I. Introduction

This document is an annex to the application of Amazon Kuiper UK Limited (hereinafter "Kuiper") for a satellite (non-geostationary earth station) licence in Bude, Cornwall, UK, and addresses the criteria set out in Section D of Ofcom's satellite (non-geostationary earth station) radio licence application form: non-geostationary – OfW564.[1]

This document provides:

- in Section II, a description of the Kuiper System including relevant technical information related to operating frequencies, the system architecture, and services offered to customers;
- in Section III, a detailed technical assessment demonstrating the ability of the proposed Kuiper System gateway to coexist with (i) other non-geostationary satellite orbit ("NGSO") systems licensed in the United Kingdom (the "UK"); (ii) other NGSO systems which have been applied for in the UK at the date of Kuiper's application, and (iii) specific co-frequency earth stations registered with the International Telecommunications Union ("ITU") as identified by Ofcom as needing to be considered by applicants as part of their co-existence analysis; and
- in Section IV, a justification for the ability of the proposed Kuiper System gateway to coexist with future NGSO systems licensed in the UK.
- in Section V, we have provided the competitive impact of issuing Kuiper a satellite (non-geostationary earth station) radio licence in terms of: any risks to competition in the UK, including the benefits for UK customers, end consumers and/or citizens.

As evidenced by the information provided in this document, the proposed Kuiper System gateway is able to coexist with existing NGSO satellite systems that are licensed in the UK, NGSO satellite systems for which an application has been made and which has been published for comment on Ofcom's website, and other specific co-frequency earth stations registered with the ITU as identified by Ofcom.

Further, the Kuiper System is designed with flexibility to operate with future NGSO systems without creating any coexistence issues in the UK.

II. Description of the Kuiper System

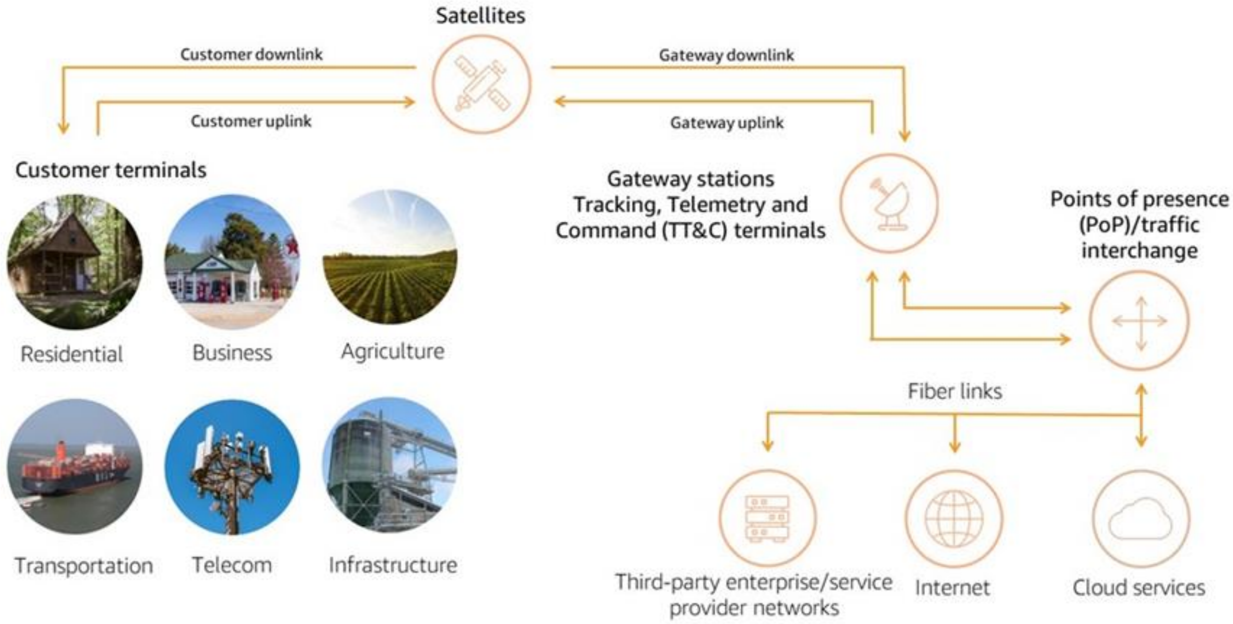
Technical Information:

The Kuiper System uses frequencies allocated to the fixed-satellite service ("FSS") and mobile-satellite service ("MSS") in the Ka-band (portions of the 17.7-20.2 GHz and 27.5-30 GHz[2]). The operator of the Kuiper System is Kuiper Systems LLC, a limited liability company organized in Delaware, U.S.A. Both the operator of the Kuiper System – Kuiper Systems LLC – and the applicant – Amazon Kuiper UK Limited – are wholly owned subsidiaries of Amazon.com, Inc. (all entities collectively referred to as "Amazon"). Amazon will operate and control the network. The architecture of the Kuiper System is described below:

[1] https://www.ofcom.org.uk/siteassets/resources/documents/manage-your-licence/satellite-earth-stations/forms/ofw564.pdf (accessed on April 16, 2025).

[2] Detailed technical information and frequency channels are included in the attached earth station technical parameter spreadsheets.

Block Diagram of the Architecture of the System:



Description of the System:

Kuiper will operate the earth stations as described below in various locations around the world.

Gateway earth stations: Gateway earth stations will be distributed throughout the service area of the Kuiper System such that each Kuiper satellite can ideally access two (2) different gateway earth stations at a time. Traffic from multiple gateway sites is aggregated via terrestrial fibre backhaul links to an internet Exchange Point or Point-of-Presence ("PoP") site where the Kuiper System connects with terrestrial backbone infrastructure.

Customer Terminals: The Kuiper System will communicate with a range of customer terminals, including enterprise, consumer and mobility (e.g., maritime, aeronautical and land-mobile) terminals using either electronically steered phased array antennas or mechanically steered parabolic antennas. Amazon will operate such customer terminals in the UK pursuant to its Satellite (Earth Station Network) Licence (licence number 1377636/1).

The current satellite (non-geostationary earth station) licence application before Ofcom is in respect of a Kuiper gateway earth station to be operated in Bude, Cornwall, UK, which will become operational in Q4 2025.

Services:

Kuiper plans to offer the following electronic communications services to customers, end consumers and/or citizens in the UK:

1. retail internet access and connectivity services to consumers, enterprises, government, and public entities, via satellite;
2. wholesale internet access services and connectivity to local/regional partners who will on-sell services to enterprise users and public entities in-country, via satellite; and
3. backhaul services to telecommunications carriers, via satellite.

Kuiper will offer these services through a flexible, high-performance NGSO FSS system that includes satellites, customer terminals, gateway stations, and global networking and infrastructure (see the "Description of the System" sub-section of this Section II above for details in respect of what earth stations will be operated within the UK).

Functional Description of the Services:

1. Internet access (Retail and Wholesale): Kuiper will deliver secure, high-speed, low-latency broadband services for a variety of customers, including individual households, schools, hospitals, government offices, businesses of all sizes, first responders, disaster relief operations, etc.

