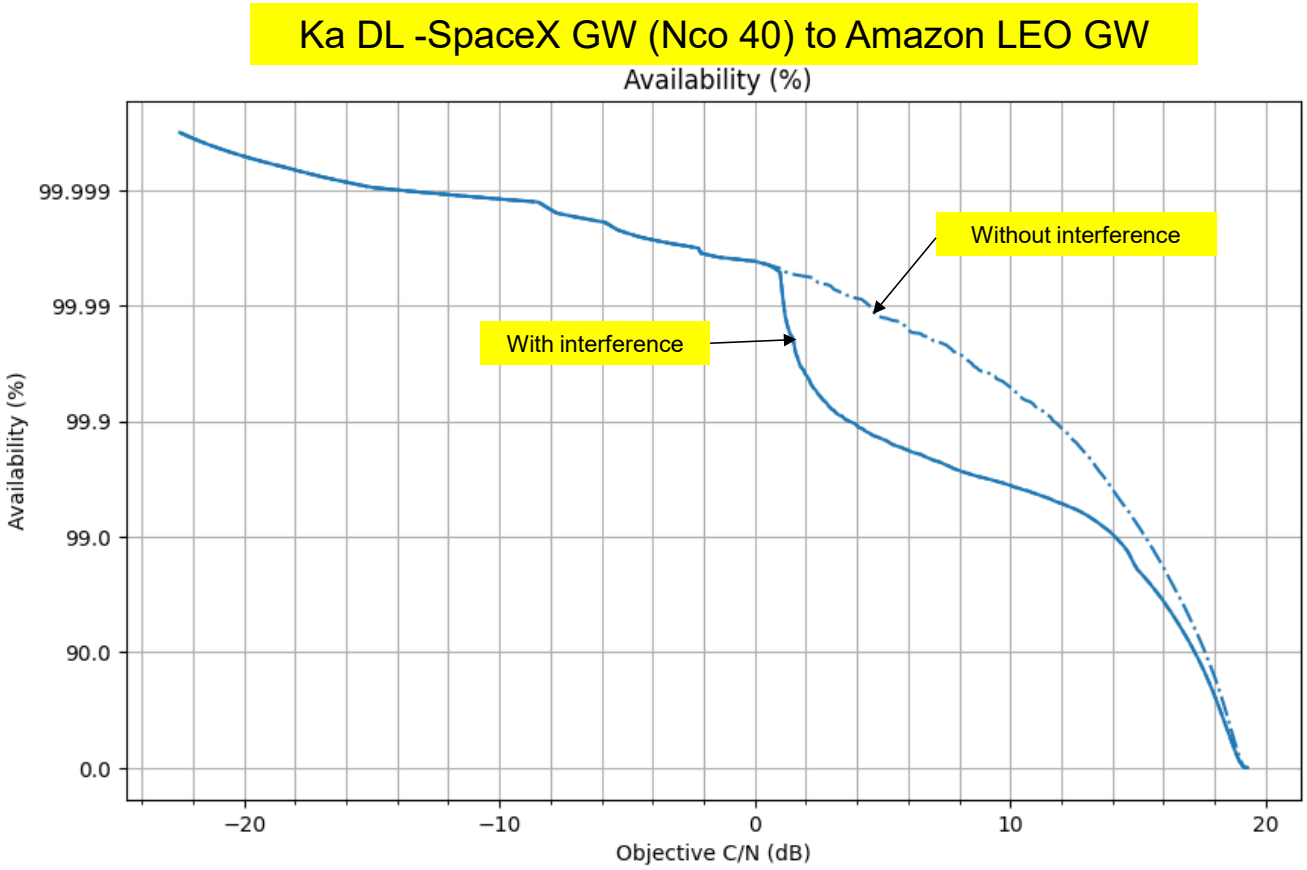


*Table A- 4 Downlink (Amazon LEO GW) Analysis Summary:*

| Baseline Availability (%) | Availability with STARLINK (%) | Difference in Availability (due to STARLINK GW) (%) | Avg. Throughput Degradation (due to STARLINK GW) (%) |
|---|---|---|---|
| 99.996 | 99.996 | 0 | 1.3 |

