Annex to Satellite (earth station network) radio licence application form non-geostationary – OfW602
Additional information D1, D2 and D3

Applicant: Mangata Edge Ltd

1. Introduction

This Annex, attached to the application made by Mangata Edge Ltd for the NGSO Network Licence, provides coexistence assessments and competitive impact assessment identified in the "Section D. Additional information" of the application form.

Information to be provided under D1 "Coexistence with existing systems" concerns the Mangata NGSO satellite system's coexistence with:

a) other existing non-geostationary satellite systems that are already licensed in the UK;
b) non-geostationary satellite system for which an application has been made and which has been published for comment on Ofcom's website; and
c) other specific co-frequency earth stations registered with the ITU.

Information to be provided under D2 "Coexistence with future systems" concerns the Mangata NGSO satellite system's coexistence with:

d) future NGSO systems.

In this Annex the NGSO systems identified under a) and b) of D1 are collectively referred to as "Existing NGSO Systems". Our responses to D1 and D2 have been prepared following the guidance issued in Ofcom's Non-geostationary satellite earth stations – Licensing guidance[1] ("NGSO Licensing Guidance"), specifically the section 2.7 onwards in the NGSO Licensing Guidance. We have analysed the interference situations between the Ka band links of Mangata NGSO satellite system's User Terminals (UTs) and Ka band links of UTs and gateways (GW) of Existing NGSO Systems.

Relevant system information on the Mangata NGSO satellite system is given in Section 2.

Response to D1, i.e. coexistence assessments for Existing NGSO Systems, can be found in Section 3.1. These coexistence assessments, results of which are presented as cumulative distribution functions (CDF) of the interference-to-noise ratio (I/N) for varying percentages of time, show the feasibility of coexistence between Mangata NGSO satellite system and the Existing NGSO Systems with a minimal impact on unavailability and throughput of such systems. We have used "lookaside", when necessary, as the method of mitigating interference that occurs during inline events. Our demonstration of the feasibility of coexisting with Existing NGSO Systems enabled us to predict the

[1] Ofcom: Non-geostationary satellite earth stations, Licensing guidance, 10 December 2021

likelihood of achieving similar coexistence with future NGSO systems. These assessments, i.e. our response to D2, are presented in Section 3.2.

The feasibility of coexistence with Existing NGSO Systems also gives us the confidence to forecast the likelihood of reaching successful frequency coordination with the operators of Existing NGSO Systems and other Ka band NGSO operators elsewhere in the world.

Item c) of D1 requires us to address the coexistence with other specific co-frequency earth stations registered with the ITU. This assessment is given in Section 4.

This report, in its Section 5, presents a competitive impact assessment. We have briefly examined the current position of the UK broadband service availability. In the competitive impact assessment we have argued that access to the UK market and its consumers and businesses for the innovative Mangata satellite services would enhance the choice available to the consumer and therefore lead to effective competition for high speed broadband and associated services throughout the UK.

2. Mangata system

Mangata system is a combination of both a medium earth orbit ("MEO") constellation and a highly elliptical orbit ("HEO") constellation with the same orbital period. The combined constellation will have a total of 791 satellites. Mangata satellite filings are ARISTARCUS and MITCHELL made via the UK administration.

Ka band spectrum available for the Mangata satellite system:

FORWARD LINKS		RETURN LINKS	
Gateway to Spacecraft	**Spacecraft to User Terminal**	**User Terminal to Spacecraft**	**Spacecraft to Gateway**
27.5 – 30.0 GHz	17.3 – 18.6 GHz	27.5 – 30 GHz	17.3 – 18.6 GHz
30 – 31 GHz	18.8 – 20.2 GHz	*30 – 31 GHz*	18.8 – 20.2 GHz
			20.2 – 21.2 GHz

Table 1: Mangata NGSO system – available Ka band spectrum

Mangata plans to deploy land earth stations (user terminals) in the UK in the frequency bands 27.5 – 27.8185 GHz, 28.4545 – 28.8265 GHz, and 29.5 – 30 GHz, as specified in the NGSO Licensing Guidance.

Mangata system orbital information:

- MEO
  - 6400 km (circular) / 45° inclination / 9 planes x 21 satellites
  - 6400 km (circular) / 50° inclination / 9 planes x 21 satellites
  - 6400 km (circular) / 52.5° inclination / 9 planes x 21 satellites
- HEO (Northern):
  - 9000 x 3800 km / 63.4° Inclination / 4 Planes x 7 satellites
  - 9800 x 3000 km / 63.4° Inclination / 4 Planes x 7 satellites
  - 11024 x 1776 km / 63.4° Inclination / 4 Planes x 7 satellites
  - 11585 x 1215 km / 63.4° Inclination / 4 Planes x 7 satellites
- HEO (Southern):
  - 9000 x 3800 km / 63.4° Inclination / 4 Planes x 7 satellites
  - 9800 x 3000 km / 63.4° Inclination / 4 Planes x 7 satellites
  - 11024 x 1776 km / 63.4° Inclination / 4 Planes x 7 satellites
  - 11585 x 1215 km / 63.4° Inclination / 4 Planes x 7 satellites

Mangata satellite system

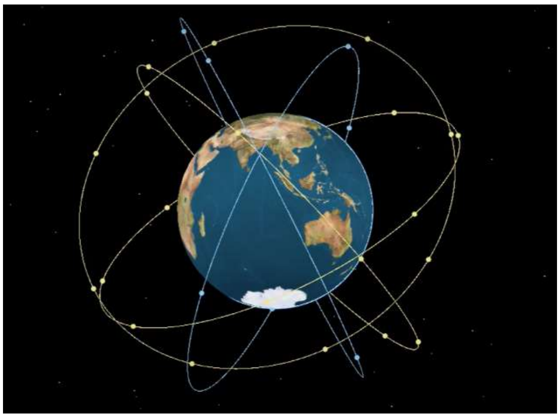

Figure 1: HEO and MEO constellation

As illustrated in Figure 1, Mangata NGSO constellation is a hybrid solution, consisting of 791 satellites distributed in 27 MEO planes with inclinations between 45-52.5 degrees and 32 HEO planes with inclinations of 63.4 degrees, designed for optimal global coverage and system performance. Each satellite in the system will be technically and functionally identical, with a mass of less than 500 kg and will have a design life of at least 10 years.

These features, in combination with a redundant payload (two-for-one redundancy for all major platform components), and a hybrid MEO/HEO configuration enable the Mangata's constellation to provide a robust, high-availability service to consumers as well as for governmental applications. The system is designed to maximise the available spectrum resources.

