**NSLComm Ltd**

**Annex to Satellite (earth station network) radio licence application form non-geostationary – OfW602**

**Supporting Information**

# 1 Introduction

**NSLComm Ltd** is pleased to provide the information under this Annex in support of its Application to Ofcom for the NGSO Network Licence (OfW602), to authorise the operation of NSLComm's new and innovative NGSO satellite network in the UK ("**BeetleSat**").

This document outlines, firstly, the details and features of the BeetleSat network, including the technology developed, the system network architecture, and the services and applications targeted. Following this, and addressing Sections D (1) – (4) of the NGSO Network Licence Application Form[1], we include a detailed technical coexistence analysis vis-à-vis BeetleSat and other existing and future NGSO systems in the UK, the protection of other services (GSO, radio astronomy, fixed links), and finally, a competitive impact assessment specific to the UK.

Information provided under "Coexistence with existing systems" (herein, Section 3.1) addresses the BeetleSat system's coexistence with both other existing non-geostationary satellite systems that are already licensed in the UK, and non-geostationary satellite system for which an application has been made and published on Ofcom's website.

The existing NGSO systems identified as licensed in the UK are the following:

| Licensee | Licence number | Date first issued |
|---|---|---|
| **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 (OneWeb)** | 1102679 | 9 November 2016 |

It has been noted that an application was recently made to Ofcom in respect of a planned NGSO system by **Rivada Space Networks**. The analysis therefore takes into account this additional system.

Interference scenarios are presented in our analysis between the Ka band earth stations (ES) user links of the BeetleSat system and both the Ka band ES links and gateways (GW) of the above Licensees (together referred to as "Existing NGSO Systems").

[1] Satellite (earth station network) radio licence application form: non-geostationary – OfW602 (September 2023 version)

The coexistence assessments are measured against a long-criteria and a short-term criteria.

The long-term criteria assumes a cumulative distribution functions (CDF) of the interference-to-noise ratio (I/N) for varying percentages of time, and assuming an aggregate interference coming from all considered systems based on ITU-R Recommendation S.1323 (Methodology B of Annex 1).



As for the short-term criterion, it is based on the increase in unavailability and reduction of spectral efficiency (in other terms, reduction of throughput) in accordance with ITU-R Recommendation S.2131-1. The results, as detailed in Section 3.1, show a marginal (sometimes negligible) increase in unavailability and degradation of spectral efficiency, together with a very low I/N criteria.

Information provided under Section 3.2 concerns the BeetleSat NGSO satellite system's coexistence with future NGSO systems. Section 3.3 comments briefly on coexistence with other specific cofrequency earth stations registered with the ITU.

Under the competitive impact assessment (herein, Section 4) we put forward the conclusion that, rather than bringing any adverse competition issues, authorising the BeetleSat system in the UK would benefit local consumers and businesses and lead to overall effective competition for high speed satellite broadband and associated services throughout the UK - in full alignment with Ofcom's guiding principles.

Section 5.1 deals with additional Ofcom conditions, namely protection of "other services" from BeetleSat NGSO satellite system (GSO, radio astronomy, fixed links) and confirms the system's compliance with the limits under Article 21 and 22 of the ITU Radio Regulations.

## 2 BeetleSat system

BeetleSat, developed and operated by NSLComm[2], is a new and highly innovative NGSO satellite constellation, delivering truly global Ka-band connectivity for secure and cost-effective point-to-point communications, cellular backhaul, mobility and additional premium services. At full deployment the BeetleSat constellation will have a total of 264 satellites, operating at 720km altitude and along 12 orbital planes, of 22 satellites each.

The ground-breaking feature of the BeetleSat constellation is a lightweight, very high data rate, expandable ka-band satellite antenna, which is made of proprietary shape memory material, and compactly folded at launch, thus allowing for low volume and mass. The lightweight antenna is extremely flexible and stowed for launch in a small volume, while expanding to a large aperture after deployment in space.

The barriers of entry for communication satellite constellations are still very high due to the high cost of launch vehicle services and this ultimately impacts customers and end users. For several years, NSLComm has been focused on solving this problem, which led to developing this new expandable antenna technology that will significantly decrease the cost per spacecraft, by reducing the satellite size and mass. NSLComm contracted with Dunmore Aerospace on the development process, a partner with significant materials expertise and space heritage. The satellites of the constellation are being manufactured in partnership with Arquimea, which provides over 15 years of experience in the engineering and production of space-qualified components and systems.

Most recently, NSLComm conducted a successful in-orbit deployment and demonstration of its new satellite antenna technology, on board a demonstration nanosatellite ("NSLSAT-2"), launched in January 2023 via SpaceX Falcon 9 rocket, and subsequently deployed in-orbit. With a payload designed by NSLComm, the demonstration satellite weighed approximately 9 kg and transmits data at up to 2 Gbps. Using innovative Software-Defined Radio (SDR) and a deployable antenna communication payload, it delivers a bit-rate performance level equal to a much larger satellite at a substantially lower capital expenditure. This in-orbit demonstration marked an industry first and a significant milestone in the development of the BeetleSat constellation, proving the viability of its proprietary expandable satellite antenna technology. The NSLSAT-2 spacecraft performed a successful on-demand Two-Way Data Communication between the NSLComm network ground and space segments.

BeetleSat system key features:

- Commercial Name of Constellation: BeetleSat
- ITU Filing: The NSLComm ITU filings for the BeetleSat constellation have been submitted under ISR as the notifying administration to ITU and under the filing references "NSL-1/BEETLE-SAT_LEO".
- Orbital Type: Non-GSO
- Satellite Life Span: 7 years per satellite
- Satellite/ Service Launch: Demonstration satellite ("NSLSAT-2") launched January 3, 2023.
  Commercial satellite constellation ("Beetlesat") planned for launch during 2026, with initial services from 2026 - 2027.

[2] https://www.nslcomm.com

- Number of satellites (full constellation): 264
- Satellite (Constellation) Altitude:  720km
- Capacity: up to 16 Gbps/satellite - up to 2 Tbps total network capacity
- Orbital Planes: 12 planes, 22 satellites each

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In the UK territorial context, and in compliance with the Ofcom NGSO Licensing Guidance[3], the BeetleSat network would be configured to ensure that the user links from the fixed and mobile earth stations (land stations, including stations on vehicles and trains, or on offshore installations and maritime stations) operate within the available frequency bands indicated by Ofcom, and within scope of the NGSO Licence framework; namely:

- 27.5–27.8185 GHz
- 28.4545–28.8265 GHz, and
- 29.5 – 30 GHz

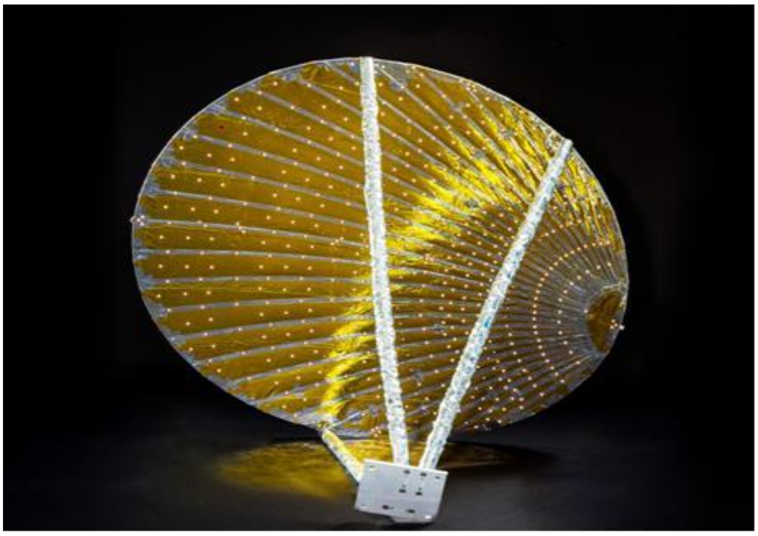


*Figure 1: NSLComm expandable Ka Antenna (fully deployed)*

[3] Non-geostationary satellite earth stations - Licensing guidance – September, 2023

*Figure 2 – Illustration of BeetleSat satellite constellation in orbital plane*

**BeetleSat Network Architecture**

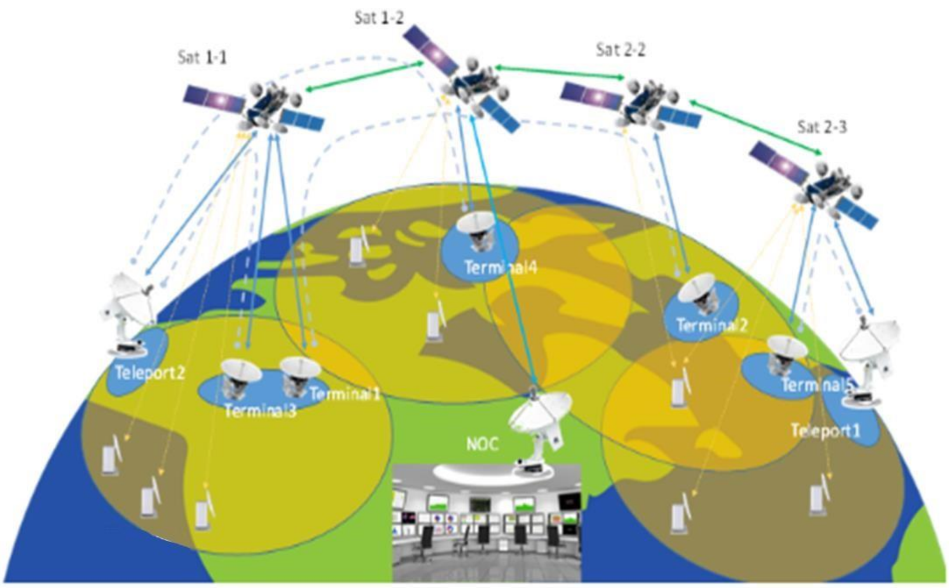



*Figure 3 – High level illustration of BeetleSat satellite system components*

The BeetleSat system Management and Control (M&C) is connected to the satellites through the BeetleSat Network Control Centre (NCC) and manages all the system elements: Satellites, Gateways, hubs and terminals.