   Customers may choose to self-install or use a professional technician to install the Kuiper customer terminal, a compact phased array antenna that allows each customer to communicate with satellites passing overhead.

2. Backhaul services to telecommunications carriers: Kuiper will offer backhaul connectivity to telecommunications carriers transporting customer traffic between a point of interconnect and the internet.

Geographical Scope of Services:

Kuiper plans to offer the services described above throughout the UK.[3]

III. Coexistence with Existing Systems

Ofcom instructions in application form OfW564 (p. 3): This is a multipart question for explaining how your proposed non-geostationary earth station(s) ("Gateways") will be able to coexist with the following:

- **Existing non-geostationary satellite systems that are licensed in the UK**
- **Non-geostationary satellite systems for which an application has been made and which has been published for comment on Ofcom's website**
- **Other specific co-frequency earth stations registered with the ITU**

Kuiper has reviewed the list of existing NGSO system licensees on the Ofcom website to determine which systems require a coexistence assessment (as of the date of this application).

The list provided in Table 1 below includes Network Access Associates Ltd ("OneWeb"), Starlink Internet Services Limited ("Starlink"), Telesat LEO Inc ("Telesat Lightspeed"), Mangata Edge Ltd ("Mangata"), Rivada Space Networks GmbH ("Rivada"), NSLComm Ltd ("NSLComm") and Kepler Communications Inc ("Kepler").

Table 1: Existing NGSO Earth Station Networks Licensed in the UK[4]

Licensee	Licence number	Date first issued
Kepler Communications Inc.	1384465	2 May 2025
NSLComm LTD	1364328	16 September 2024
Rivada Space Networks GmbH	1347891	29 April 2024

[3] The coverage limit of Kuiper's first-generation NGSO system is 56 degrees latitude North. In successive generations, Kuiper plans to cover latitudes above 56 degrees latitude North.

[4] Available at https://www.ofcom.org.uk/spectrum/space-and-satellites/non-geo-fss/ (accessed on April 16, 2025).

Mangata Edge Ltd	1309175	22 March 2023
Telesat LEO Inc	1297041	14 November 2022
Starlink Internet Services Limited	1239247	16 November 2020
Network Access Associates Ltd	1102679	9 November 2016

Ofcom's "non-geostationary satellite earth stations licensing guidance" (the "Ofcom Guidance") sets out that the preferred method for an applicant to demonstrate coexistence is through reaching a coordination agreement with each relevant system.[5] For this reason, Kuiper confirms that it has already completed coordination, and can coexist, with the Telesat Lightspeed™ system (as currently licenced by Ofcom), under a coordination agreement with Telesat.[6]

The Ofcom Guidance provides that where an ITU coordination agreement is not in place, applicants should specify in detail how the different systems can co-exist, and provide evidence that reasonable measures can be put in place by the applicant or the existing licensee (or both) to achieve coexistence. To achieve this, in respect of the remaining existing systems, Kuiper has undertaken a coexistence assessment to demonstrate its ability to coexist with such existing systems. In respect of these demonstrations, Kuiper determined there is no frequency overlap between the Kuiper System and the Kepler System[7] and, therefore, we do not include the Kepler System in the demonstrations as there will not be interference between these two systems in the UK. The OneWeb system uses Ku-band frequencies for their user links and Ka-band frequencies for their gateway links. Since the Kuiper System does not use Ku-band frequencies and OneWeb does not have any licenced or operational gateway stations in the UK, there is no frequency overlap between the Kuiper System and the OneWeb System in the UK and thus these systems can coexist. For the remaining systems that Kuiper has not yet reached a coordination agreement with and where there is a frequency overlap (i.e., NSLComm, Mangata, Rivada, and Starlink), we provide demonstrations that show the impact of the proposed Kuiper System gateway on each of the licensed systems would be modest in terms of reduction in throughput and increased unavailability.

Background to NGSO Coexistence Assessment:

The demonstrations Kuiper prepared are supported by interference analysis to assess the ability of two (2) NGSO systems to coexist while serving customers, end consumers and/or citizens in the UK. These assessments rely on methodologies to compute throughput degradation and increased unavailability metrics. First, the interference simulations compute statistics on each systems Carrier-to-Noise ("C/N") ratio in a non-interfered scenario while still considering atmospheric losses using ITU Recommendations ITU-R P.618 and ITU-R P.676. Second, the simulations compute each systems Carrier-to-Noise-plus-Interference ("C/[N+I]") ratio to determine the impact of the potential interference from the Kuiper System while still considering atmospheric losses. The C/N and C/[N+I] statistics are converted into spectral efficiency using ITU Recommendation ITU-R S.2131-1 and the average throughput degradation is computed. Additionally, the likelihood a system is unavailable (C/N or C/[N+I] < -3 dB) is computed for both the non-interfered and interfered scenarios and compared. This results in the increase in unavailability metric defined as $\text{Unavail}_{\text{INT}} - \text{Unavail}_{\text{ORIG}}$ where $\text{Unavail}_{\text{ORIG}}$ is the unavailability of a system without any

[5] Section 2.9, Ofcom's NGSO Licensing Guidance (accessed on April 16, 2025).

[6] Please see paragraph 8 of Kuiper Systems LLC, Request for Modification of the Authorization for the Kuiper NGSO Satellite System, Order and Authorization, DA 24-224 (rel. March 8, 2024) (FCC notes that Kuiper has completed coordination with Telesat Canada, Space Norway AS, and O3b Limited), available at: https://docs.fcc.gov/public/attachments/DA-24-224A1.pdf (accessed on April 16, 2025). Additionally, please see the "Kuiper-Telesat Coordination Letter" listing (filed September 21, 2022) on this page: https://licensing.fcc.gov/cgi-bin/ws.exe/prod/ib/forms/reports/related_filing.hts?f_key=-434810&f_number=SATLOA2019070400057 (accessed on April 16, 2025).

[7] Kepler specifies they rely on the KELYPSIS ITU satellite network filing for their study, which does not include any Ka-band frequencies.

interference from the Kuiper System and $Unavail_{INT}$ is the unavailability of a system including interference from the Kuiper System.

Kuiper has performed the analysis assuming that a Kuiper System earth station is collocated with an existing earth station of the other existing NGSO system. The ground location where the earth stations are placed in the analysis is set to the proposed Kuiper System gateway in Bude, Cornwall, UK: 50.797611 °N, -4.50075 °E. The simulation is run for over 1,000,000-time steps. At each time step, a selection algorithm determines which satellites are actively serving each earth station. This algorithm considers the minimum elevation angle and the GSO arc avoidance constraints for each system to determine the eligible satellites and then randomly selects from that pool.

Kuiper has made a number of conservative assumptions in this analysis to demonstrate that coexistence is possible even in worst-case scenarios. This ensures coexistence will be possible in realistic operational scenarios. The assumption that earth stations for both NGSO systems will be collocated is quite conservative. In reality, there will likely be some distance between these earth stations, which leads to reduced levels of interference. Kuiper uses maximum values for radio frequency ("RF") parameters which will operationally vary at levels below the simulated values. In addition, Kuiper models both systems using 100% bandwidth overlap for all time steps. In practice, the bandwidth overlap may be less than 100% depending on each systems operational plan and real-time usage.