General system architecture of the Mangata satellite system is shown in the Figure 2 below. As shown, this architecture allows us to offer a multitude of services, including fixed and mobility networks (land, air and sea), community and enterprise WiFi, services associated with our MangataEdge™ micro data centres.

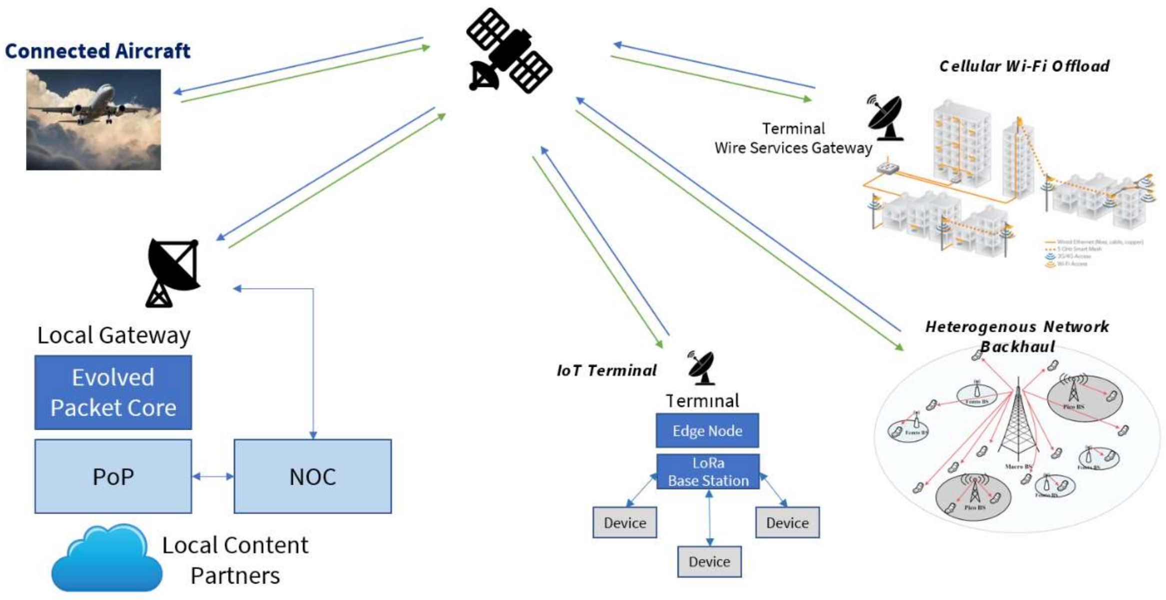

Figure 2. Mangata System Architecture

Mangata satellite services

Mangata system's orbital configuration is constructed for accelerated deployment, providing services to all of North America and Northern Europe after the first two launches of HEO satellites (i.e., a constellation of 8 satellites in two planes, with four satellites in each plane) planned for 2024. This arrangement allows capacity to be targeted to specific markets or specific latitudes. The Figure 3 shows the continuous coverage available from 8 satellites over Northern latitudes, which includes the UK, and services offerings could be initiated by the year 2025.

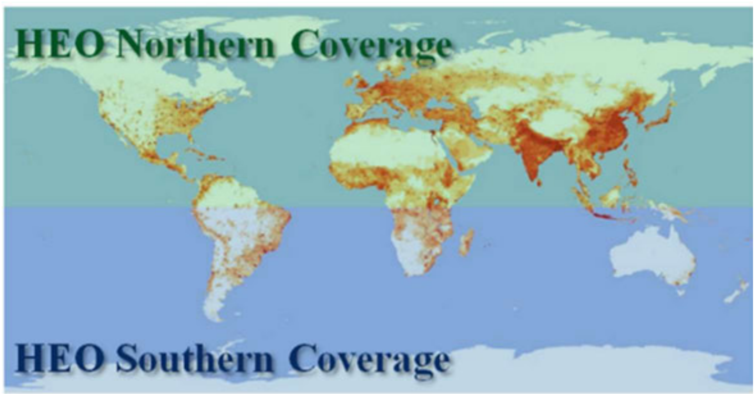

Figure 3: Mangata HEO (Northern) coverage

The user terminals deployed by Mangata satellite system will serve fixed and mobility markets discussed above. Terminal size will be dependent on capacity served, with terminals less than 1 m in diameter serving capacities between 50-500 Mbps, and terminals greater than 1 m serving capacities 500 Mbps and greater. Terminal technology will include traditional parabolic reflectors for terminals greater than 1 meter, and a mix of parabolic reflectors and phased arrays for terminals less than 1 meter. In both cases, the technology implementation will provide for inherent redundancy either through dual parabolic reflectors (nominally supporting make-before-break handovers), or active/passive phased arrays.

MangataEdge™

MangataEdge™ is a revolutionary product combining a satellite terminal, an integrated micro data centre, and an open Radio Access Network (RAN) layer that can be easily integrated into terrestrial networks such as LTE/5G cellular networks. MangataEdge™ offers high network reliability and enhances security and traffic management capability, including in case of outages, localized congestion, or bad weather. These ruggedized and secure micro edge data centres, conceptual design of which is shown in Figure 4, are deployable near end-users such as at existing cellular towers.

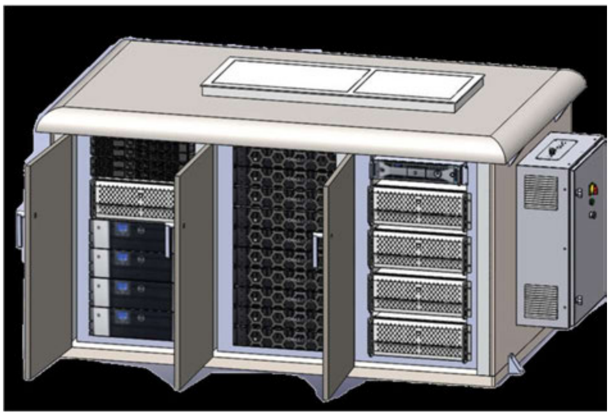

Figure 4: MangataEdge™ conceptual design

MangataEdge™ is designed to provide 500Mbps, 1 Gbps, and 2 Gbps data rates to micro data centres at the edge of the network. The micro data centres include resource management capability for both data management and dynamic control of virtual network slices for 5G or 4G/LTE cellular networks, Wi-Fi networks, and IoT networks. Applications and content can be stored locally at the edge, close to the users.

We can deploy >1,200 micro data centres with our initial 8 satellites and scale to >170,000 when we operate the full system of 791 satellites. MangataEdge™ comes in three sizes to serve different numbers and concentrations of users. The smallest can support up to 200 simultaneous users while the largest can support 2,000 users. The product can be used for private networks and can be deployed directly into ISP or cellular operator networks.