The following diagram depicts the interfaces between the ground segment and the space segment:

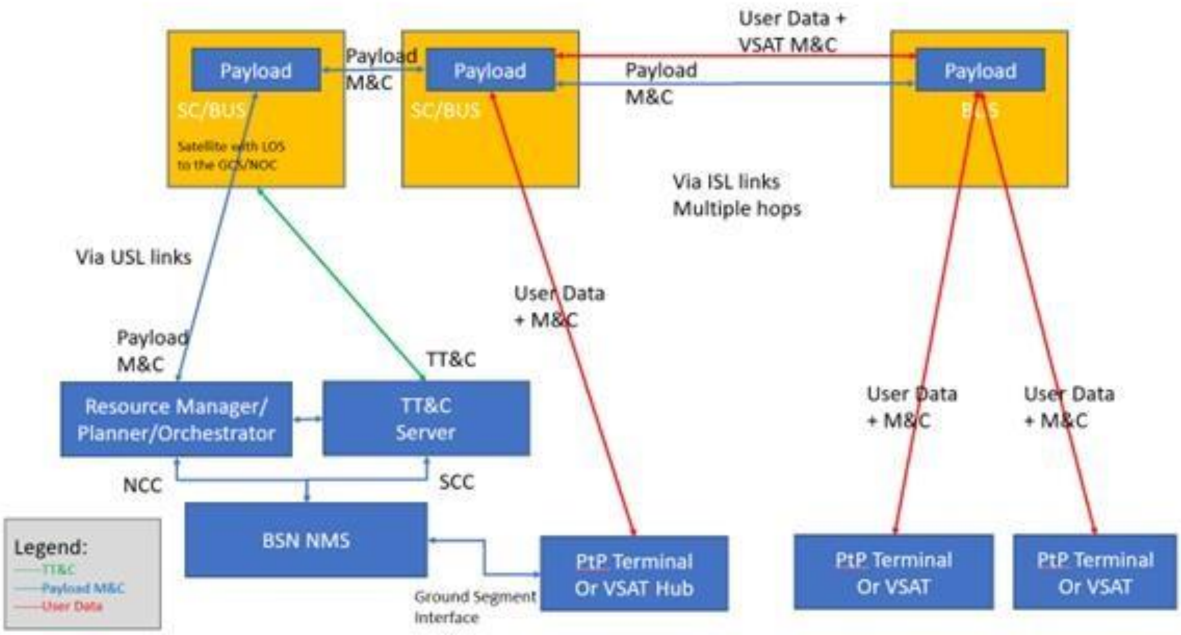



*Figure 4 - Interfaces between the ground segment and the space segment*

As stated above, the Beetlesat LEO satellite network has an “open architecture” mode, whereby the satellites are generally agnostic to the customer terminal waveform and type/ model deployed, through incorporating transparent switching into the satellite payload ("digital bent pipe"): In other words, data from ground is transmitted to the satellite, which simply retransmits the data back down to earth again. The only processing performed is to retransmit the signals. This allows the Beetlesat network to serve many satellite communication service providers having existing ground equipment (terminals or VSAT hubs). The ground equipment will have an appropriate interface to the Beetlesat constellation's Network Management System (NMS) in order to ensure proper operation with the Beetlesat Network. For example, the necessary functions to control allocation of resources and directing the terminals/ antennas to the right Beetlesat satellite while passing over. In particular, the appropriate communication protocol software will be implemented between the NMS and the ground segment and will be embedded in the customer hubs. This interface software will give NSL Comm the necessary control over any terminal/station accessing the Beetlesat system. As mentioned above, NSLComm will have a strategic collaboration with multiple large terminal/ hub manufacturers.

As the satellite operator, BeetleSat confirms that it will have control over the whole satellite network including associated user terminals/earth stations operating from the ground. This control includes the ability to act upon and eliminate any interferer transmission/s at any time, as well as the ability to negotiate and agree coexistence arrangements.

The ground terminals operating under the BeetleSat network architecture will comply with the relevant regional (FCC, ECC, etc.) and international (ITU) Standards and Recommendations (Ka-band FSS/ VSAT/ ESIMs) for the purpose of ensuring interference avoidance and mitigation measures are duly implemented.

## II. Services and Applications

Through the new and innovative Beetlesat LEO satellite constellation, NSLComm will offer a satellite backhaul connectivity service (pure bandwidth capacity) to key global and regional customers, comprising of satellite operators, mobile network operators, and internet service providers. The BeetleSat satellite capacity service will be used by these customers for supporting various in-country telecommunications applications and services to end users, in both the commercial and government sectors, as well as inter-satellite links. In other words, the Beetlesat constellation will provide a premium complementary backhaul layer (in LEO) for both terrestrial and satellite operators and telecommunications providers looking to enhance their existing solutions for the benefit of their user base. Thanks to BeetleSat's expandable antenna technology, among other features, customers of the Beetlesat network services can enjoy low-latency, high-frequency throughput, and sustainable satellite communications at a fraction of the cost of other systems, resulting in very attractive prices for premium services that will ultimately pass down to the end users.

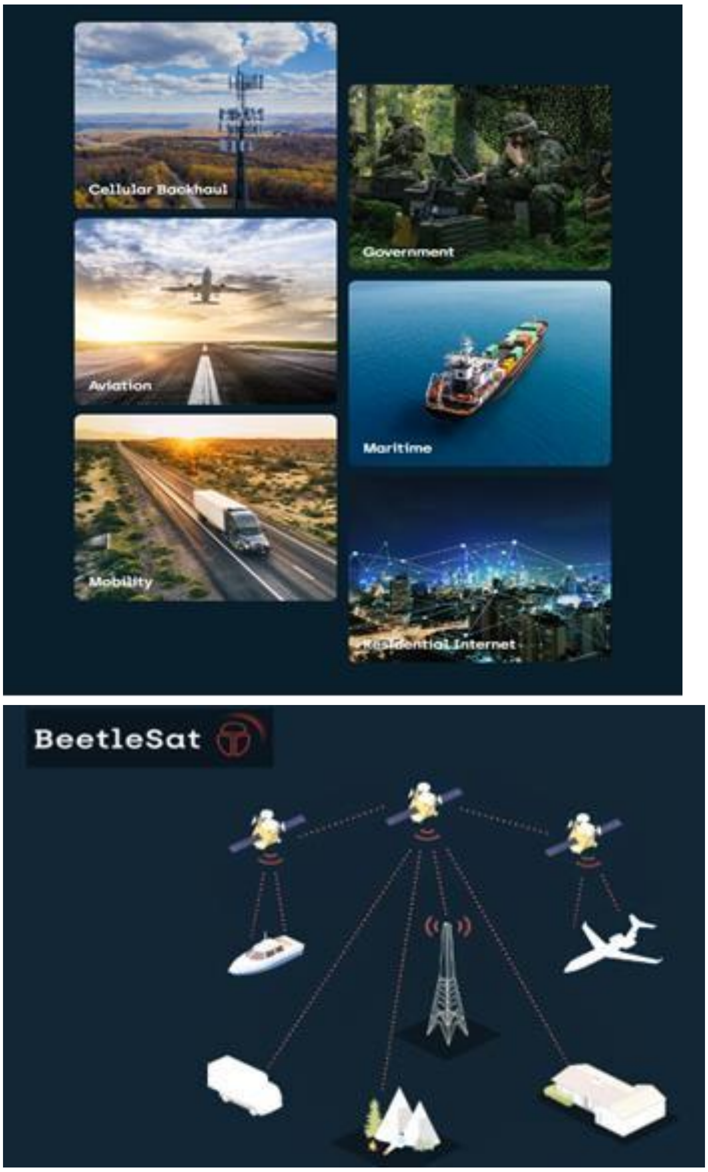


*Figure 5: End user segments/ applications using BeetleSat system*

As illustrated in Figure 5, the BeetleSat network will serve a variety of verticals and end user applications, for both fixed and mobile uses, within the terrestrial (land-based), maritime and aeronautical sectors. Including:

- Aviation: airport hubs and high traffic areas
- Maritime: cruise ships, super yachts, cargo ships, ports
- Trunking/VSAT backhaul for terrestrial-based services: 4G/5G cellular towers
- Military SatCom: satcom on the move (SOTM) point-to-point links, satcom on the pause (SOTP) pointto-point links
- Enterprise: multi-national corporates, oil and gas, embassies, etc. BeetleSat's intelligent LEO network will support allocation of bandwidth over areas with high traffic demand, requiring high-quality and reliable satellite backhaul.

The connectivity service offered by BeetleSat's network can be divided generally into two types:

i. Point-to-point (PtP): Broadband connectivity between two terminals. The two terminals can be connected to the same satellite (single hop) or different satellites. If the two terminals are on different satellites, the connection uses inter-satellite links (multiple hops). Terminals may be anywhere within the BeetleSat constellation coverage. This service can be proposed to Corporates, IP trunking, or optical fiber replacement. Verticals can be Mobile Network Operators, Telcos, Corporations, Governments, or Maritime: Cruise ships or Superyachts.

ii. Internet Access: Internet connectivity to a single or group of terminals from a gateway that is connected to the Internet. Topology is either PtP or point-to-multipoint (P2MP). When providing internet access, the forward downlink of 500 MHz is shared between the terminals within the beam. This service fits Corporates, Enterprises, small fleets of ships in the same beam, etc.

# 3 Coexistence assessment

## 3.1 Coexistence with Existing NGSO Systems

Existing NGSO Systems are listed in the Ofcom's website[3]. They are:

- **Starlink Internet Services Limited ("Starlink")**
- **Network Access Associates Ltd ("OneWeb")**
- **Telesat Lightspeed ("Telesat")**
- **Mangata**

In addition to those above, this analysis also takes into account the planned NGSO System of **Rivada Space Networks**, for which an application has recently been made to Ofcom and published for comment on Ofcom's website.