**[CONFIDENTIAL ✂]**

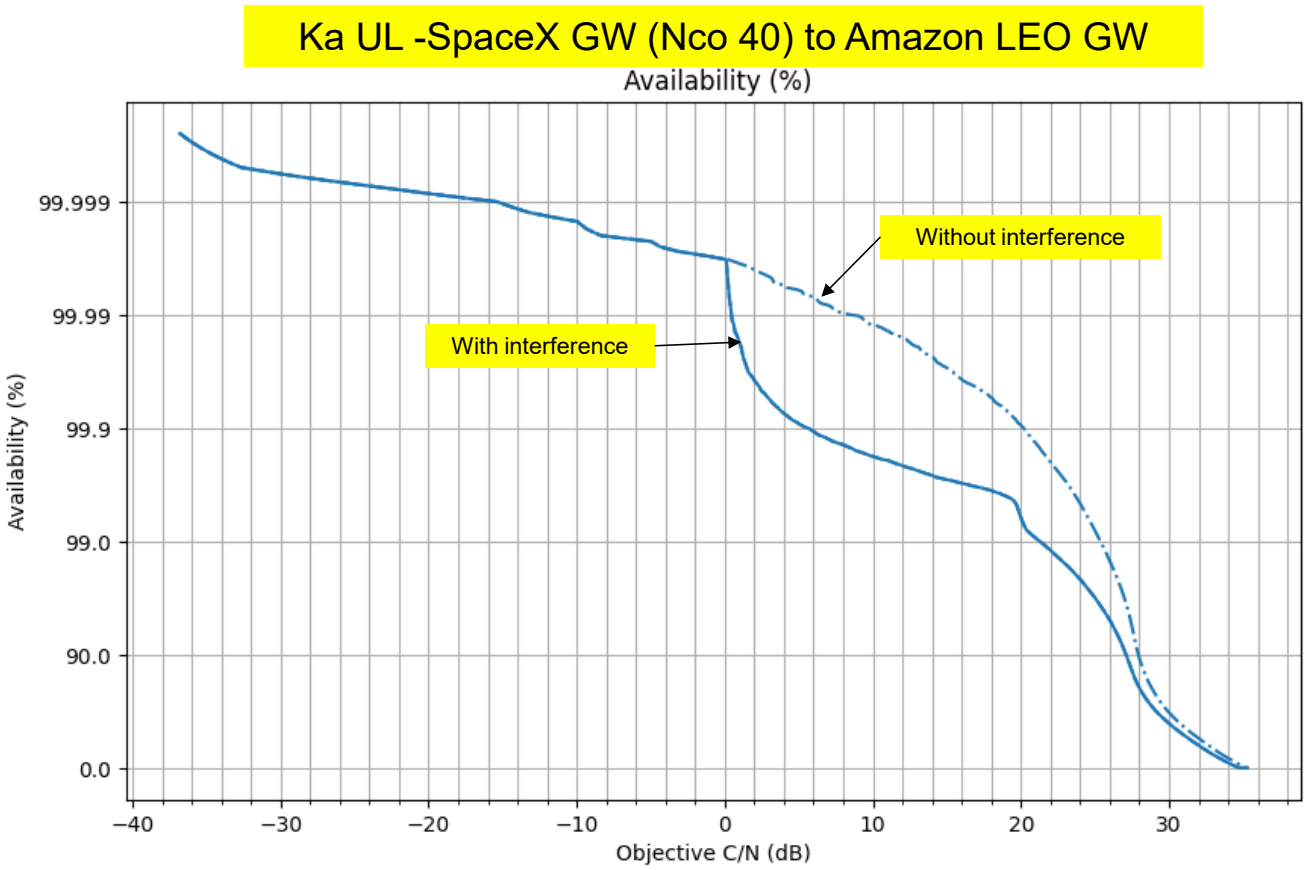


*Table A- 6 Uplink (Amazon LEO GW) Analysis Summary*

| Baseline Availability (%) | Availability with STARLINK (%) | Difference in Availability (due to STARLINK GW) (%) | Avg. Throughput Degradation (due to STARLINK GW) (%) |
|---|---|---|---|
| 99.996 | 99.996 | 0.0 | 0.42 |