3. Coexistence assessment

We are currently initiating discussions with the operators of Existing NGSO Systems with a view to reaching detailed frequency coordination agreements. However, following the directions given by Ofcom (see NGSO Licensing Guidance[2]) we elected to demonstrate the coexistence of the Mangata NGSO satellite system with Existing NGSO Systems and future NGSO systems, by carrying out necessary detailed technical assessments as described below.

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")

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 Mangata NGSO satellite system and the Ka band links of Existing NGSO Systems, listed in Table 2 below.

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[2] As set out in section 2.9 of Ofcom's NGSO Licensing Guidance: *If no such agreement exists, applicants should specify in detail how it would be possible for the different systems to coexist. They should provide evidence that reasonable measures can be put in place -* ***by either the applicant, the existing licensee, or by both*** *- to achieve coexistence. Specifically, applicants should provide enough evidence to demonstrate that the impact to existing licensees in terms of increased unavailability and of reduction in throughput would be modest.*

[3] https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/satellite-earth/non-geo-fss

Mangata link	Existing NGSO Satellite System link	Comments
Mangata user terminal links	Starlink gateway links	Starlink gateways are located in the UK. A Starlink gateway in Buckinghamshire collocating with a Mangata UT was considered for this coexistence assessment.
	OneWeb gateway links	OneWeb gateways are not located in the UK. Therefore, one of the gateways in Europe, Sinatra, Portugal, was considered for the coexistence assessment with a Mangata UT located in the UK.
	Telesat user terminal links	Telesat user terminals could be located in the UK. A Telesat user terminal colocated with Mangata user terminal in the UK was considered for the coexistence assessment.

Table 2: Ka band links of Existing NGSO Systems considered for coexistence assessments

3.1.1 I/N Criteria considered in this assessment

The long term and short term interference criteria have been derived using methodology B of Recommendation S.1323-2 and presented in the Table 3 below.

I/N Criteria in dB	% of time
-12.2	100
-12.2	10
1.8	0.0001

Table 3: Long term and short term I/N criteria

3.1.2 Results of coexistence assessment between Mangata NGSO satellite system and Existing NGSO Systems

Interference assessments for each of the Existing NGSO Systems are presented as cumulative distribution functions (CDF) of the interference-to-noise ratio (I/N) for varying percentages of time. These results are assessed against the long term and short term interference criteria established using ITU-R Recommendation S.1323-2 and listed in Table 3 above.

The typical unavailability due to interference can be calculated using ITU-R Recommendation S. 1323-2. The corresponding impact on capacity, i.e., throughput loss, can be assessed using the formulae given in ITU-R Recommendation S.2131.

Techniques for mitigating of interference between NGSO systems have been well established and include:

- Lookaside
- Avoidance of overlapping frequency bands
- Use of opposite polarisation

In this assessment, when inline interference is detected, lookaside is deployed as the first approach for mitigating such interference, since it presents a minimal adverse impact on spectrum available for the satellite systems concerned. Results presented below identify when lookaside is deployed.

Results:
Coexistence assessments were carried out for situations listed in Table 2 above. The CDFs of I/N for varying percentages of time derived for interference situations between UT links of Mangata NGSO satellite system and Ka band links of Existing NGSO Systems are given in Figures 5 to 11 below. Transfinite software was used for these assessments, with Tracking Strategy options set as follows:

a) Minimum elevation angle as specified in the satellite filing;
b) GSO arc avoidance angle of specified in the satellite filing
c) avoidance angle is set at an appropriate angle to avoid interference when long term or short term interference criteria were is exceeded.

Examination of these CDFs show that the long term and short term criteria are not met in several cases. Such cases are identified in summary tables provided for each assessment given below. The interference avoidance is achieved with lookaside and the avoidance angle deployed for each case is presented with the results in the summary tables below.

Our coexistence results are summarised below.

Starlink Gateway (GW) and Mangata User Terminal (UT) colocated – situation as described in Table 2