The system characteristics of these Existing NGSO Systems, necessary for carrying out coexistence assessments, were identified from information published on Ofcom's website and also from the ITU databases on satellite filings. We have also noted the information published by the FCC of the USA following disclosures made by licence applicants. The system characteristics used in our assessments for Existing NGSO Systems can be found in Appendix 1 to this Annex.

It has been well established that the potential for interference between two NGSO systems utilising the same frequency bands exists only when there is a likelihood of inline events. Assessments for coexistence were made for such interference events between Ka band UT links of BeetleSat NGSO satellite system and the Ka band links of Existing NGSO Systems, listed in the table below.

| NSL Links | Existing NGSO satellite System Link |
|---|---|
| NSL User links | Mangata User link |
| | Starlink Gateway Links |
| | Oneweb Gateway links |
| | Telesat User links |
| | Rivada User links |

### 3.1.1 Methodology

The present coexistence assessment is based on a long-term and a short-term criteria. Both criteria have to be satisfied in order to demonstrate that coexistence is possible.

#### 3.1.1.1 Long-term criteria

The long-term criterion is based on ITU-R Recommendation S.1323 and more specifically *Recommends 9)*

> *that this allowance corresponding to long-term interference […] should be expressed by requiring that the aggregate interference should not exceed 6% of the total system noise power for more than 10% of the time*

Furthermore Methodology B of Annex 1 to ITU-R Recommendation S.1323 provides further background and deems it appropriate to apportion (1/n) of the long-term interfering signal power to each of the n considered sources of interference and to deal separately with them. Methodology B is deemed to be appropriate for considering interference to non-GSO/MSS feeder links (or non-GSO FSS) and GSO/FSS systems operating either with on-board processing or with transparent transponders in the 20/30 GHz band.

As described in this Methodology B (Assumption 2b – long-term interference): If there are n systems sharing the same spectrum with the desired system that can potentially cause interference, for large percentage of time, the aggregate interference level adds in power. Hence it is appropriate to allocate each system 1/n of the aggregate power allowance for long-term interference.

Assuming the present coexistence assessment involves a total of 6 systems (Beetlesat, Mangata, Telesat, OneWeb, Starlink and Rivada), i.e. 1 desired system vs 5 other systems sharing the same spectrum, *Recommends 9)* of Recommendation ITU-R S.1323 together with the further clarifications provided in Methodology B translate into an aggregate I/N Threshold of -19.2 dB (-12.2 – 10 x log 2) not to be exceeded for more than 10% of the time.

#### 3.1.1.2 Short-term criteria

For the short-term criterion, the assessment is based in the increase in unavailability and reduction of spectral efficiency (in other terms, reduction of throughput).
The reduction in spectral efficiency is computed in accordance with Recommendation ITU-R S.2131-1. The average spectral efficiency and link unavailability are calculated based on an assumed C/N objective of -2 dB.

#### 3.1.1.3 Analysis

This interference and coexistence assessment is based on a dynamic analysis. The simulation was run for 1,000,000 time steps in order to get stability of statistics at low percentages of time. When using Monte Carlo simulation the time step size does not have an impact on the results, but in the present case it was set to 1 second.
From that dynamic interference analysis were derived the cumulative distribution functions of I/N, C/N and C/(N+I) for each of the victim system, before and after the introduction of interference due to the BeetleSat system.

Each constellation was configured with their own minimum elevation angle and GSO exclusion angle as defined in Annex 1. The tracking strategy is based on a random selection that matches both the elevation angle and the GSO avoidance angle.
The simulations use the Recommendations ITU-R P.618 and ITU-R P.676 for the propagation models.

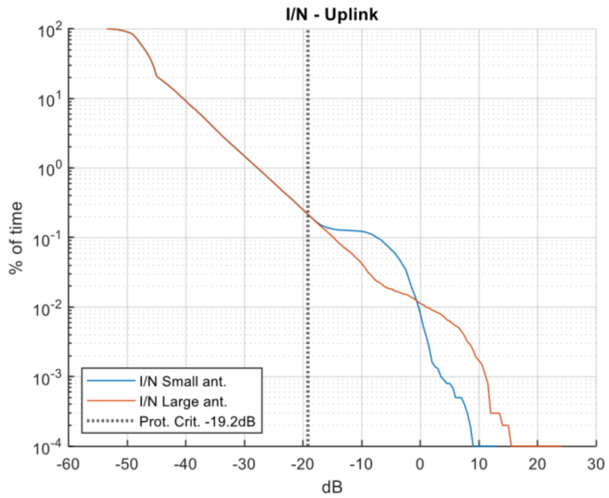
As the Beetlesat network might use earth station with different gains, the following analyses have been carried out for both the smaller and the larger interfering Earth station. Unlike the downlink, the uplink performances of the victim network will be impacted by the size of the interfering Earth stations. For that reason, uplink analyses include I/N, C/N and C/(N+I) for the smaller and the larger antennas.

The C/N and C/(N+I) values typically exhibit minimal differences, and when represented on a full-scale graph, they do not lend themselves to clear visualization. A zoomed-in view has been included primarily to offer additional information.

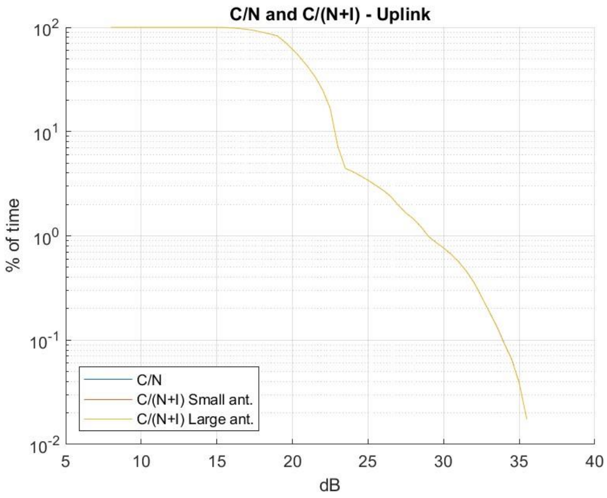
## 3.1.2 Coexistence with Mangata

### 3.1.2.1 Uplink

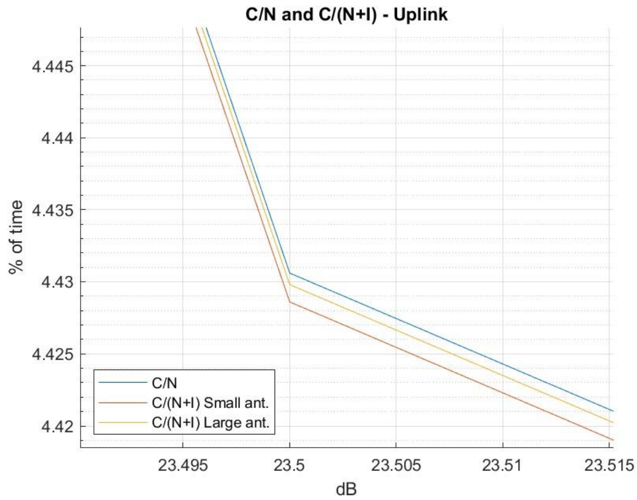
a) *Long term criteria*




b) *Short term criteria*




Full-Scale view

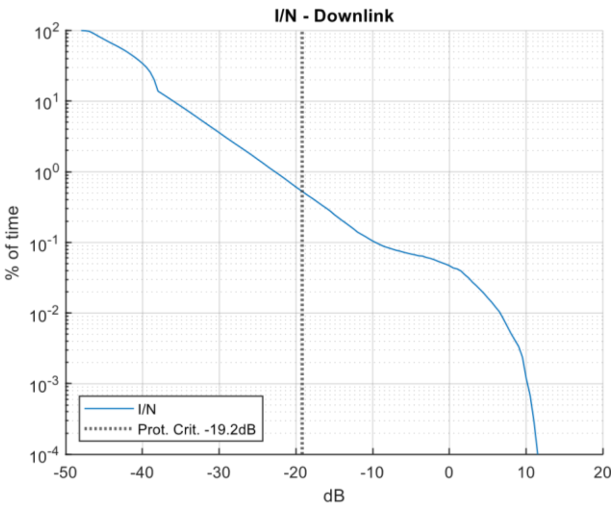



Zoomed in view

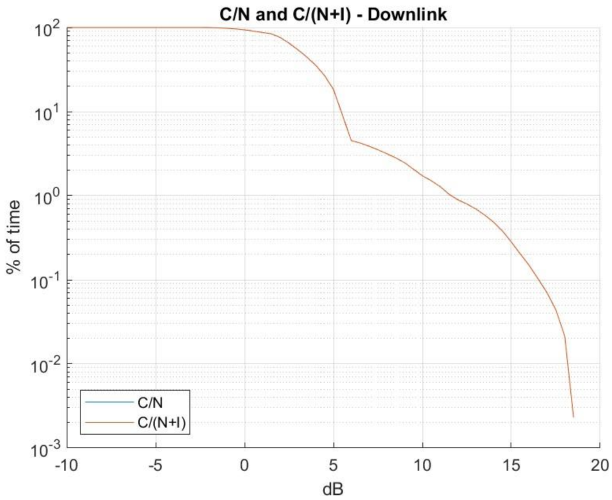
| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0 | % |
| Increase in availability | 0 | % |
| Reduction in spectral efficiency | 0.0122 | % |