**[CONFIDENTIAL ✂]**

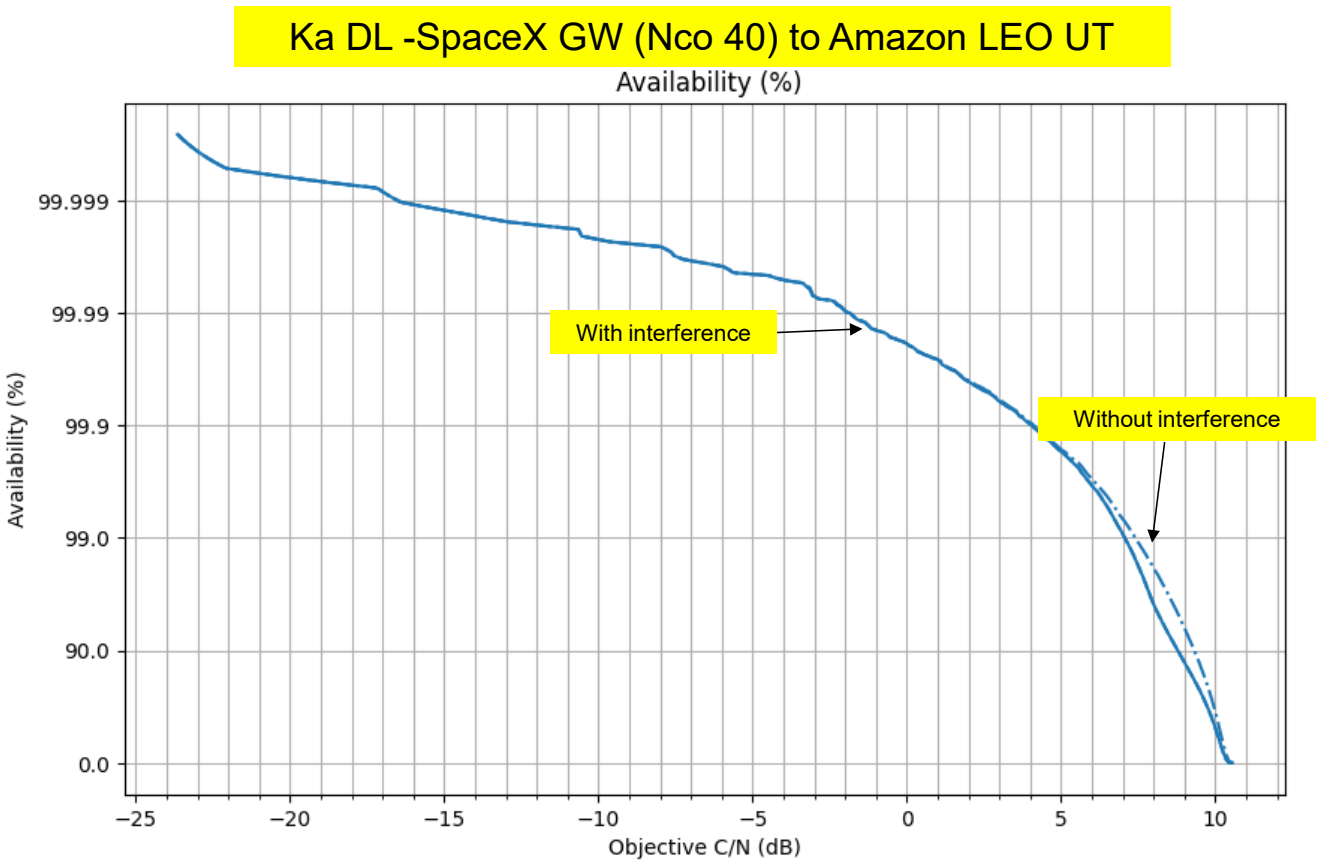

*Table A- 8 Downlink (Amazon LEO UT) Analysis Summary:*

| Baseline Availability (%) | Availability with STARLINK (%) | Difference in Availability (due to STARLINK GW) (%) | Avg. Throughput Degradation (due to STARLINK GW) (%) |
|---|---|---|---|
| 99.981 | 99.981 | 0 | 1.71 |