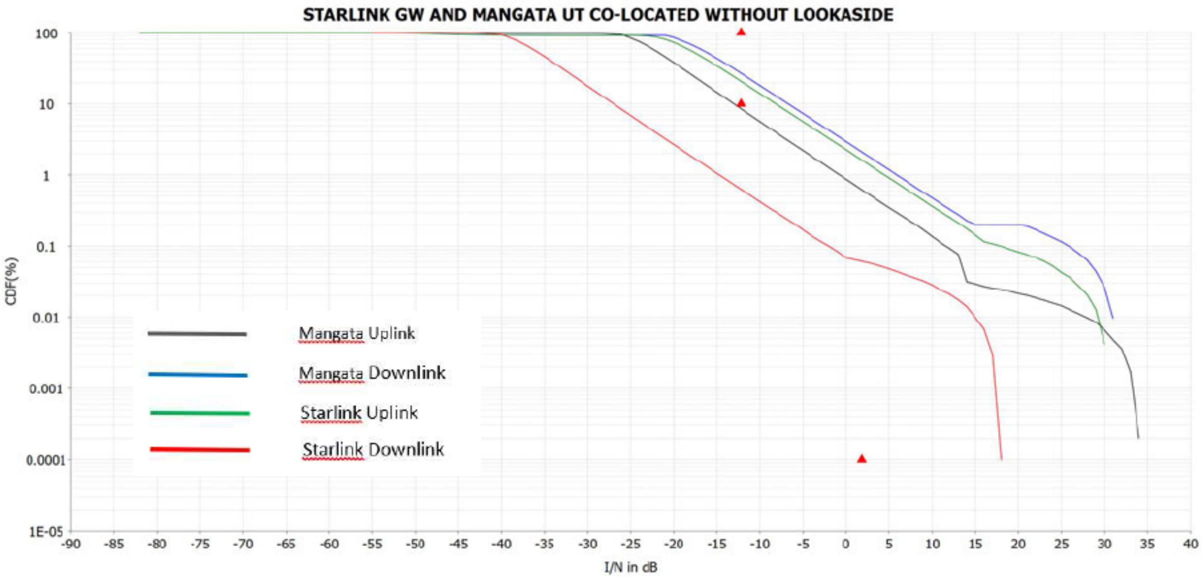

Figure 5: Starlink GW and Mangata UT colocated without lookaside

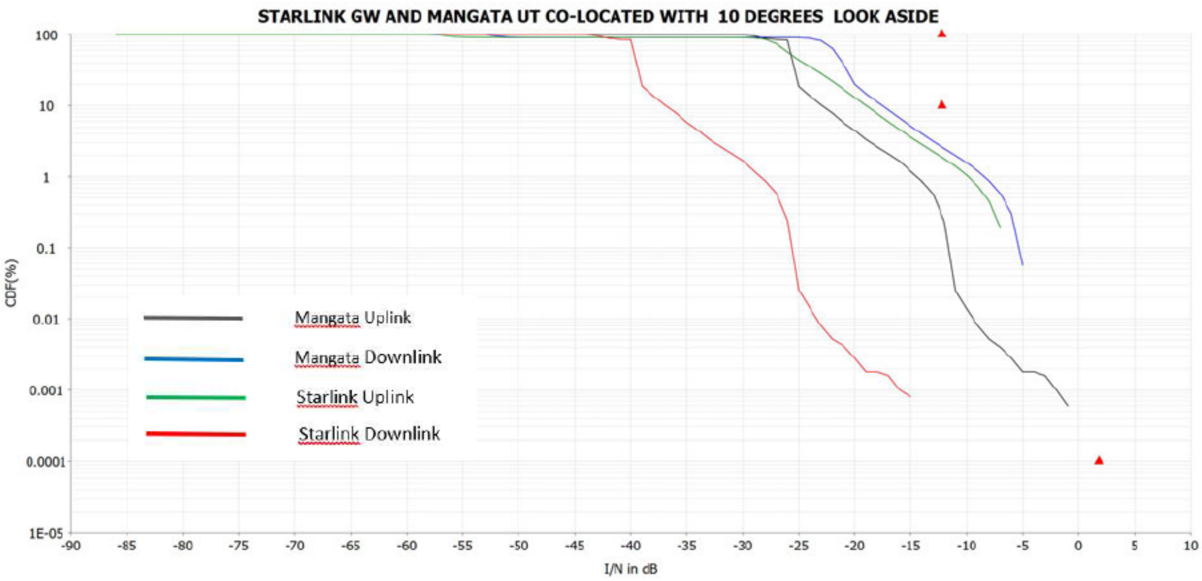

Figure 6: Starlink GW and Mangata UT colocated with lookaside of 10 degrees

The results of the above CDFs are summarised in the Table below:

	Colocated – No lookaside		Colocated – With lookaside 10 degrees	
	Long term I/N Criterion	**Short term I/N Criterion**	**Long term I/N Criterion**	**Short term I/N Criterion**
Mangata Uplink	Met	Not met	Met	Met
Mangata Downlink	Not met	Not met	Met	Met
Starlink Uplink	Not Met	Not met	Met	Met
Starlink Downlink	Met	Not met	Met	Met

Table 4: Summary of compliance with long term and short term interference criteria

Unavailability and throughput loss with deployment of lookaside:

	Unavailability (%)	**Throughput Loss (%)**
Mangata System: Uplink	0.004404	1.34E-01
Mangata System: Downlink	0.009905	1.45E+00
Starlink System: Uplink	0.986628	2.53E-01
Starlink System: Downlink	0.029185	4.23E-03

Table 5: Unavailability and throughput loss

<u>OneWeb Gateway (GW) and Mangata User Terminal (UT) – situation as described in Table 2</u>

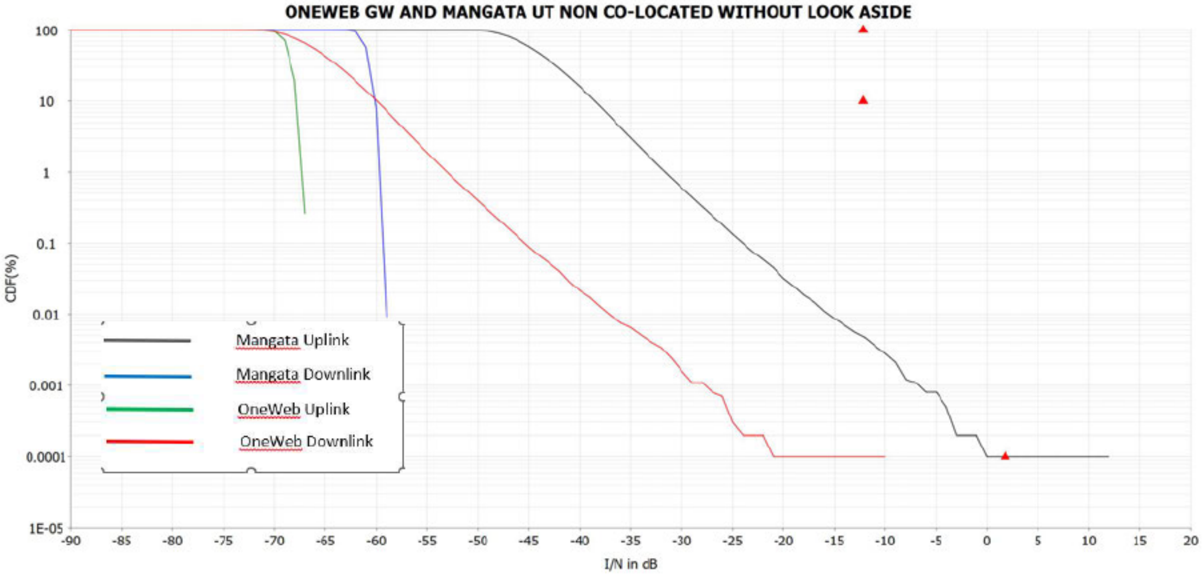

Figure 7: OneWeb GW and Mangata UT not colocated and without lookaside

The results of the above CDFs are summarised in the Table below:

	Colocated – No lookaside	
	Long term I/N Criterion	**Short term I/N Criterion**
Mangata Uplink	Met	Met
Mangata Downlink	Met	Met
OneWeb Uplink	Met	Met
OneWeb Downlink	Met	Met

Table 6: Summary of compliance with long term and short term interference criteria

Unavailability and throughput loss:

	Unavailability (%)	**Throughput Loss (%)**
Mangata System: Uplink	0.05888	1.01E-03
Mangata System: Downlink	0.0	8.86E-05
OneWeb System: Uplink	0.01021	3.80E-06
Oneweb System: Downlink	0.01021	1.04E-05

Table 7: Unavailability and throughput loss

<u>Telesat User Terminal (UT) and Mangata User Terminal (UT) colocated – situation as described in Table 2</u>