In **Appendix A** to this document, Kuiper provides the set of analysis assumptions used for each NGSO system. These assumptions are taken from associated ITU satellite network filings, coexistence studies provided to Ofcom from the other systems, or from regulatory filings made to the Federal Communications Commission in the USA.

Summary of NGSO Coexistence Assessment:

The results of the coexistence analysis simulations are shown in Table 3 below. Each system has been analysed for the potential interference from a Kuiper gateway station in both the uplink (Earth-to-space) and downlink (space-to-Earth) directions. The results are shown in terms of average degraded throughput and absolute increase in unavailability. These results show that the proposed Kuiper System gateway will have minimal impact on the existing and applicant NGSO systems studied and thus provides evidence of the ability of the proposed Kuiper System gateway to coexist with other systems. Under real-world conditions with operational power levels, dynamic demand-based bandwidth usage, and separation distance between earth stations, the increase in unavailability and throughput degradation would be further reduced. The detailed assumptions, resulting statistical plots and interference levels for each system are provided in **Appendix A** to this document.

Table 2: Summary of Coexistence Assessment

NGSO System	Earth Station	Uplink		Downlink	
		Degraded Throughput (%)	Increased Unavailability (%)	Degraded Throughput (%)	Increased Unavailability (%)
Mangata	Collocated Customer Terminal	0.17	0.000000	0.71	0.00592
NSLComm	Collocated Customer Terminal	1.06	0.0117	0.48	0.0182
Rivada	Collocated Customer Terminal	0.06	0.000003	0.20	0.000003
Starlink	Collocated 1.5-meter Gateway	0.26	0.00458	0.35	0.00203
	Collocated 1.85-meter Gateway	0.13	0.000000	0.26	0.00118

Coexistence with Other Co-Frequency Earth Stations:

Kuiper will operate in accordance with agreed coordination terms to protect specific co-frequency earth stations subject to coordination under provisions No. 9.7A and No. 9.7B of the ITU Radio Regulations.

IV. Coexistence with Future NGSO Systems

Ofcom instructions in application form OfW564 (p. 3): You need to state what flexibility your Gateways have to coexist with future non-geostationary satellite systems. You should include measures you would be able to put in place if another non-geostationary satellite system were to enter the market in the future, and the expected benefits of such measures. Also state what measures future non-geostationary satellite systems could reasonably be expected to put in place to coexist with your Gateways.

The Kuiper System is designed as a flexible system, by implementing sophisticated frequency and beam planning algorithms, adaptive coding and modulation techniques, and often has redundant communication paths for unforeseen outages or interference. The Kuiper System plans the frequency allocations between satellites and gateway earth stations. Planning software has been designed to consider regulatory constraints and implements frequency stay-out zones, satellite avoidance angles, or power reductions in specific areas. In addition, we plan to coordinate in good faith with any future NGSO system as a first step to achieving compatibility.

The Kuiper System leverages the inherent properties of the Ka-band frequencies, resulting in narrow beamwidths for our satellites and earth stations. Narrow beams ensure that energy transmitted is only received in areas near the intended receiver. Other unintended receivers observe significantly reduced levels of interference because of the narrow beamwidths. It also ensures that the Kuiper System receivers reject unintended interference from other systems. This is a highly efficient use of spectrum because it does not prohibit other NGSO systems from using co-frequency spectrum. There may be future NGSO systems that implement earth and space stations with very large EIRP density levels relative to those used by the Kuiper System. Those hypothetical systems may need to implement reasonable mitigation measures for earth stations in close proximity to authorized earth stations in order to protect existing NGSO system licensees. These would be the same type of mitigation techniques the Kuiper System has the ability to implement such as satellite avoidance angles to limit interference to the Kuiper System.

V. Competitive Impacts

Ofcom instructions in application form OfW564 (p. 3): This is a multipart, optional question for explaining the impact of issuing you a licence (combined with other non-geostationary satellite system licences held or applied for by you) in terms of:

- **Any risks to competition in the UK. This may refer to the ability to coexist with other non-geostationary satellite systems.**
- **Benefits for UK customers, end consumers and/or citizens.**

Issuing a satellite (non-geostationary earth station) licence to Kuiper does not pose any risks to the competitive landscape of broadbands access services in the UK. As demonstrated in our coexistence study, the Kuiper System is able to coexist with other existing and applicant NGSO systems, GSO systems, and FSS services in the UK. Issuance of this license does not prohibit future NGSO systems from operating in the UK.

The Kuiper System will provide high-speed, low-latency broadband services to households, businesses and other customers in the UK, benefiting competition by providing additional high-quality satellite-based connectivity options for users in the UK. Our primary goal will be to connect households and Small and Medium Businesses which do not have access to at least 100mbps speed. Further to this, Kuiper's broadband services have the capability of connecting customers in some of the hardest to reach locations in the UK, aligning with the UK Government's goals for nationwide coverage for gigabit broadband by 2030. We expect more than 75% of our customers to be located outside the South East of England, including Wales and Scotland. For Enterprise customers, we will provide backup, primary and temporary connectivity for Retail, Energy, Media & Entertainment, Manufacturing, Agriculture, Construction and Infrastructure applications.

Appendix A: Coexistence Assessments with Existing and Applicant Systems

Simulation Assumptions

Table A-1: Orbital Assumptions

	Kuiper	SpaceX	Mangata	Rivada	NSLComm
Number of Satellites	3232	4408	791	576	264
Number of Planes	289, 1292, 782, 1	72, 72, 36, 6, 4	9, 9, 9, 8, 8, 8, 8	24	12
Satellites per Plane	4, 1, 1, 2	22, 22, 20, 58, 43	21, 21, 21, 7, 7, 7, 7	24	22
Inclination (deg)	30, 33, 42, 51.9	53, 53.2, 70, 97.6, 97.6	45, 50, 52.2, 63.4, 63.4, 63.4, 63.4	89	53
Apogee (km)	590, 590, 610, 630	550, 540, 570, 560, 560	6400, 6400, 6400, 11585, 11024, 9800, 9000	1050	720
Perigee (km)	590, 590, 610, 630	550, 540, 570, 560, 560	6400, 6400, 6400, 1215, 1776, 3000, 3800	1050	720

Table A-2: Detailed Kuiper System Orbital Assumptions

	Sub Constellation 1	Sub Constellation 2	Sub Constellation 3
Number of Satellites	1156	1292	782
Number of Planes	289	1292	782
Satellites per Plane	4	1	1
Inclination (deg)	51.9	42	33
Apogee (km)	630	610	590
Perigee (km)	630	610	590
Sub-constellations 1, 2, and 3 are associated with ITU filings USASAT-NGSO-8A, USASAT-NGSO-8B, and USASAT-NGSO-8C.[8]			

Table A-3: Simulation Assumptions

	Kuiper	SpaceX	Mangata	Rivada	NSLComm
Minimum Elevation Angle (deg)	20	25	15	10	15
GSO Exclusion Angle (deg)[9]	18	18	3	4	5
Satellite Selection	Random	Random	Random	Random	Random
Number of Co-frequency Antennas ("Nco")	4[10]	8	1	1	1

[8] We have recently submitted the following ITU filings, which will support future developments of the Kuiper System: KBSAT-NGSO-P-R (Germany) and USASAT-NGSO-8E and USASAT-NGSO-8F (USA). None of these recently submitted ITU filings are in use with this application for a satellite (non-geostationary earth station) license in Bude, Cornwall, UK.