### 3.1.2.2 Downlink

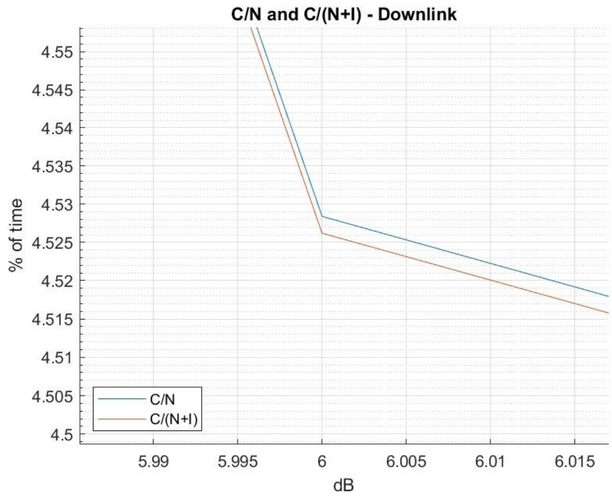
*a) Long term criteria*




*b) Short term criteria*




Full-scale



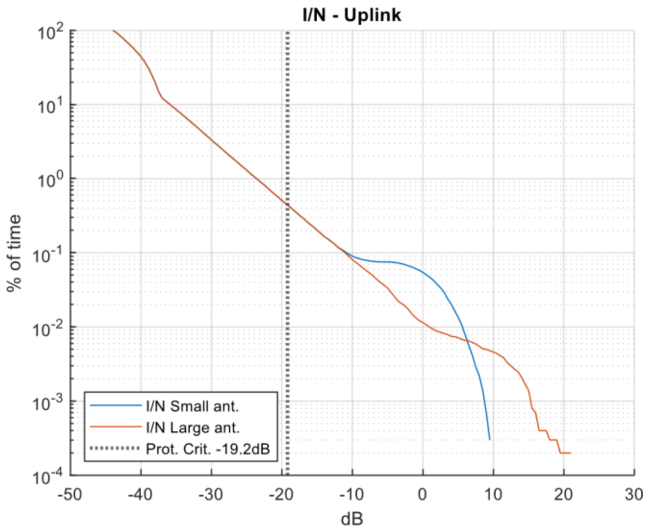

Zoomed in

| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0.029 % | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.1873 | % |

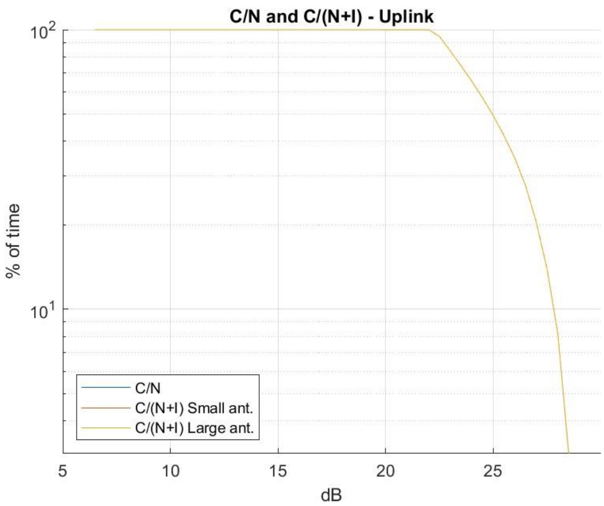
### 3.1.3 Coexistence with Starlink

3.1.3.1 Uplink

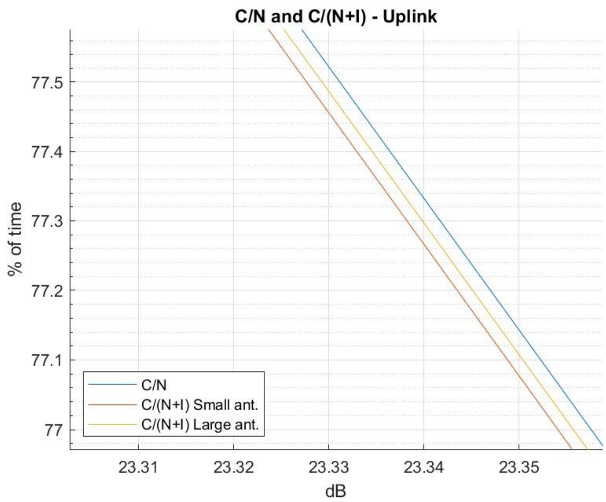
*a)* *Long term criteria*




*b)* *Short term criteria*




Full-scale

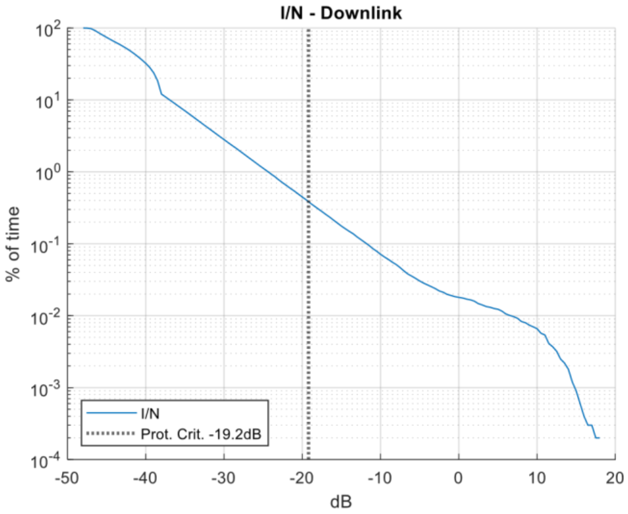



Zoomed in

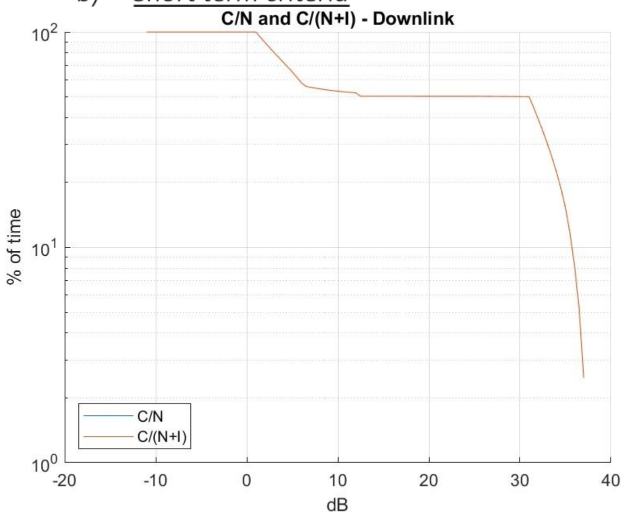
| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0 | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.0161 | % |

3.1.3.2

*a)* *Long term criteria*




*b)* *Short term criteria*

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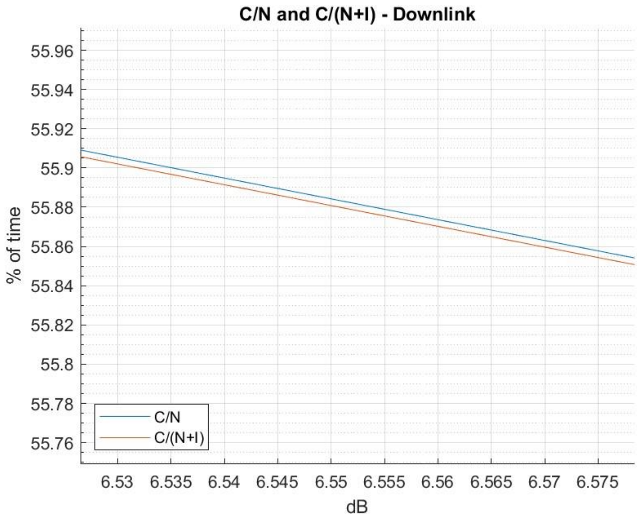


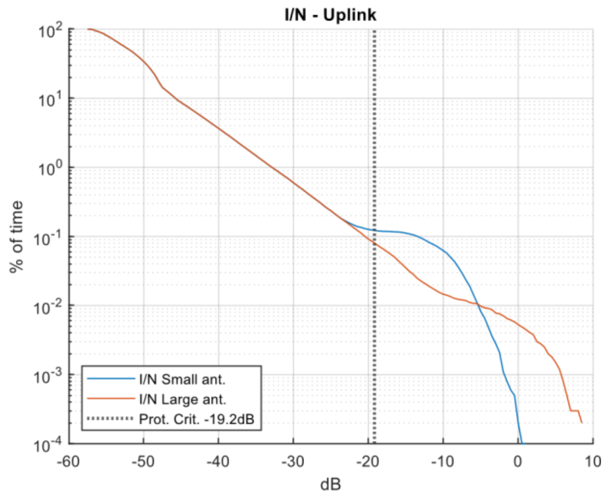

Zoomed in

| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0.006 | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.007 | % |

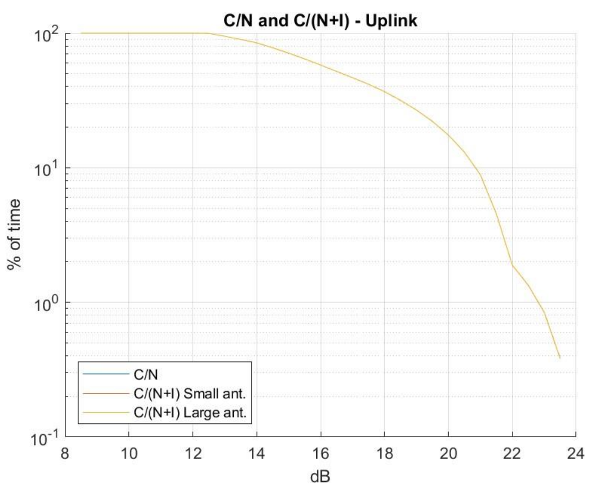
### 3.1.4 Coexistence with Telesat

#### 3.1.4.1 Uplink

*a) Long term criteria*




*b) Short term criteria*

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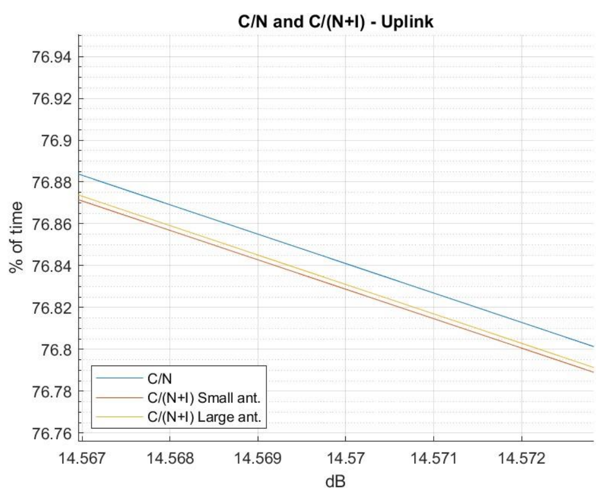
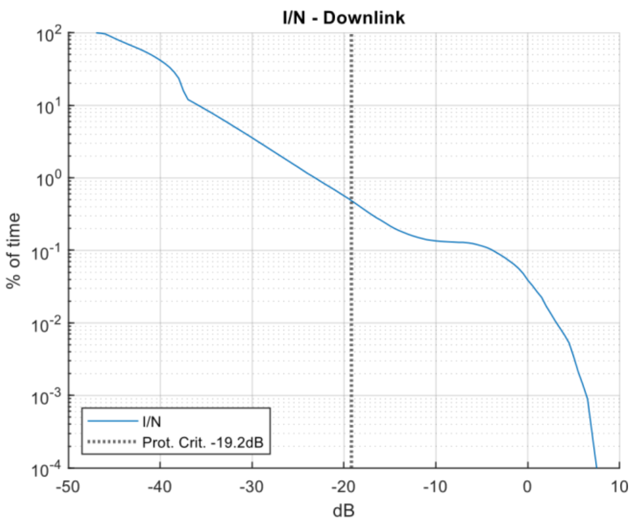