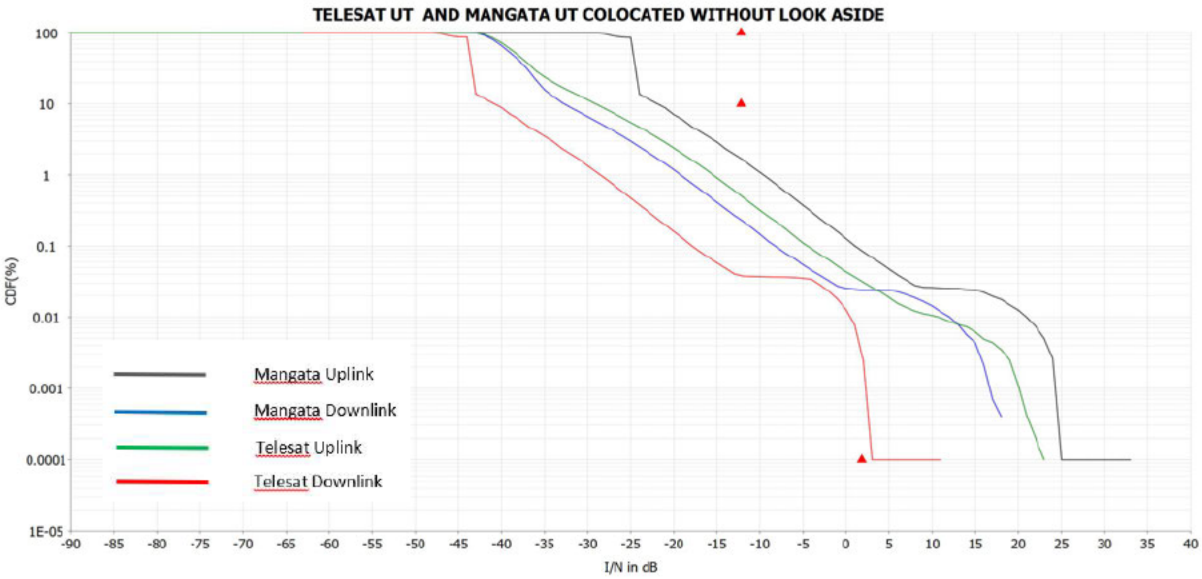

Figure 8: Telesat UT and Mangata UT colocated without lookaside

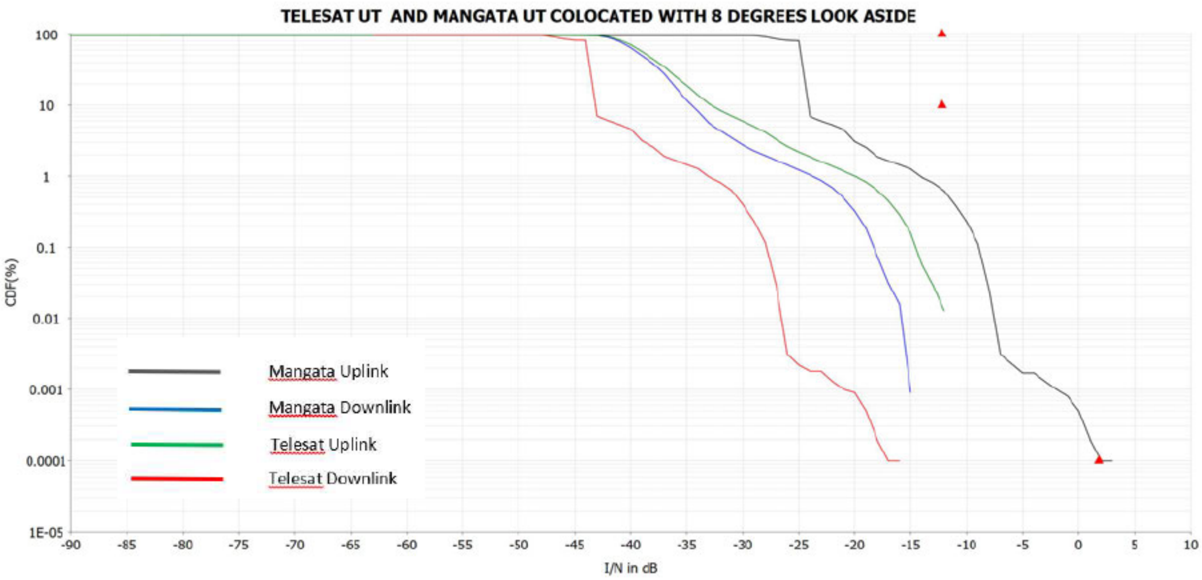

Figure 9: Telesat UT and Mangata UT colocated with lookaside of 8 degrees

The results of the above CDFs are summarised in the Table below:

	Colocated – No lookaside		Colocated – With lookaside 8 degrees	
	Long term I/N Criterion	**Short term I/N Criterion**	**Long term I/N Criterion**	**Short term I/N Criterion**
Mangata Uplink	Met	Not met	Met	Met
Mangata Downlink	Met	Not met	Met	Met
Telesat Uplink	Met	Not met	Met	Met
Telesat Downlink	Met	Not met	Met	Met

Table 8: Summary of compliance with long term and short term interference criteria

Unavailability and throughput loss with lookaside:

	Unavailability (%)	**Throughput Loss (%)**
Mangata System: Uplink	0.000401	1.48E-01
Mangata System: Downlink	0.00015	2.32E-02
Telesat System: Uplink	0.0002	4.64E-04
Telesat System: Downlink	0.00017	3.80E-06

Table 9: Unavailability and throughput loss

3.2 coexistence with future NGSO systems

It was established with the coexistence assessments shown in the above section, that when long term and/or short term interference criteria cannot be met for two NGSO satellite systems (i.e. Mangata NGSO satellite system and one Existing NGSO Systems), then by deploying lookaside such interference situations could be overcome. In these cases we found that there was no need to consider other available mitigations techniques, namely avoidance of overlapping frequency bands and use of opposite polarisation.

The lookaside approach should offer a suitable interference mitigation for future NGSO systems as long as the concerned NGSO satellite systems are designed in such a way to offer at least one alternative satellite within the field of view of the earth station (UT or GW). This filed of view is taken as that provides for the minimum elevation angle defined for the satellite system. Most prominent NGSO systems published by the ITU and examined by us seem to provide such alternative satellites in the field of view of the earth stations. However, it is not possible to provide individual assessments on each of the published NSGO satellite systems, but our general assessments allow us to be confident about the possibility of arriving at required coexistence with such future NGSO systems by deploying lookaside.

If for any reason we find that lookaside doesn't offer for the required coexistence, then the opportunity exists for reaching required coexistence by deploying other available mitigation techniques, namely avoidance of overlapping frequency bands and use of opposite polarisation. Such techniques have been proposed by other administrations for achieving coexistence. Deployment of such techniques will require close cooperation of the operators concerned and will have to be documented in coordination agreements.