[9] We assume these GSO arc avoidance angles for the purposes of this coexistence analysis, but recognize that Kuiper and other NGSO systems may operate with different GSO arc avoidance angles in practice. Based on our experience, we assess that any difference to the GSO arc avoidance angle from what is studied herein will not materially change the conclusions of this analysis.

[10] While the Kuiper System Gateway site is composed of five antennas, only four antennas will be simultaneously transmitting at any time.

Starlink Analysis

Table A-4: Kuiper and Starlink Uplink RF Parameters

Parameter	**Kuiper 2.4m GW**	**Starlink 1.5m GW**	**Starlink 1.85m GW**
Carrier Centre Frequency (GHz)	29	29	29
Bandwidth (MHz)	490	480	480
E/S Transmit Power (dBW)	10	7.96	7.96
E/S EIRP (dBW)	62.8	57.46	60.56
E/S Peak Gain (dBi)	52.8	49.5	52.6
E/S Antenna Pattern	ITU Appendix 8 Annex 3	ITU-R S.580	ITU-R S.580
E/S Antenna Diameter (m)	2.4	1.5	1.85
Sat Peak Gain (dBi)	38.2	38.5	38.5
Sat Antenna Pattern	G_{max} = 38.2 dBi Off-Axis Angle (q) : Gain [dBi] 0° to 1.88° : $G_{max} - 3*(q/0.94)^2$ 1.88° to 20° : $34 - 25*\log_{10}(q)$ 20° to 180° : 1.5	ITU-R S.1528	ITU-R S.1528
Sat Noise Temperature (K)	460	501.2	501.2

Table A-5: Kuiper and Starlink Downlink RF Parameters

Parameter	**Kuiper 2.4m GW**	**Starlink 1.5m GW**	**Starlink 1.85m GW**
Carrier Centre Frequency (GHz)	19	19	19
Bandwidth (MHz)	490	1	1
Sat Transmit Power (dBW)	Variable (See PFD)	Variable (See PFD)	Variable (See PFD)
Sat Peak EIRP (dBW)	Variable (See PFD)	Variable (See PFD)	Variable (See PFD)
Sat Peak Gain (dBi)	34.4	34.5	34.5
Sat Antenna Pattern	Gmax = 34.4 dBi Off-Axis Angle (q) : Gain [dBi] 0° to 2.92° : $G_{max} - 3*(q/1.46)^2$ 2.92° to 20° : $34 - 25*\log_{10}(q)$ 20° to 180° : 1.5	ITU-R S.1528	ITU-R S.1528
Sat PFD on Ground ($dBW/m^2/MHz$)	-123 @ 30°-90° elevation angles -125.2 @ 20° elevation angle	-126.3	-126.3
E/S Peak Gain (dBi)	49	46.9	49.1
E/S Antenna Pattern	ITU Appendix 8 Annex 3	ITU-R S.580	ITU-R S.580
E/S Antenna Diameter (m)	2.4	1.5	1.85
E/S Noise Temperature (K)	195	200	297

Figure A-1: Starlink 1.5-meter Gateway Uplink C/N and C/[N+I] Cumulative Density Function

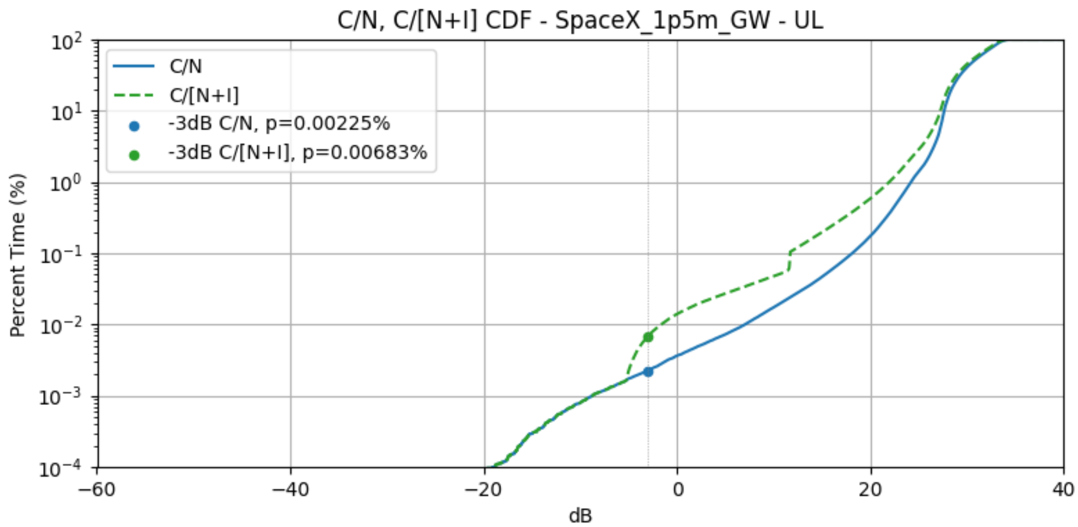


Figure A-2: Starlink 1.5-meter Gateway Downlink C/N and C/[N+I] Cumulative Density Function

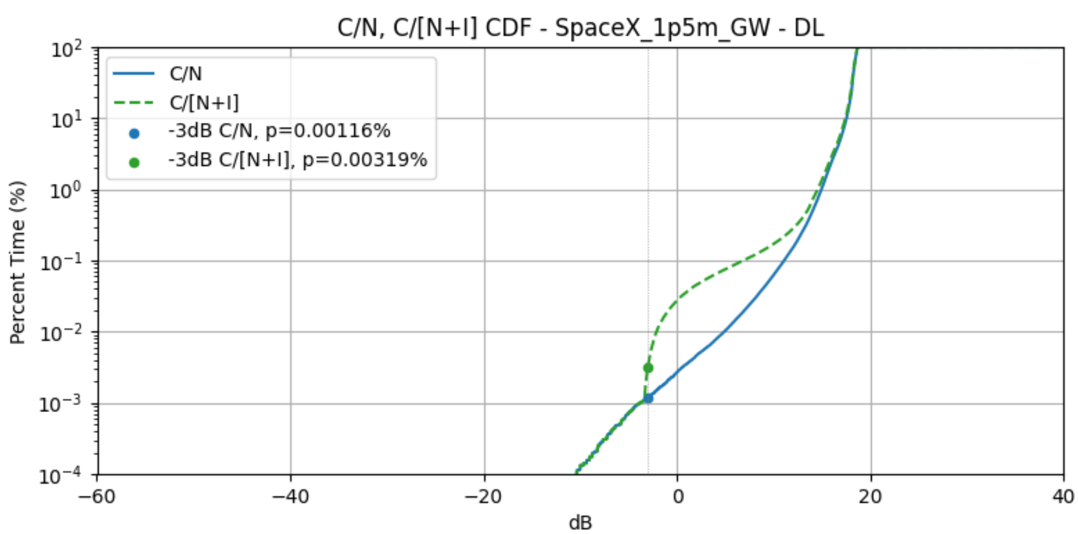


Figure A-3: Starlink 1.85-meter Gateway Uplink C/N and C/[N+I] Cumulative Density Function