**[CONFIDENTIAL ✂]**

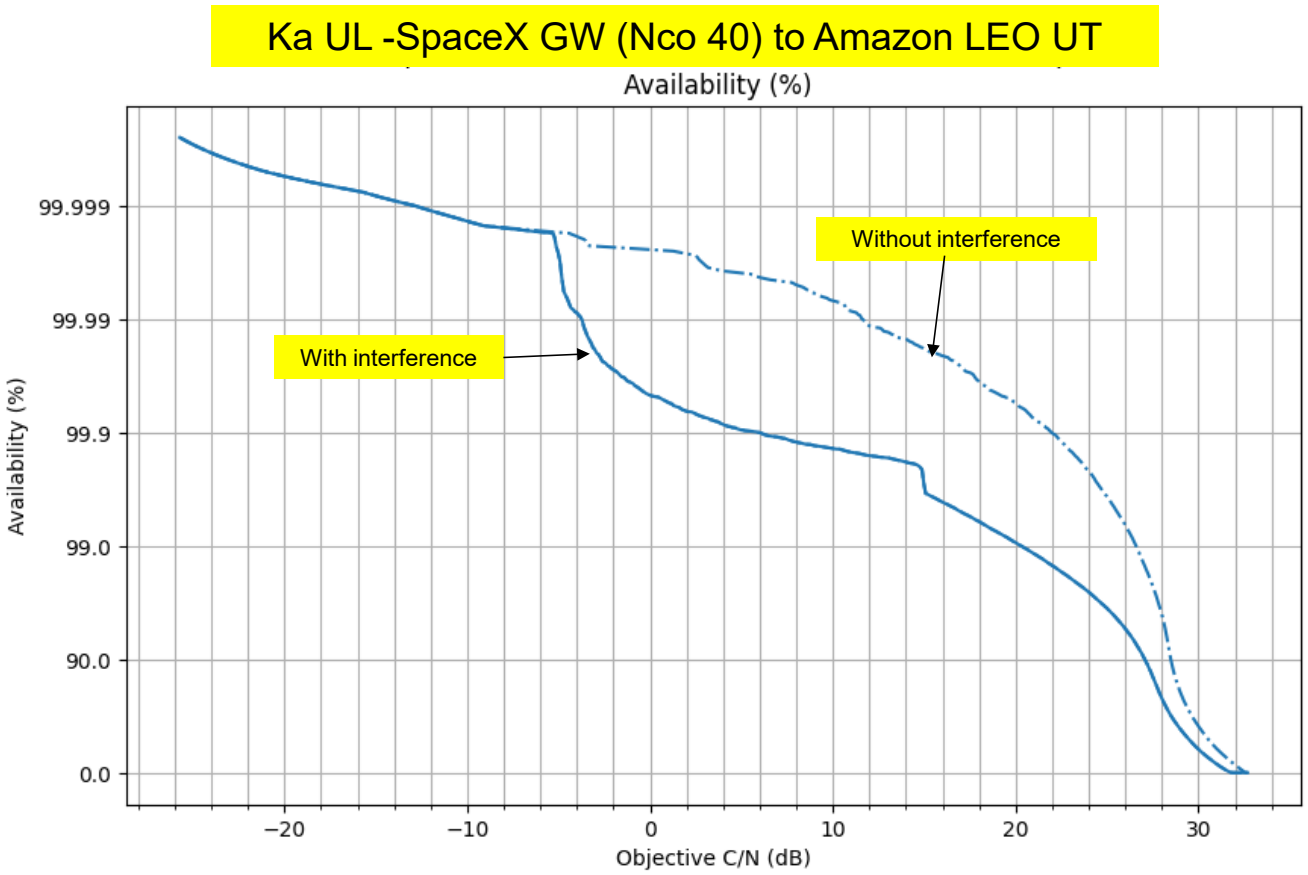


*Table A- 10 Uplink (Amazon LEO UT) Analysis Summary*

| Baseline Availability (%) | Availability with STARLINK (%) | Difference in Availability (due to STARLINK GW) (%) | Avg. Throughput Degradation (due to STARLINK GW) (%) |
|---|---|---|---|
| 99.997 | 99.953 | 0.044 | 0.568 |

**Summary:**

SpaceX's analysis confirms that no harmful interference is incurred by an Amazon LEO system even under some very conservative assumptions such as hypothetical collocation of the two systems i.e., Starlink GW and Amazon ground station (GW or UT). Furthermore, the interference environment is expected to be more benign than what was modelled in this study due to spatial separation between the two systems during actual deployment.

**References:**

[1]: SAT-LOA-20190704-00057 Sched S Tech Report
https://licensing.fcc.gov/myibfs/download.do?attachment_key=1773983