Zoomed in

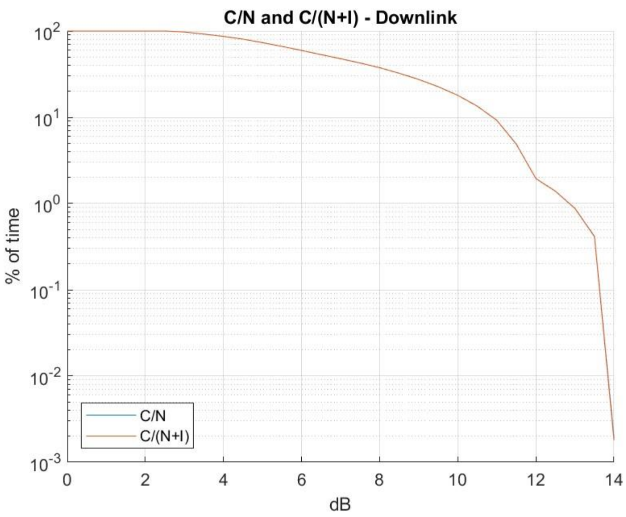
| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0 | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.005 | % |

3.1.4.2

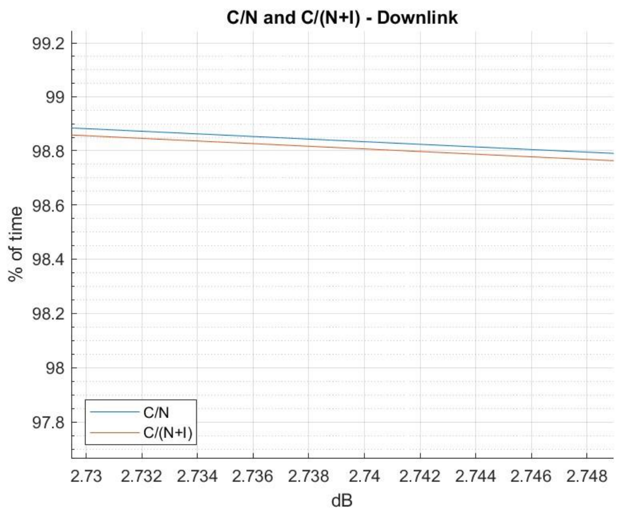
*a)* *Long term criteria*




*b)* *Short term criteria*




Full-scale



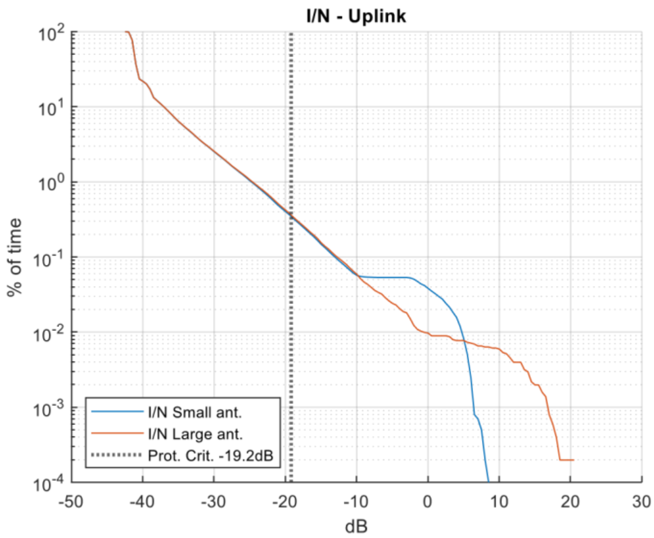

Zoomed in

| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0 | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.048 | % |

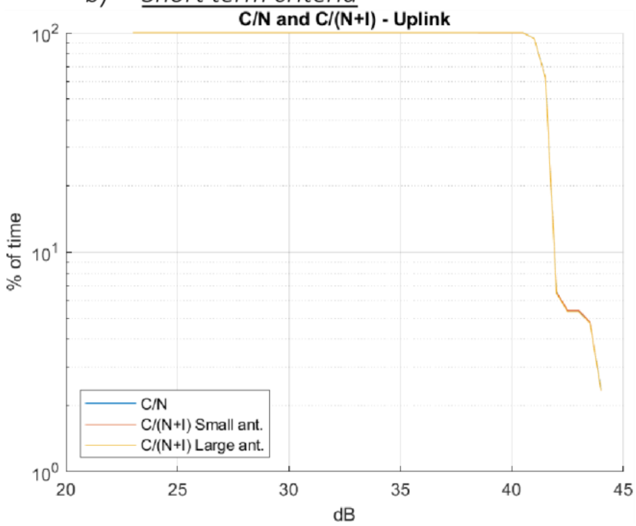
### 3.1.5 Coexistence with OneWeb

#### 3.1.5.1 Uplink

*a)* *Long term criteria*




*b)* *Short term criteria*

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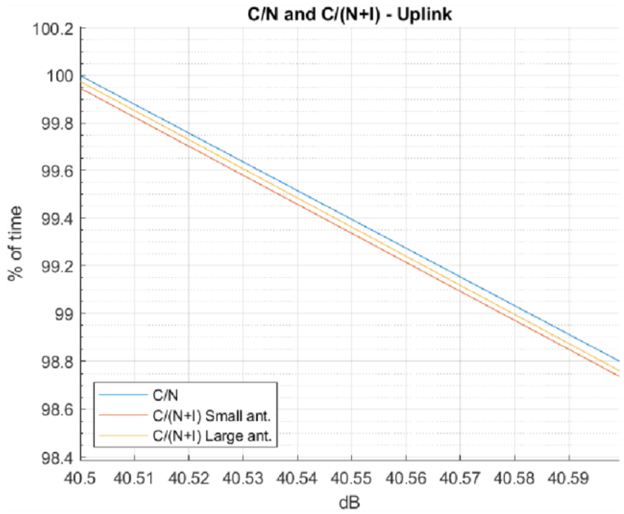


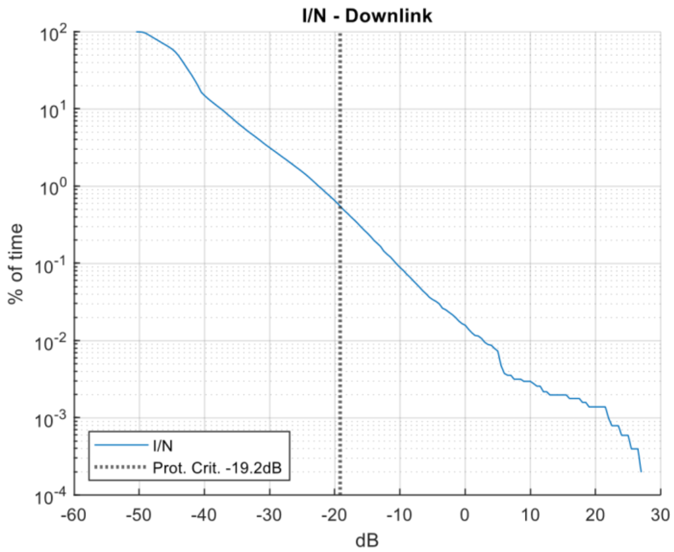

Zoomed in

| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0 | % |
| Increase in availability | n/a | % |

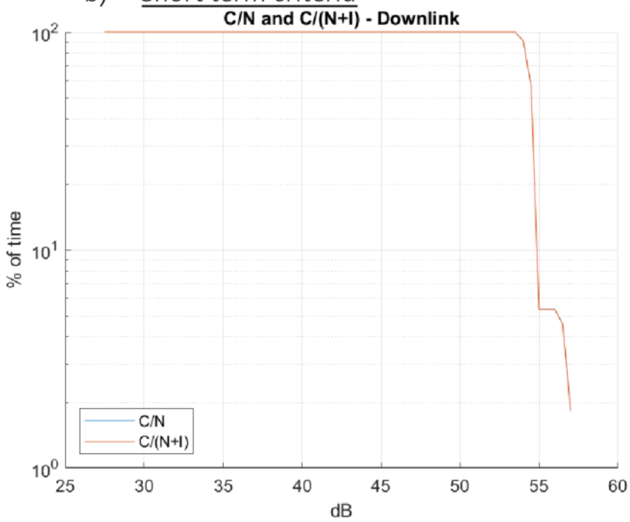
| | | |
|---|---|---|
| Reduction in spectral efficiency | 0 | % |