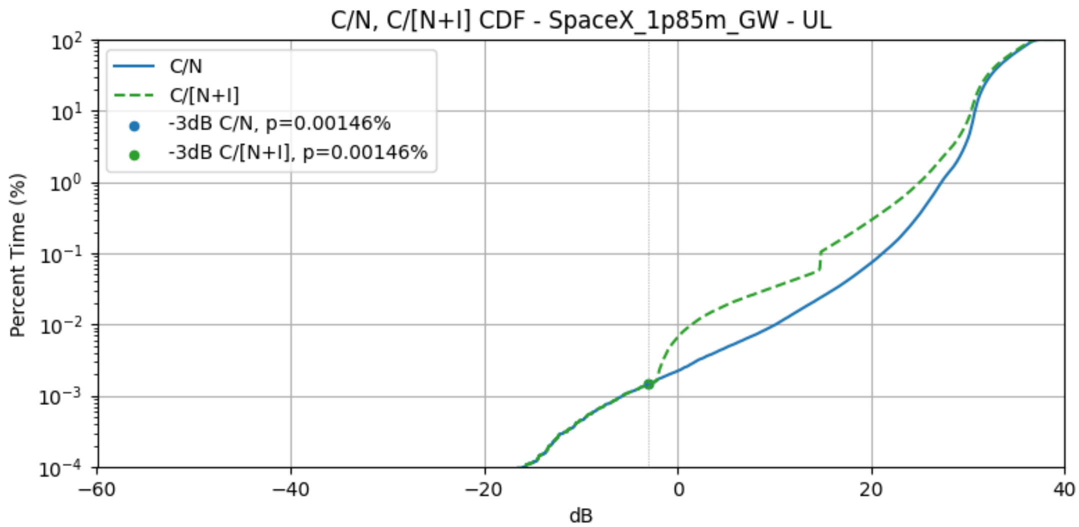


Figure A-4: Starlink 1.85-meter Gateway Downlink C/N and C/[N+I] Cumulative Density Function

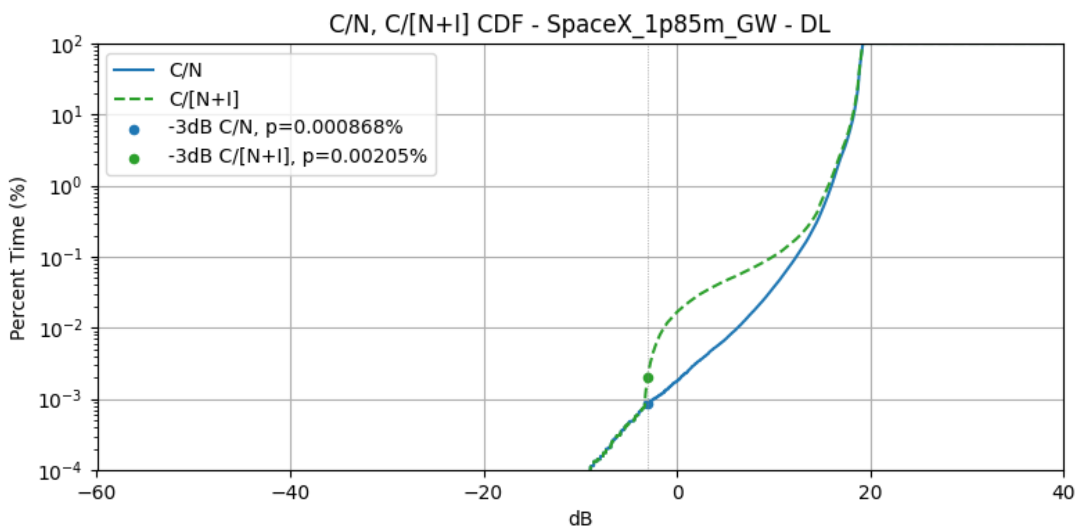


Table A-6: Starlink Interference Summary

Earth Station	Earth Station Variant	Uplink		Downlink	
		Degraded Throughput (%)	Increased Unavailability (%)	Degraded Throughput (%)	Increased Unavailability (%)
Collocated Gateway[11]	1.5-meter	0.26	0.00458	0.35	0.00203
	1.85-meter	0.13	0.000000	0.26	0.00118

[11] The closest licensed Starlink gateway earth station to this proposed Kuiper System gateway is 95-km away which would result in even reduced interference levels.

Mangata Analysis

Table A-7: Kuiper and Mangata Uplink RF Parameters

<table>
<tr><th>Parameter</th><th>Kuiper 2.4m GW</th><th>Mangata CT</th></tr>
<tr><td>Carrier Centre Frequency (GHz)</td><td>29</td><td>29</td></tr>
<tr><td>Bandwidth (MHz)</td><td>490</td><td>1</td></tr>
<tr><td>E/S Transmit Power (dBW)</td><td>10</td><td>Min: -20.1
Max: -10.0</td></tr>
<tr><td>E/S EIRP (dBW)</td><td>62.8</td><td>Min: 25.5
Max: 35.6</td></tr>
<tr><td>E/S Peak Gain (dBi)</td><td>52.8</td><td>45.6</td></tr>
<tr><td>E/S Antenna Pattern</td><td>ITU Appendix 8 Annex 3</td><td>ITU Appendix 8 Annex 3</td></tr>
<tr><td>E/S Antenna Diameter (m)</td><td>2.4</td><td>-</td></tr>
<tr><td>Sat Peak Gain (dBi)</td><td>38.2</td><td>46.7</td></tr>
<tr><td>Sat Antenna Pattern</td><td><table>
<tr><td>G_{max} = 38.2 dBi</td><td></td></tr>
<tr><td>Off-Axis Angle (q)</td><td>Gain [dBi]</td></tr>
<tr><td>0° to 1.88°</td><td>$G_{max} - 3*(q/0.94)^2$</td></tr>
<tr><td>1.88° to 20°</td><td>$34 - 25*\log_{10}(q)$</td></tr>
<tr><td>20° to 180°</td><td>1.5</td></tr>
</table></td><td>ITU-R S.1528</td></tr>
<tr><td>Sat Noise Temperature (K)</td><td>460</td><td>646</td></tr>
</table>