4 Other specific co-frequency earth stations registered with the ITU

It is also necessary to examine whether the Mangata satellite emissions would cause interference to other co-frequency earth stations (in the UK) registered with the ITU. Such earth stations located in the UK are listed in Ofcom's website. We have reproduced below the list of the earth stations with an overlap of frequency bands (Ka band) with the Mangata NGSO satellite system.

Earth station name	Earth station location (decimal degrees)	Associated space station name	Associated space station geostationary orbit location	Minimum frequency (MHz)	Maximum frequency (MHz)
MENWITH HILL-A1	1.6833°W, 54.0167°N	USCSID-A1	0	17800	20200
MENWITH HILL-A2	1.6833°W, 54.0167°N	USCSID-A2	44	17800	20200
MENWITH HILL-E1	1.6833°W, 54.0167°N	USCSID-E1	-10	17800	20200
MENWITH HILL-E2	1.6833°W, 54.0167°N	USCSID-E2	-13	17800	20200
MENWITH HILL-E3	1.6833°W, 54.0167°N	USCSID-E3	-24	17800	20200
MENWITH HILL-E4	1.6833°W, 54.0167°N	USCSID-E4	-30	17800	20200

Table 10: List of earth stations registered with the ITU

All these earth stations are located at Menwith Hill. One such station has been examined using the Visulyze EPFD software with the downlink EPFD masks filed for ARISTARCHUS filing.
Menwith hill earth station considered is:

- Earth Station Name: MENWITH HILL- E2
- Latitude: 54.0167N
- Longitude: 1.6833W
- GSO Satellite: USCSID-E2 at 13W

Our results on the probability distribution of the EPFD is shown in Figure 10 below,

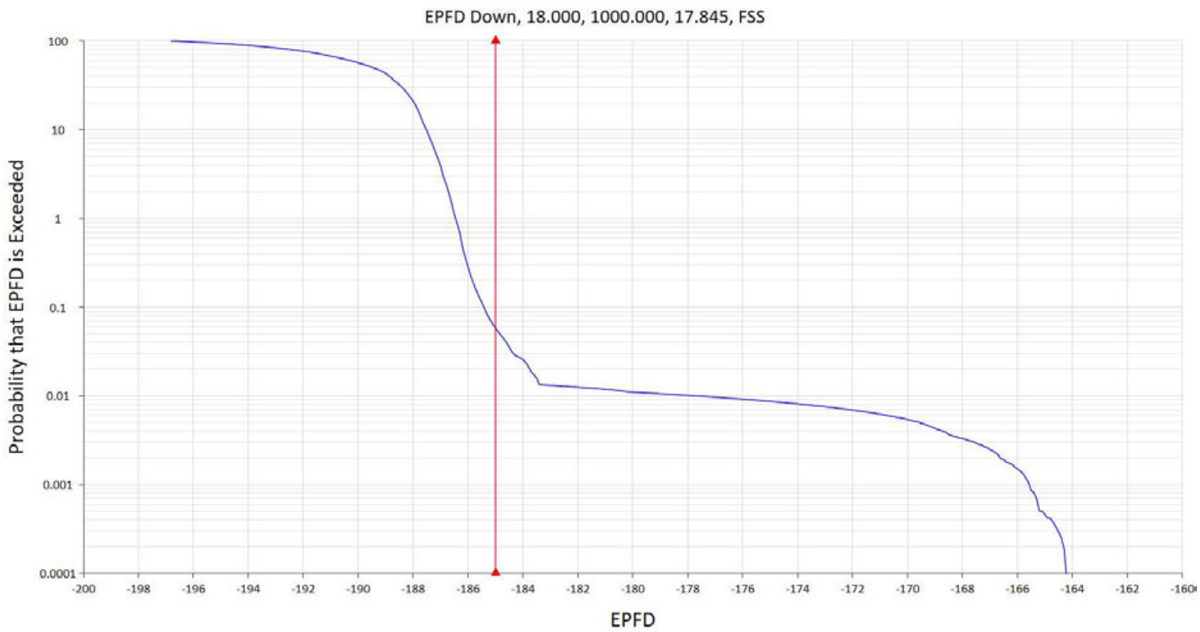

Figure 10: Probability distribution of the EPFD

These results show that the EPFD limit –185 dB(W/(m2 · MHz)) specified in considering d), ii) b) of ITU-R Recommendation S.1714 has been exceeded, triggering coordination under RR Nos. 9.7A and 9.7B. Mangata NGSO system's capability to offer protection these earth stations has been notified to the operator of these earth stations. Further, we give our assurances on providing required protection by deploying necessary technical and operational measures with our Mangata NGSO system.

5 Competitive impact assessment

The most recent study commissioned by Ofcom[4] and also the study commissioned by DCMS[5] suggest that investment in broadband has had significant benefits to the UK economy. These reports also found that broadband adoption over the 2002 – 2016 period (a 15 year period) led to an increase in GDP of 0.37% per annum in the UK, amounting to a cumulative increase of around 5.3% over the period. In addition, a strong positive relationship between broadband speed and economic growth was identified, whilst noting that there are speed thresholds at which the GDP effects start to tail off. The report produced for Ofcom concludes with the statement "*The overarching message given by the research appears to be that there will continue to be economic benefits from broadband investment to the UK in the future, in terms of availability, take-up and speed*".

The term "decent broadband" is used to define the speed of broadband associated with Universal Service Obligation (USO): i.e., at least 10Mbit/s download and 1Mbit/s upload speed. Ofcom has estimated[6] that there are about 190,000 homes currently without access to decent broadband, and recognised the very high costs of building to the most remote locations across the UK. Ofcom research[7] on fixed line broadband delivered in the UK at March 2021 found the median download speed of those connected to be 50.4 Mbits/s, while only 5% of connections were ultrafast packages with advertised speeds of 300 Mbit/s or more.

Mangata service provision to meet UK consumer demand

The above summary on Ofcom's research illustrates the case for more easily accessible high speed broadband services delivered to consumers and also to businesses at affordable costs. Mangata's NGSO satellite system will cater for these demands. Mangata will partner with UK Telecom Operators, Internet Service Providers (ISPs), Enterprises, IoT companies, and Governments to help them deploy their services to the edge of the network. The user terminals deployed by Mangata will serve various fixed and mobility markets. Terminal size will be dependent on capacity served, with terminals less than 1 m in diameter serving capacities between 50-500 Mbps, and terminals greater than 1 m serving capacities 500 Mbps and greater.