3.1.5.2

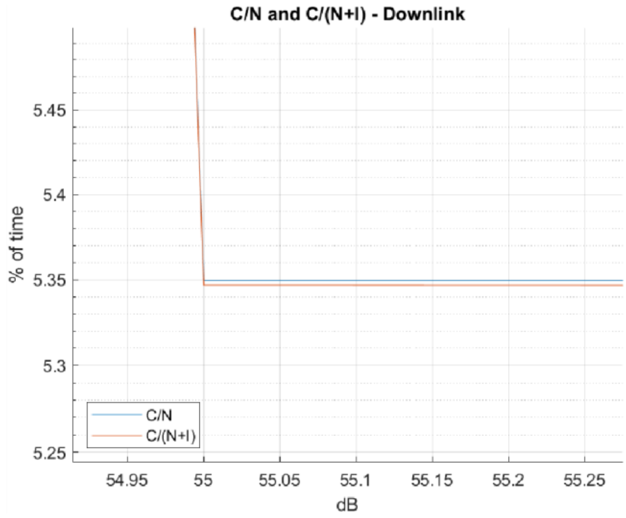
a) *Long term criteria*




b) *Short term criteria*




Full-scale



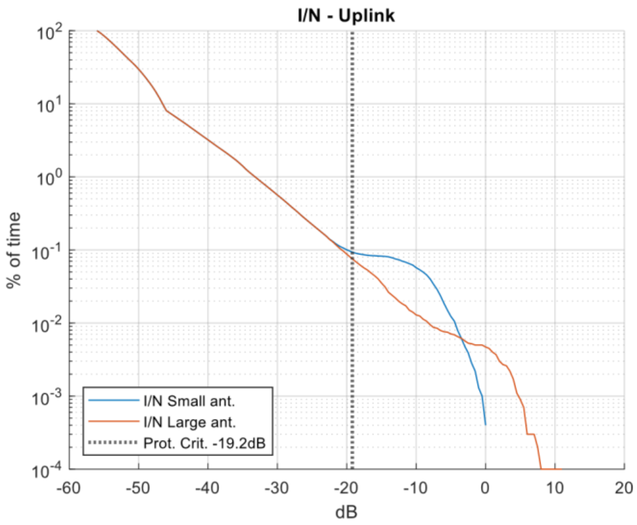

Zoomed in

| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0 | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0 | % |

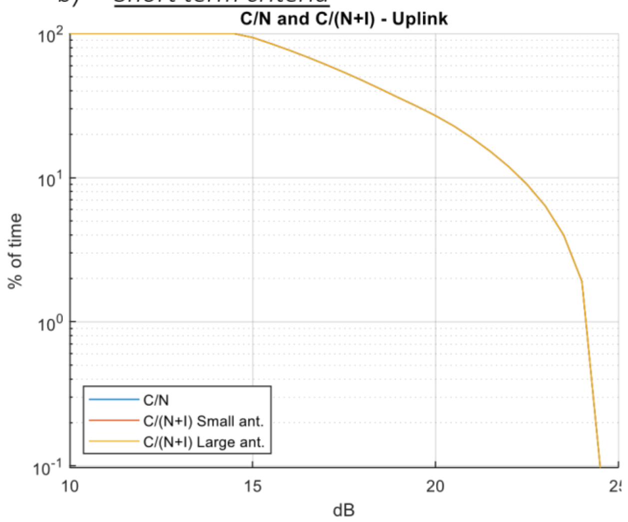
### 3.1.6 Coexistence with Rivada

#### 3.1.6.1 Uplink

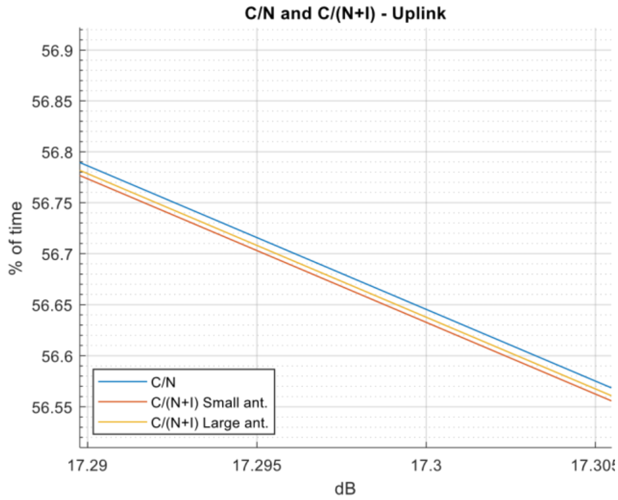
*a)* *Long term criteria*




*b)* *Short term criteria*




Full-scale

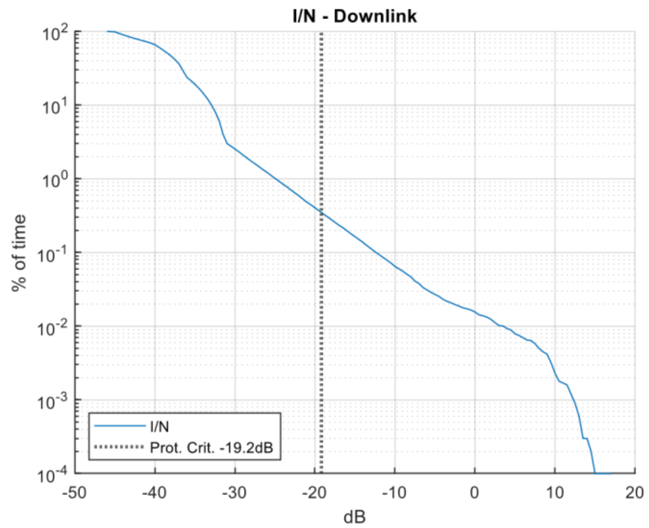



Zoomed in

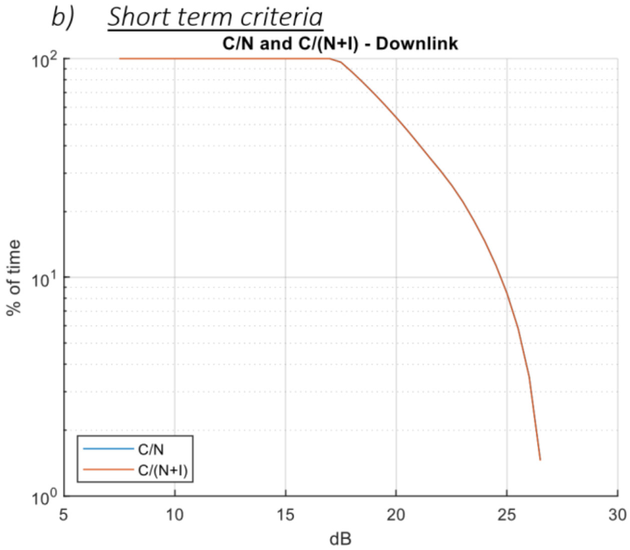
| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0% | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.005 | % |

3.1.6.2

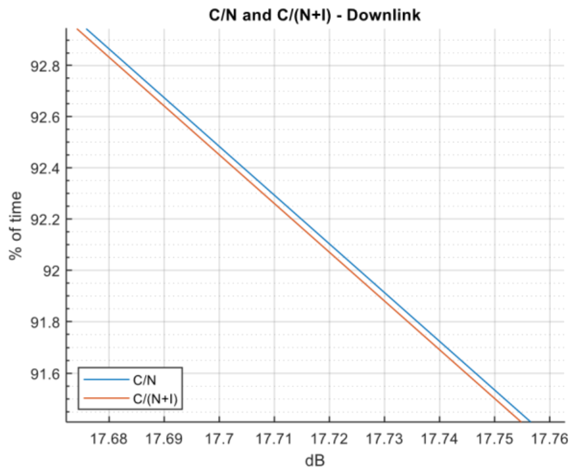
*a)* *Long term criteria*




*b)* *Short term criteria*




Full-scale



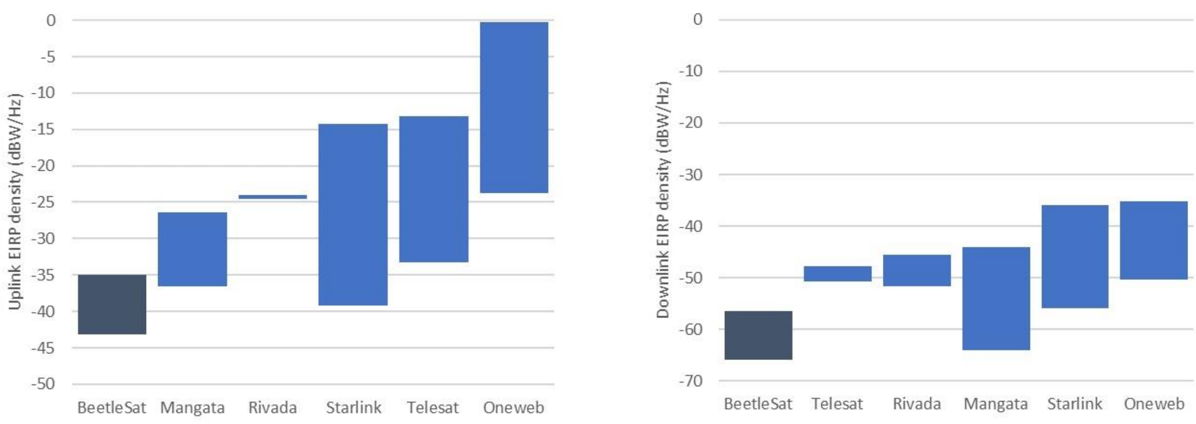

Zoomed in

| Parameter | Value | Unit |
|---|---|---|
| Unavailability after interference | 0% | % |
| Increase in availability | n/a | % |
| Reduction in spectral efficiency | 0.015 | % |

### 3.1.7 Summary

Thanks to its power levels relatively lower than the other systems (as depicted below), the BeetleSat system has a minimal impact on the increase in unavailability and degradation of spectral efficiency, together with a very low I/N criteria.

The above studies and results demonstrate that coexistence is possible without the need for mitigation techniques.




*BeetleSat EIRP density (uplink and downlink) compared to other existing systems*

Based on the above simulation, there does not any risk of harmful interference from the BeetleSat system towards the existing NGSO systems.