Table A-8: Kuiper and Mangata Downlink RF Parameters

<table>
<tr><th>Parameter</th><th>Kuiper 2.4m GW</th><th>Mangata CT</th></tr>
<tr><td>Carrier Centre Frequency (GHz)</td><td>19</td><td>19</td></tr>
<tr><td>Bandwidth (MHz)</td><td>490</td><td>-</td></tr>
<tr><td>Sat Transmit Power (dBW)</td><td>Variable (See PFD)</td><td>Variable (See PFD)</td></tr>
<tr><td>Sat EIRP (dBW)</td><td>Variable (See PFD)</td><td>Variable (See PFD)</td></tr>
<tr><td>Sat Peak Gain (dBi)</td><td>34.4</td><td>43.2</td></tr>
<tr><td>Sat Antenna Pattern</td><td><table>
<tr><td>Gmax = 34.4 dBi</td><td></td></tr>
<tr><td>Off-Axis Angle (q)</td><td>Gain [dBi]</td></tr>
<tr><td>0° to 2.92°</td><td>$G_{max} - 3*(q/1.46)^2$</td></tr>
<tr><td>2.92° to 20°</td><td>$34 - 25*\log_{10}(q)$</td></tr>
<tr><td>20° to 180°</td><td>1.5</td></tr>
</table></td><td>ITU-R S.1528</td></tr>
<tr><td>Sat PFD on Ground ($dBW/m^2/MHz$)</td><td>-123 @ 30°-90° elevation angles
-125.2 @ 20° elevation angle</td><td>-126.3</td></tr>
<tr><td>E/S Peak Gain (dBi)</td><td>49</td><td>42.1</td></tr>
<tr><td>E/S Antenna Pattern</td><td>ITU Appendix 8 Annex 3</td><td>ITU Appendix 8 Annex 3</td></tr>
<tr><td>E/S Antenna Diameter (m)</td><td>2.4</td><td>-</td></tr>
<tr><td>E/S Noise Temperature (K)</td><td>195</td><td>290</td></tr>
</table>

Figure A-5: Mangata User Terminal Uplink C/N and C/[N+I] Cumulative Density Function

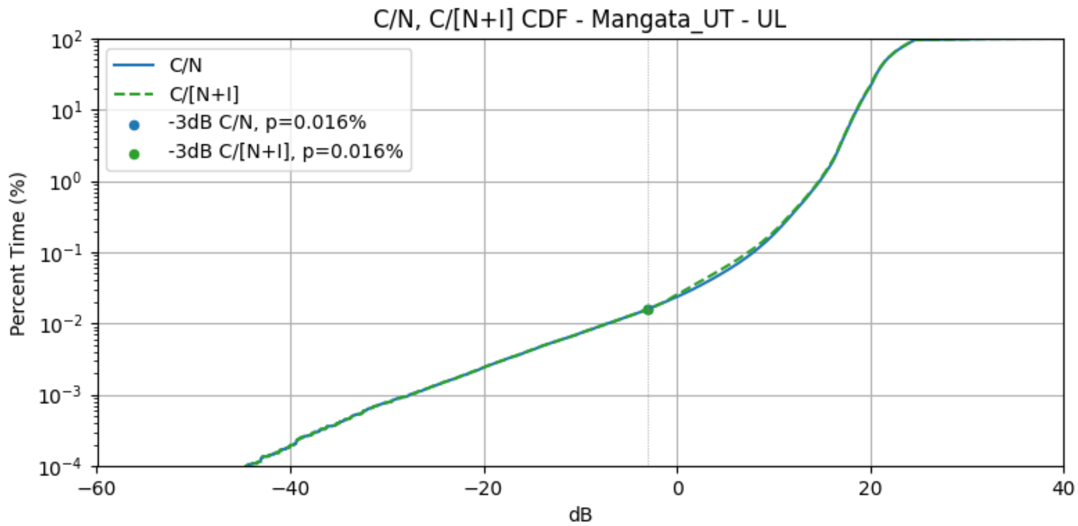


Figure A-6: Mangata User Terminal Downlink C/N and C/[N+I] Cumulative Density Function

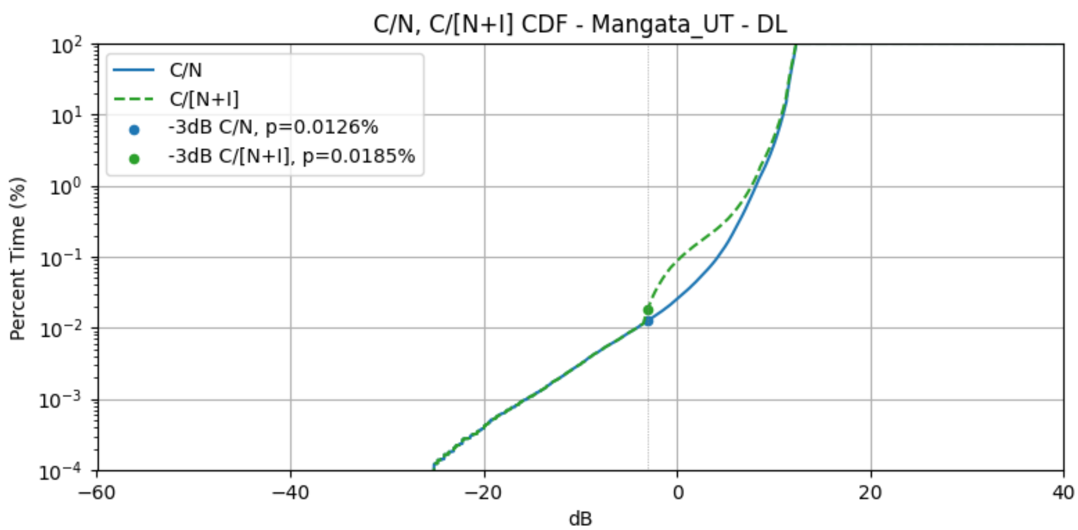


Table A-9: Mangata Interference Summary

Earth Station	Uplink		Downlink	
	Degraded Throughput (%)	Increased Unavailability (%)	Degraded Throughput (%)	Increased Unavailability (%)
Collocated User Terminal	0.17	0.000000	0.71	0.00592

Rivada Analysis

Table A-10: Kuiper and Rivada Uplink RF Parameters

<table>
<tr><th>Parameter</th><th>Kuiper 2.4m GW</th><th>Rivada CT</th></tr>
<tr><td>Carrier Centre Frequency (GHz)</td><td>29</td><td>29</td></tr>
<tr><td>Bandwidth (MHz)</td><td>490</td><td>1</td></tr>
<tr><td>E/S Transmit Power (dBW)</td><td>10</td><td>-13</td></tr>
<tr><td>E/S EIRP (dBW)</td><td>62.8</td><td>35.9</td></tr>
<tr><td>E/S Peak Gain (dBi)</td><td>52.8</td><td>49</td></tr>
<tr><td>E/S Antenna Pattern</td><td>ITU Appendix 8 Annex 3</td><td>ITU Appendix 8 Annex 3</td></tr>
<tr><td>E/S Antenna Diameter (m)</td><td>2.4</td><td>-</td></tr>
<tr><td>Sat Peak Gain (dBi)</td><td>38.2</td><td>30</td></tr>
<tr><td>Sat Antenna Pattern</td><td><table>
<tr><td>G_{max} = 38.2 dBi</td><td></td></tr>
<tr><td>Off-Axis Angle (q)</td><td>Gain [dBi]</td></tr>
<tr><td>0° to 1.88°</td><td>G_{max} – 3*(q/0.94)^2</td></tr>
<tr><td>1.88° to 20°</td><td>34 – 25*log$_{10}$(q)</td></tr>
<tr><td>20° to 180°</td><td>1.5</td></tr>
</table></td><td>ITU-R S.1528</td></tr>
<tr><td>Sat Noise Temperature (K)</td><td>460</td><td>500</td></tr>
</table>