Land User Terminals

Mangata' land UTs deployed at consumer/business premisses anywhere in the UK (more emphasis will be placed on remote parts of the UK lacking decent broadband) will offer high speed broadband (50-500 Mbps to terminals with 1m antennas) services at affordable costs. In addition, MangataEdge™ micro data centres will extend the cloud to the edge of the network, close to our

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[4] The economic impact of broadband: evidence from OECD countries - Pantelis Koutroumpis, 27 April 2018
[5] Evaluation of the Economic Impact and Public Value of the Superfast Broadband Programme Final Report, August 2018
[6] Ofcom's plan of work 2021/22
[7] UK Home Broadband Performance. Published 9 September 2021

users. Our single unified network will provide scalable connectivity that is both affordable and accessible to anyone, anywhere on the planet.

Aeromobility

Aeromobility is a market targeted by Mangata, specifically to address the increasing consumer demands in European countries such as the UK. 85% of the global aeromobility traffic is in the northern hemisphere. Our 8 initial HEOs can provide >300 Gbps into this market, representing 60% of the projected 2025 aeromobility demand of 480Gbps, even when taking post-Covid recovery into account. Mangata's ability to keep multiple satellites in view afford higher capacity in a given location, enabling us to deliver high throughput capacity to aircraft, dense aero corridors over the UK airspace

and also for busy UK airports which routinely require 10s of Gbps in a small area. Such arrangements will ensure that Mangata aeromobility services effectively contribute to meeting UK consumers demands.

Our commitments to deliver such services to the UK consumers have been demonstrated with early customer capacity pre-bookings worth tens of millions of US dollars. Our advanced capabilities and aggressive pricing strategy for aircraft internet service providers have enabled us to achieve these early successes.

Maritime

Mangata NGSO satellite system will operate in a competitive market served by other NGSO satellite systems offering similar services. The spectrum available will be effectively shared between these operators.

Satellite is the ideal and perhaps the only means of connectivity for maritime vessels, mobile offshore drilling units and oil rigs, the latter cases due to their distances from shore. Mangata's hybrid satellite constellations enable us to provide high-speed, low-latency satellite communications to every major ocean and body of water meeting the requirements of such applications. Mangata system is designed to deliver forward and return traffic in excess of 1 Gbps, in each direction for maritime applications.

We plan to integrate our satellite services with MangataEdge™ micro data centres to act as local data aggregation and processing platforms. This architecture would allow a host of other applications, such as private networks (i.e. network approved by national regulators, such as WiFi, extending 4G/5G services), security and surveillance, container tracking, automated cranes, to be deployed seamlessly over our networks.

These concepts are illustrated in the Figures 11 and 12 below.

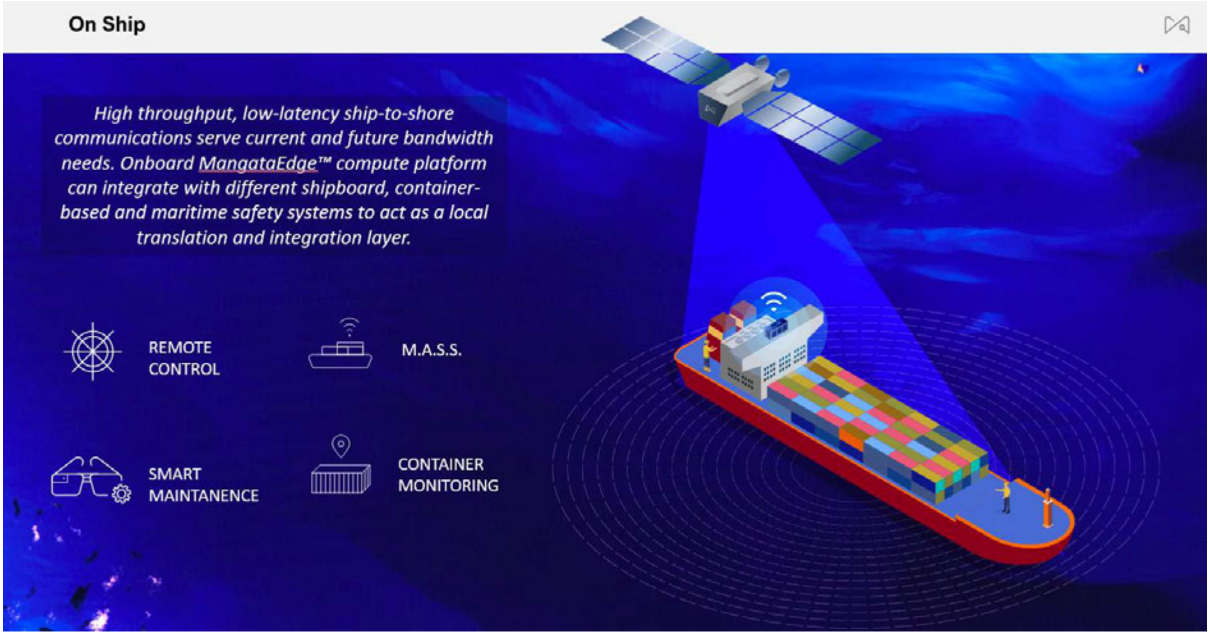

Figure 11 Mangata maritime service – conceptual arrangement for ship communications