## 3.2 Coexistence with future NGSO systems

Coexistence among NGSO systems essentially involves limiting the number of, or mitigating the impact of, inline events. When implementable in practice, mechanisms such as exclusion angles can be defined in coordination discussions to limit the number of in-line events, while dynamically assigning power and bandwidth can mitigate their impact. The possibility of benefitting from any of these techniques to accommodate future systems requires that a system be flexible, agile and technically advanced. The BeetleSat system meets all such requirements and details as to how to implement any of these techniques, when and where possible, will be discussed among the interested operators during coordination discussions.

Such mechanisms could include, but not limited to, implementation of lookaside angle, avoidance of overlapping frequency bands or use of opposite polarization.

## 3.3 Coexistence with other specific co-frequency earth stations registered with the ITU

BeetleSat will operate in accordance with agreed coordination terms to protect specific co-frequency Earth stations registered under the provisions of No. 9.7B.

## 4 Competitive impact assessment

We have examined the existing market for UK-based satellite broadband services and it is clear that, rather than bringing any adverse competition issues, enabling access to the UK market for the BeetleSat system would stand to benefit local consumers and businesses and lead to effective competition for high speed satellite broadband and associated services throughout the UK.

### 4.1 BeetleSat network will improve accessibility and cost of remote, high speed Broadband solutions across UK

The fostering of remote, low cost and reliable Broadband solutions lie at the heart of Ofcom's and UK Government (DCMS) principles and objectives, allied with supporting optimum diversity in the connectivity platforms and providers for achieving these aims, and supporting UK economic growth more widely. Below are key points noted from the Ofcom Space Spectrum Strategy, 2022[4]:

- *Ofcom's principal statutory duty is to further the interests of citizens in relation to communications matters, and consumers in relevant markets, where appropriate by promoting competition. In meeting this duty, we also have a number of specific duties, including to secure the optimal use of spectrum; ensure the availability throughout the UK of a wide range of electronic communication services; and to take account of the different needs and interests of all current or potential users of the spectrum frequencies* (2.9, Space Spectrum Strategy).
- *Competition challenges. We want to enable as many NGSO systems as possible, to provide services and increase choice for people and businesses in the UK. But if NGSO operators use their ITU regulatory status or early deployment as a means to create or raise barriers to entry to other operators, this might raise some competition concerns* (4.14, Space Spectrum Strategy).

Moreover, under Ofcom's Work Plan 2023-24[5] the first priority identified is "*Internet we can rely on*", which includes:

- *Availability of high-quality networks where they are needed*
- *Reliable and secure networks that people can depend on*
- *People trust the networks and services that they use*
- *Consumers are confident and able to engage and make choices in the market to get the right services for them*
- *Consumers are able to access services which are affordable*

As Ofcom also notes, under the Work Plan, "*technological changes can help unlock better consumer outcomes, improving choice, price and innovation for consumers*".

As can be seen from Section 1, the BeetleSat proposition fits very well within the above Ofcom frameworks and principles. The BeetleSat network, operated by NSLComm, will serve to *improve competition for the benefit of UK consumers and industry*, rather than bring any adverse competition issues to the existing market landscape.

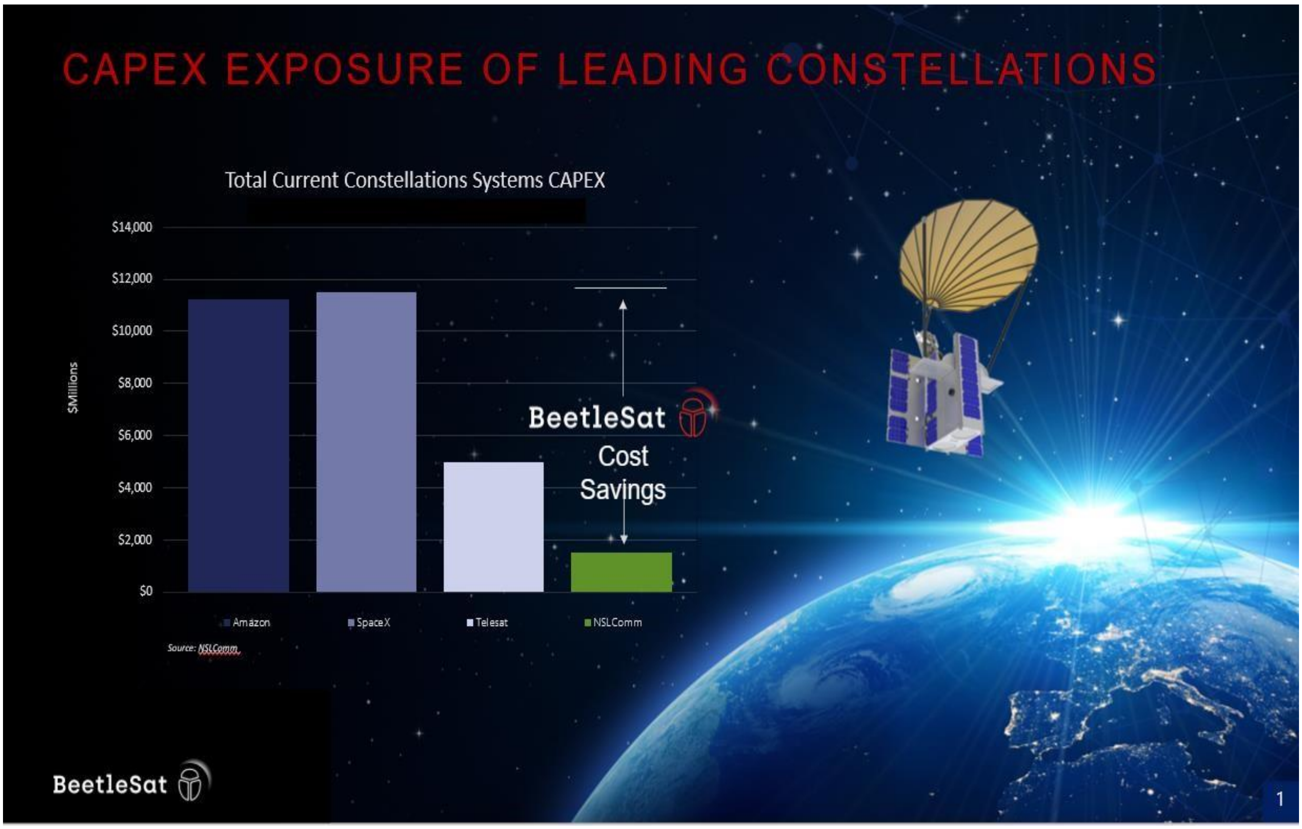
### 4.2 BeetleSat network technology aims to deliver cost savings for UK business and consumers through reduced deployment CAPEX

[4] Space spectrum strategy (ofcom.org.uk)
[5] Statement: Ofcom's Plan of Work 2023–24

As outlined in Section 1, NSLComm has over many years been developing a new satellite communications network technology with the primary aim to bring down overall deployment costs (CAPEX) and consequently unlock cost-savings throughout the entire connectivity value chain, that will ultimately pass down to the end users and customers in UK and other markets who will ultimately connect onto the BeetleSat network.

The barriers of entry for communication satellite constellations, while significantly improved over recent years, are still very high due to (primarily) the high cost of launch vehicle services and this ultimately impacts customers and end users. For several years, NSLComm has been focused on solving this problem, which led to developing its new patented expandable antenna technology that will significantly decrease the cost per spacecraft, by reducing the satellite size and mass thus allowing more BeetleSat satellites to be stowed and launched per mission. NSLComm contracted with Dunmore Aerospace on the development process, a partner with significant materials expertise and space heritage. The satellites of the constellation are being manufactured in partnership with Arquimea, which provides over 15 years of experience in the engineering and production of space-qualified components and systems.

The graphic below illustrates the cost savings offered by BeetleSat's system in comparison with other key players offering NGSO satellite broadband, including SpaceX and Telesat, both of which are operational and licensed by Ofcom in the UK.




*Comparison on CAPEX vs. other NGSO (USD)*

## 4.3 BeetleSat network will support nationwide Broadband and serve a wide range of UK customers and business verticals

Aside from the cost savings, there are ample other benefits of NSLComm's BeetleSat network technology to the UK competition landscape: for bringing diversity in the available solutions on the UK market for supporting nationwide broadband connectivity and 5G roll out, for both UK retail customers (e.g. residential, MNO service customers) and specialist customers in vital industries and enterprise, like shipping, aeronautical, and landbased applications. For instance, BeetleSat's system can offer rapidly deployable, low latency, high speed broadband Backhauling to 4G and 5G Sites in remote areas of the UK, ensuring UK MNOs and telecoms providers can efficiently handle the demands of countless user terminals, each consuming hundreds of Mbps. As well as for enabling mission-critical mobile (on the move) and fixed (point-to-point) applications through high throughput, low latency and rapidly deployable connectivity.

The user terminals deployed under BeetleSat will serve various fixed and mobility markets, as outlined in Section 1. The terminal size will vary depending on the capacity requirements, between 30cm to 2.4m parabolic (m), serving capacities up to 500 Mbps. BeetleSat is also working closely with various hardware partners to help deliver a compelling solution.

Ofcom's Connected Nations report[6], published September 2023, shows that gaps still remain in nationwide Broadband coverage where satellite can offer a role:

- 25% of all UK homes are still unable to receive gigabit-capable broadband is up to almost 22.4 million homes. While 3% of homes are still without superfast Broadband.
- Full fibre coverage, for the UK as a whole, is at 52%
- The number of premises unable to get access to decent broadband, when factoring in fixed wireless and fixed line networks, is around 62,000 premises.

Aside from supporting residential connectivity and satellite backhaul for terrestrial networks in the UK, as described in Section 1, the BeetleSat network would benefit a wide variety of verticals and end user applications in the UK, for both fixed and mobile uses, within the terrestrial (land-based), maritime and aeronautical sectors. Including:

- Maritime: UK registered cruise ships, super yachts, cargo ships, ports
- Enterprise: resilience to corporate networks, remote industrial sites, offshore oil and gas sites in the North Sea, etc.
- BeetleSat's intelligent LEO network will support allocation of bandwidth over areas with high traffic demand, requiring high-quality and reliable satellite backhaul.