Table A-11: Kuiper and Rivada Downlink RF Parameters

<table>
<tr><th>Parameter</th><th>Kuiper 2.4m GW</th><th>Rivada CT</th></tr>
<tr><td>Carrier Centre Frequency (GHz)</td><td>19</td><td>19</td></tr>
<tr><td>Bandwidth (MHz)</td><td>490</td><td>-</td></tr>
<tr><td>Sat Transmit Power (dBW)</td><td>Variable (See PFD)</td><td>Variable (See PFD)</td></tr>
<tr><td>Sat EIRP (dBW)</td><td>Variable (See PFD)</td><td>Variable (See PFD)</td></tr>
<tr><td>Sat Peak Gain (dBi)</td><td>34.4</td><td>30</td></tr>
<tr><td>Sat Antenna Pattern</td><td><table>
<tr><td>Gmax = 34.4 dBi</td><td></td></tr>
<tr><td>Off-Axis Angle (q)</td><td>Gain [dBi]</td></tr>
<tr><td>0° to 2.92°</td><td>G_{max} – 3*(q/1.46)^2</td></tr>
<tr><td>2.92° to 20°</td><td>34 – 25*log$_{10}$(q)</td></tr>
<tr><td>20° to 180°</td><td>1.5</td></tr>
</table></td><td>ITU-R S.1528</td></tr>
<tr><td>Sat PFD on Ground (dBW/m^2/MHz)</td><td>-123 @ 30°-90° elevation angles
-125.2 @ 20° elevation angle</td><td>-123</td></tr>
<tr><td>E/S Peak Gain (dBi)</td><td>49</td><td>46.9</td></tr>
<tr><td>E/S Antenna Pattern</td><td>ITU Appendix 8 Annex 3</td><td>ITU Appendix 8 Annex 3</td></tr>
<tr><td>E/S Antenna Diameter (m)</td><td>2.4</td><td>-</td></tr>
<tr><td>E/S Noise Temperature (K)</td><td>195</td><td>200</td></tr>
</table>

Figure A-7: Rivada User Terminal Uplink C/N and C/[N+I] Cumulative Density Function

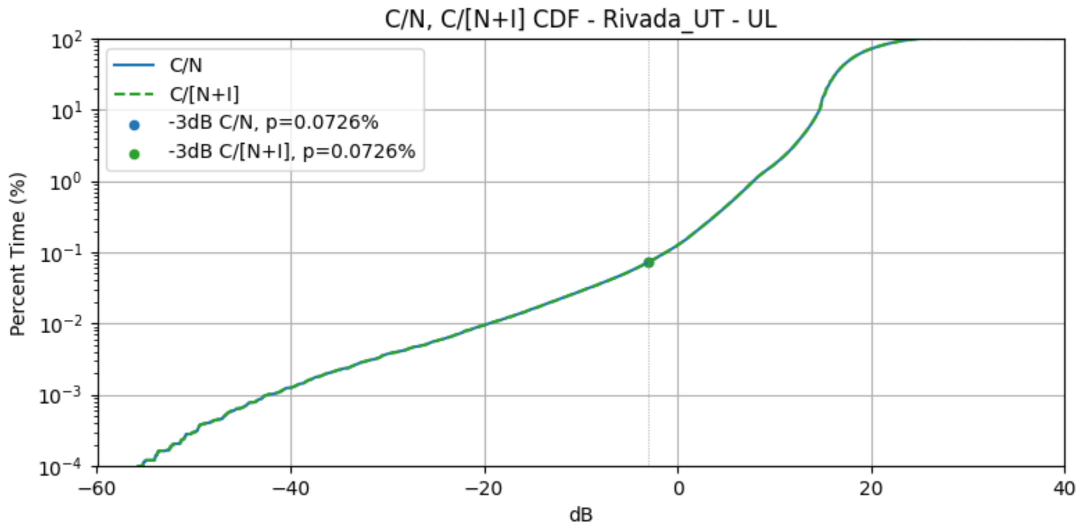


Figure A-8: Rivada User Terminal Downlink C/N and C/[N+I] Cumulative Density Function

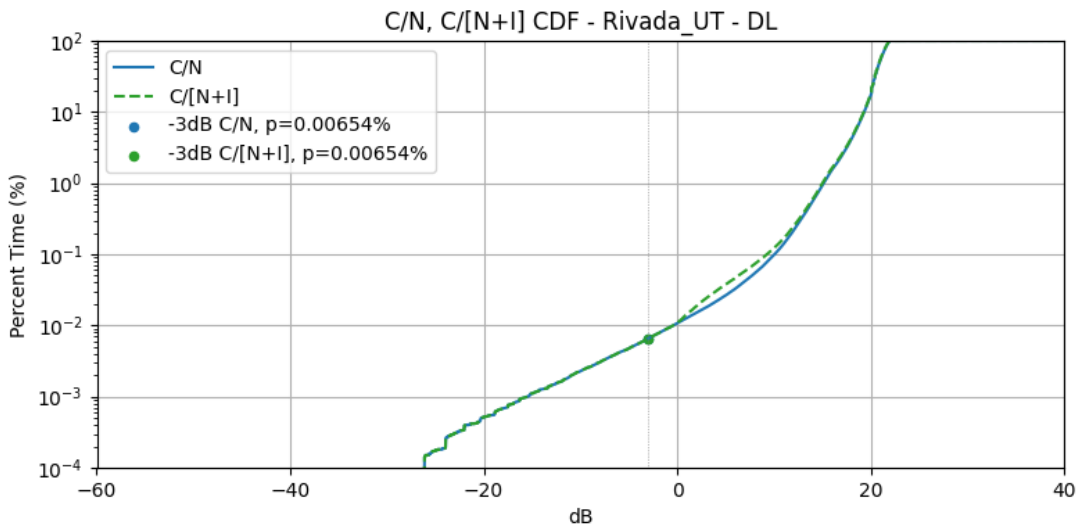


Table A-12: Rivada Interference Summary

Earth Station	Uplink		Downlink	
	Degraded Throughput (%)	Increased Unavailability (%)	Degraded Throughput (%)	Increased Unavailability (%)
Collocated User Terminal	0.06	0.000003	0.20	0.000003