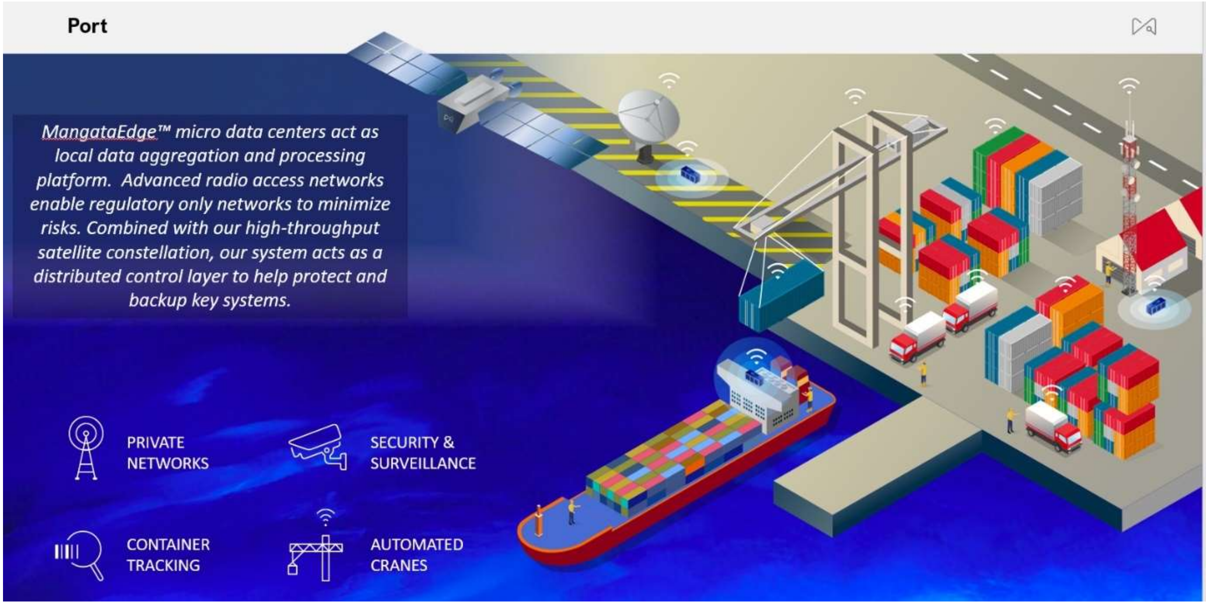

Figure 12 Mangata maritime service – conceptual arrangement for port communications

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

MANGATA

Table-A1: Mangata General Parameters

Parameter	**Value**	**Unit**
MEO Constellation		
Number of planes	27	
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	
Satellites per plane	7	
Total number of satellites	224	
Apogee	11585, 9800, 9000, 11024	Km
Perigee	1215, 3000, 3800, 1776	Km
Inclination	63.4	Deg
General additional Parameters		
GSO exclusion angle	3	Deg
Minimum elevation angle	15	Deg
Total number of satellites	791	Deg

Table-A2: Antenna Parameters

Parameters for the UT Link	**Value**	**Unit**
UT Antenna TX Gain	43.6	dBi
UT Antenna Receive Gain	40.2	dBi
Antenna Radiation Pattern Transmit side	Rec 465-5	deg
Antenna Radiation Pattern Receive side	Rec 580-6	deg
Antenna Receiver Noise Temperature	290	Deg K
Satellite Antenna TX Gain	43.2	dBi
Satellite Antenna Receive Gain	46.7	dBi

Satellite Antenna Radiation Pattern	Rec 1528	Ln = -25
Satellite Receiver Noise Temperature	600	Deg K

Table-A3: Emission Parameters

Parameters for the UT Link	**Value**	Unit
Uplink Power Spectral Density (maximum)	-70	dBW/Hz
Uplink Power Spectral Density (minimum)	-80.1	dBW/Hz
Downlink Power Spectral Density (maximum)	-87.2	dBW/Hz
Downlink Power Spectral Density (minimum)	-107.2	dBW/Hz

STARLINK

Table-A4: Starlink General Parameters

1500 orbital planes with one satellite each in plane
25 orbital planes with sixty satellites in each plane
Total Number of satellites: 3000
Inclination angle: 85 degrees
Apogee/Perigee: 539.7 km/539.7 km

Table-A5: Antenna Parameters

Parameters for the GW Link	**Value**	**Unit**
GW Antenna TX Gain	49.5	dBi
GW Antenna Receive Gain	46.9	dBi
Antenna Radiation Pattern	Rec 580-6	deg
Antenna Receiver Noise Temperature	100	deg K
Satellite Antenna TX Gain	30	dBi
Satellite Antenna Receive Gain	30	dBi
Satellite Antenna Radiation Pattern	Rec 1528	Ln = -25
Satellite Receiver Noise Temperature	350	deg K

Table-A6: Emission Parameters

Parameters for the GW Link	**Value**	Unit
Uplink Power Spectral Density (maximum)	-65.0	dBW/Hz
Uplink Power Spectral Density (minimum)	-90.0	dBW/Hz
Downlink Power Spectral Density (maximum)	-70.4	dBW/Hz
Downlink Power Spectral Density (minimum)	-90.4	dBW/Hz

ONEWEB

Table-A7: OneWeb General Parameters

18 orbital planes with 20 satellites in each plane
31 orbital planes with 52 satellites in each plane
18 orbital planes with 40 satellites in each plane
18 orbital planes with 55 satellites in each plane
18 orbital planes with 15 satellites in each plane
Total Number of satellites: 3952
Inclination angle: around 88 degrees
Apogee: 800 – 1200 km
Perigee: 800 – 1200 km

Table-A8: Antenna Parameters

Parameters for the GW Link	**Value**	**Unit**
GW Antenna TX Gain	52.8	dBi
GW Antenna Receive Gain	49.2	dBi
Antenna Radiation Pattern	App-8	deg
Antenna Receiver Noise Temperature	120	deg K
Satellite Antenna TX Gain	27.6	dBi
Satellite Antenna Receive Gain	31.2	dBi
Satellite Antenna Radiation Pattern	Rec 1528	Ln = -25
Satellite Receiver Noise Temperature	600	deg K

Table-A9: Emission Parameters

Parameters for the GW Link	**Value**	**Unit**
Uplink Power Spectral Density (maximum)	-69.7	dBW/Hz
Uplink Power Spectral Density (minimum)	-85.0	dBW/Hz
Downlink Power Spectral Density (maximum)	-58.3	dBW/Hz
Downlink Power Spectral Density (minimum)	-81.7	dBW/Hz

TELESAT

Table-A10: Telesat General Parameters

6 orbital planes with 13 satellites in each plane (Polar)
Inclination angle: 99.98 degrees
Apogee: 1015km; Perigee: 1015 km
20 orbital planes with 11 satellites in each plane (inclined)
Inclination angle: 50.88 degrees
Apogee: 1315km; Perigee: 1315 km
Total Number of satellites: 298
GSO Exclusion angle: 4.5 degrees
Minimum Elevation Angle: 10 degrees

Table-A11: Antenna Parameters

Parameters for the UT Link	**Value**	**Unit**
UT Station Antenna TX Gain	38.9	dBi
UT Station Antenna Receive Gain	35.4	dBi
Antenna Radiation Pattern	Rec 580-6	deg
Antenna Receiver Noise Temperature	250	deg K
Satellite Antenna TX Gain	30.8	dBi
Satellite Antenna Receive Gain	31.1	dBi
Satellite Antenna Radiation Pattern	Rec 1528	Ln = -25
Satellite Receiver Noise Temperature	730	deg K

Table-A12: Emission Parameters

Parameters for the UT Link	**Value**	**Unit**
Uplink Power Spectral Density (maximum)	-64.0	dBW/Hz
Uplink Power Spectral Density (minimum)	-74.07	dBW/Hz
Downlink Power Spectral Density (maximum)	-78.5	dBW/Hz
Downlink Power Spectral Density (minimum)	-81.5	dBW/Hz