# 5 Compliance with additional conditions (protection of other services)

## 5.1 Protection of Fixed Service Links

Beetlesat hereby confirms the compliance of the system with the power flux density limits set forth in Article 21 of the ITU Radio Regulations.

## 5.2 Protection of Radioastronomy

[6] https://www.ofcom.org.uk/__data/assets/pdf_file/0033/267594/SummerUpdate2023Final.pdf

The Beetlesat system will not operate in Ku-band. As such the radio astronomy service operating in the bands 14.25-14.5 Ghz and 10.6-10.7 GHz will be protected from any harmful interference.

### 5.3 Protection of GSO Services

Beetlesat hereby confirms the compliance of the system with the equivalent power flux density limits set forth in Article 22 of the ITU radio Regulations.

For bands not subject to the provisions of Article 22, Beetlesat will operate in accordance with agreed coordination terms with other potentially affected networks.

**Appendix 1: Satellite, Gateway/UT and Emission Parameters of NGSO Systems considered in this assessment**

**BEETLESAT**

| Parameter | Value | Unit |
|---|---|---|
| Shell #1 | | |
| Number of planes | 12 | |
| Number of satellites per plane | 22 | |
| Total number of satellites | 264 | |
| Apogee | 720 | Km |
| Perigee | 720 | km |
| Inclination | 53.5 | deg |
| General additional parameters | | |
| GSO exclusion angle | 5 | Deg |
| Minimum elevation angle | 15 | Deg |
| Total number of satellites | 264 | |

Downlink Parameters

| Parameter | Value | Unit |
|---|---|---|
| Satellite antenna Transmit gain | 25 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-25 | |
| UT Antenna receive gain | 34 - 46 | dBi |
| UT Antenna radiation pattern (receive) | Rec 580-6 | |
| Antenna receiver noise temperature | 290 | K |
| Power Spectral Density (Min/Max) | -90.8 / -81.5 | dBW/Hz |

Uplink Parameters

| Parameter | Value | Unit |
|---|---|---|
| UT Antenna transmit gain | 37.5 – 49.6 | dBi |
| UT Antenna radiation pattern (transmit) | Rec 580-6 | |
| Satellite antenna receive gain | 42.5 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-25 | |
| Satellite receiver noise temperature | 500 | K |
| Power Spectral Density (Min/Max) | -92.8 / -84.6 | dBW/Hz |

**MANGATA**

| Parameter | Value | Unit |
|---|---|---|
| MEO Constellation | | |
| Number of planes | 27 | |
| Number of satellites per plane | 21 | |
| Total number of satellites | 567 | |
| Apogee | 6400 | Km |
| Perigee | 6400 | km |
| Inclination | 45, 50, 52.5 | deg |
| HEO Constellation | | |
| Number of planes | 32 | |
| Number of satellites per plane | 7 | |
| Total number of satellites | 224 | |
| Apogee | 611585, 9800, 9000, 11024 | Km |
| Perigee | 1215, 3000, 3800, 1776 | km |
| Inclination | 63.4.5 | deg |
| General additional parameters | | |
| GSO exclusion angle | 3 | Deg |
| Minimum elevation angle | 15 | Deg |
| Total number of satellites | 791 | |

Downlink Parameters

| Parameter | Value | Unit |
|---|---|---|
| Satellite antenna Transmit gain | 43.2 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-25 | |
| UT Antenna receive gain | 40.2 | dBi |
| UT Antenna radiation pattern (receive) | Rec 580-6 | |

| | | |
|---|---|---|
| Antenna receiver noise temperature | 290 | K |
| Power Spectral Density (Min/Max) | -107.2 / -87.2 | dBW/Hz |

Uplink Parameters

| Parameter | Value | Unit |
|---|---|---|
| UT Antenna transmit gain | 43.6 | dBi |
| UT Antenna radiation pattern (transmit) | Rec 465-5 | |
| Satellite antenna receive gain | 46.7 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-25 | |
| Satellite receiver noise temperature | 600 | K |
| Power Spectral Density (Min/Max) | -80.1 / -70 | dBW/Hz |

**STARLINK**

| Parameter | Value | Unit |
|---|---|---|
| Sub constellation 1 | | |
| Number of planes | 1500 | |
| Number of satellites per plane | 1 | |
| Total number of satellites | 1500 | |
| Apogee | 539.7 | Km |
| Perigee | 539.7 | km |
| Inclination | 85 | deg |
| Sub constellation 2 | | |
| Number of planes | 25 | |
| Number of satellites per plane | 60 | |
| Total number of satellites | 1500 | |
| Apogee | 539.7 | Km |
| Perigee | 539.7 | km |
| Inclination | 85 | deg |
| General additional parameters | | |
| GSO exclusion angle | 18 | Deg |
| Minimum elevation angle | 25 | Deg |
| Total number of satellites | 3000 | |

Downlink Parameters

| Parameter | Value | Unit |
|---|---|---|
| Satellite antenna Transmit gain | 34.5 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| UT Antenna receive gain | 47.5 | dBi |

| | | |
|---|---|---|
| UT Antenna radiation pattern (receive) | Rec S.1428 | |
| Antenna receiver noise temperature | 240 | K |
| Power Spectral Density (Min/Max) | -90.4 / -70.4 | dBW/Hz |

Uplink Parameters

| Parameter | Value | Unit |
|---|---|---|
| UT Antenna transmit gain | 50.8 | dBi |
| UT Antenna radiation pattern (transmit) | Rec S.1428 | |
| Satellite antenna receive gain | 38.5 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| Satellite receiver noise temperature | 501.2 | K |
| Power Spectral Density (Min/Max) | -90 / -65 | dBW/Hz |

**ONEWEB**

| Parameter | Value | Unit |
|---|---|---|
| Number of planes | 18 | |
| Number of satellites per plane | 49 | |
| Total number of satellites | 882 | |
| Apogee | 1200 | Km |
| Perigee | 1200 | km |
| Inclination | 87.9 | deg |
| General additional parameters | | |
| GSO exclusion angle | 6 | Deg |
| Minimum elevation angle | 5 | Deg |
| Total number of satellites | 880 | |

Downlink Parameters

| Parameter | Value | Unit |
|---|---|---|
| Satellite antenna Transmit gain | 34.6 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| GW Antenna receive gain | 54.6 | dBi |
| GW Antenna radiation pattern (receive) | Rec S.1428 | |
| Antenna receiver noise temperature | 240 | K |
| Power Spectral Density (Min/Max) | -85 / -69.7 | dBW/Hz |

Uplink Parameters

| Parameter | Value | Unit |
|---|---|---|
| GW antenna Transmit gain | 58 | dBi |
| GW Antenna radiation pattern (transmit) | Rec S.1428 | |
| Satellite antenna receive gain | 38 | dBi |

| | | |
|---|---|---|
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| Satellite receiver noise temperature | 440 | K |
| Power Spectral Density (Min/Max) | -81.7 / -58.3 | dBW/Hz |

**TELESAT**

| Parameter | Value | Unit |
|---|---|---|
| Sub constellation 1 | | |
| Number of planes | 6 | |
| Number of satellites per plane | 13 | |
| Total number of satellites | 78 | |
| Apogee | 1015 | Km |
| Perigee | 1015 | km |
| Inclination | 99.98 | deg |
| Sub constellation 2 | | |
| Number of planes | 20 | |
| Number of satellites per plane | 11 | |
| Total number of satellites | 220 | |
| Apogee | 1315 | Km |
| Perigee | 1315 | km |
| Inclination | 50.88 | deg |
| General additional parameters | | |
| GSO exclusion angle | 4.5 | Deg |
| Minimum elevation angle | 10 | Deg |
| Total number of satellites | 298 | |

Downlink Parameters

| Parameter | Value | Unit |
|---|---|---|
| Satellite antenna Transmit gain | 30.8 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-25 | |
| UT Antenna receive gain | 35.4 | dBi |
| UT Antenna radiation pattern (receive) | Rec S.580-6 | |
| Antenna receiver noise temperature | 250 | K |
| Power Spectral Density (Min/Max) | -81.45 / -78.5 | dBW/Hz |

Uplink Parameters

| Parameter | Value | Unit |
|---|---|---|
| UT antenna Transmit gain | 50.8 | dBi |

| | | |
|---|---|---|
| UT Antenna radiation pattern (transmit) | Rec S.580-6 | |
| Satellite antenna receive gain | 31.1 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| Satellite receiver noise temperature | 730 | K |
| Power Spectral Density (Min/Max) | -84.07 / -64 | dBW/Hz |

**RIVADA**

| Parameter | Value | Unit |
|---|---|---|
| Number of planes | 24 | |
| Number of satellites per plane | 24 | |
| Apogee | 1050 | Km |
| Perigee | 1050 | km |
| Inclination | 89 | deg |
| General additional parameters | | |
| GSO exclusion angle | 4 | Deg |
| Minimum elevation angle | 10 | Deg |
| Total number of satellites | 576 | |

Downlink Parameters

| Parameter | Value | Unit |
|---|---|---|
| Satellite antenna Transmit gain | 30 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| UT Antenna receive gain | 46.5 | dBi |
| UT Antenna radiation pattern (receive) | Rec S.1428 | |
| Antenna receiver noise temperature | 120 | K |
| Power Spectral Density (Min/Max) | -81.6 / - 75.6 | dBW/Hz |

Uplink Parameters

| Parameter | Value | Unit |
|---|---|---|
| UT antenna Transmit gain | 49 | dBi |
| UT Antenna radiation pattern (transmit) | Rec S.1428 | |
| Satellite antenna receive gain | 30 | dBi |
| Satellite antenna radiation pattern | Rec S.1528, Ln=-20 | |
| Satellite receiver noise temperature | 600 | K |
| Power Spectral Density (Min/Max) | -13/-13 | dBW/Hz |