NSLComm Analysis

Table A-13: Kuiper and NSLComm Uplink RF Parameters

<table>
<tr><th>Parameter</th><th>Kuiper 2.4m GW</th><th>NSLComm CT</th></tr>
<tr><td>Carrier Centre Frequency (GHz)</td><td>29</td><td>29</td></tr>
<tr><td>Bandwidth (MHz)</td><td>490</td><td>1</td></tr>
<tr><td>E/S Transmit Power (dBW)</td><td>10</td><td>Min: -32.8
Max: -24.6</td></tr>
<tr><td>E/S EIRP (dBW)</td><td>62.8</td><td>Min: 16.8
Max: 25</td></tr>
<tr><td>E/S Peak Gain (dBi)</td><td>52.8</td><td>49.6</td></tr>
<tr><td>E/S Antenna Pattern</td><td>ITU Appendix 8 Annex 3</td><td>ITU Appendix 8 Annex 3</td></tr>
<tr><td>E/S Antenna Diameter (m)</td><td>2.4</td><td>-</td></tr>
<tr><td>Sat Peak Gain (dBi)</td><td>38.2</td><td>42.5</td></tr>
<tr><td>Sat Antenna Pattern</td><td>G_{max} = 38.2 dBi<table>
<tr><td>Off-Axis Angle (q)</td><td>Gain [dBi]</td></tr>
<tr><td>0° to 1.88°</td><td>$G_{max} - 3*(q/0.94)^2$</td></tr>
<tr><td>1.88° to 20°</td><td>$34 - 25*\log_{10}(q)$</td></tr>
<tr><td>20° to 180°</td><td>1.5</td></tr>
</table></td><td>ITU-R S.1528</td></tr>
<tr><td>Sat Noise Temperature (K)</td><td>460</td><td>500</td></tr>
</table>

Table A-14: Kuiper and NSLComm Downlink RF Parameters

<table>
<tr><th>Parameter</th><th>Kuiper 2.4m GW</th><th>NSLComm CT</th></tr>
<tr><td>Carrier Centre Frequency (GHz)</td><td>19</td><td>19</td></tr>
<tr><td>Bandwidth (MHz)</td><td>490</td><td>1</td></tr>
<tr><td>Sat Transmit Power (dBW)</td><td>Variable (See PFD)</td><td>Min: -30.8
Max: -21.5</td></tr>
<tr><td>Sat EIRP (dBW)</td><td>Variable (See PFD)</td><td>Min: -5.8
Max: 3.5</td></tr>
<tr><td>Sat Peak Gain (dBi)</td><td>34.4</td><td>25</td></tr>
<tr><td>Sat Antenna Pattern</td><td>Gmax = 34.4 dBi<table>
<tr><td>Off-Axis Angle (q)</td><td>Gain [dBi]</td></tr>
<tr><td>0° to 2.92°</td><td>$G_{max} - 3*(q/1.46)^2$</td></tr>
<tr><td>2.92° to 20°</td><td>$34 - 25*\log_{10}(q)$</td></tr>
<tr><td>20° to 180°</td><td>1.5</td></tr>
</table></td><td>ITU-R S.1528</td></tr>
<tr><td>Sat PFD on Ground ($dBW/m^2/MHz$)</td><td>-123 @ 30°-90° elevation angles
-125.2 @ 20° elevation angle</td><td>Variable</td></tr>
<tr><td>E/S Peak Gain (dBi)</td><td>49</td><td>46</td></tr>
<tr><td>E/S Antenna Pattern</td><td>ITU Appendix 8 Annex 3</td><td>ITU Appendix 8 Annex 3</td></tr>
<tr><td>E/S Antenna Diameter (m)</td><td>2.4</td><td>-</td></tr>
<tr><td>E/S Noise Temperature (K)</td><td>195</td><td>290</td></tr>
</table>

Figure A-9: NSLComm User Terminal Uplink C/N and C/[N+I] Cumulative Density Function

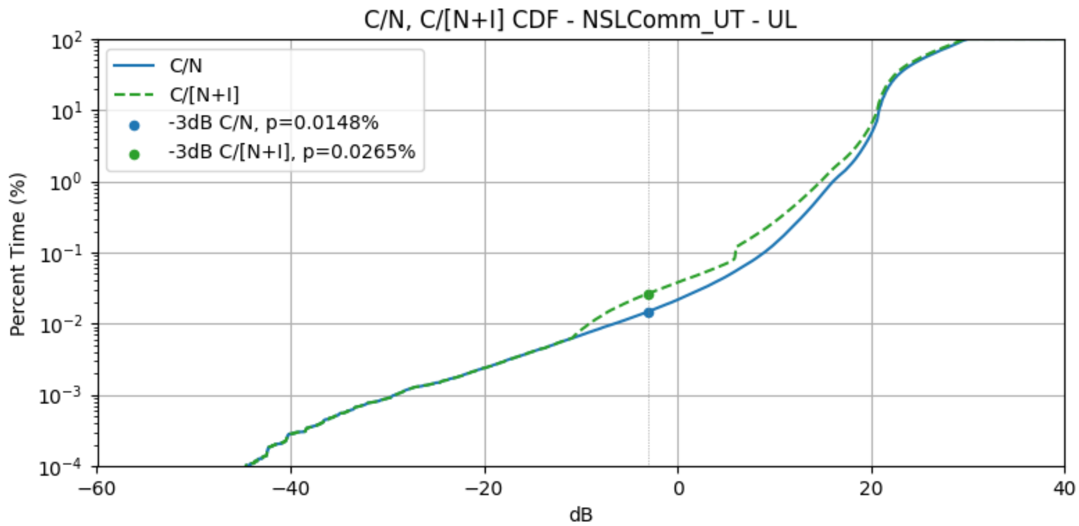


Figure A-10: NSLComm User Terminal Downlink C/N and C/[N+I] Cumulative Density Function

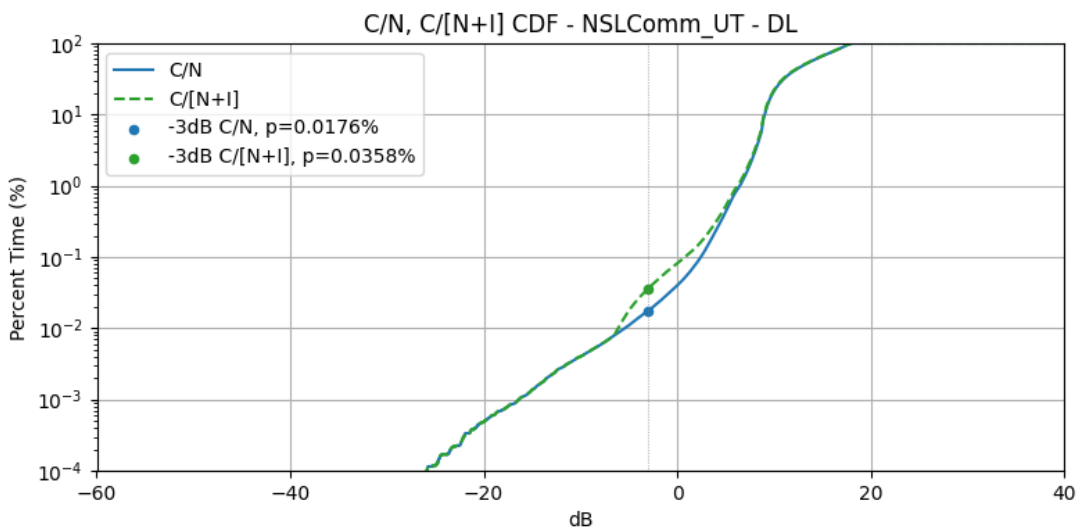


Table A-15: NSLComm Interference Summary

Earth Station	Uplink		Downlink	
	Degraded Throughput (%)	Increased Unavailability (%)	Degraded Throughput (%)	Increased Unavailability (%)
Collocated User Terminal	1.06	0.0117	0.48	0.0182