Annex to Application

D. Additional Information

Inmarsat Global Limited (IGL) and Space Norway Heosat AS (a subsidiary of Space Norway and hereafter referred to as "Space Norway" or "Heosat") are party to a Satellite Capacity Service Agreement pursuant to which: (i) Space Norway, which owns and operates ASBM-1 and -2 satellites and the GX10A and B payloads on board those satellites, leases capacity made available over those payloads to IGL;[1] and (ii) IGL has the right to access and use capacity made available over the GX10A and B payloads on an exclusive basis to provide service to customers within the coverage of the satellites, including the UK.

For the purpose of this application and with reference to Ofcom guidelines, IGL is the applicant and will act as the provider of Ka-band services to UK customers using the GX10 payloads, although Space Norway is and will remain primarily responsible for GX10 ITU satellite filings and coordination with other operators.

D.1 Coexistence with existing systems

Explain how your non-geostationary earth station(s) ("User terminals") will be able to coexist with the following:

a) Existing non-geostationary satellite systems that are licensed in the UK:

As of the date of submitting this application, the existing NGSO licensees mentioned in point (a) are:
1. Network Access Associates Ltd (license number 1102679);
2. Telesat LEO Inc (license number 1297041);
3. Starlink Internet Services Limited (license number 1239247); and,
4. Mangata Edge Ltd (license number 1309175)
5. Rivada Space Networks GmbH (license number TBC by Ofcom)

As described above, Inmarsat Global Limited will provide service using the GX10 payloads, which will operate under ITU network filings made on behalf of Space Norway. Space Norway has executed ITU coordination agreements covering the GX10 filings with the following operators: Network Access Associates Ltd, Telesat LEO Inc and Starlink Internet Services Limited. This demonstrates that the network can coexist with networks 1., 2. And 3. above in line with section 2.9 (a) of the Ofcom document "non-geostationary satellite earth stations Licensing guidance."

As we do not currently have a frequency coordination agreement with Mangata Edge Ltd, we provide technical analysis **(*Appendix 1*)** to show how coexistence is feasible between GX10 and Mangata Edge Ltd. We specifically show that the impact of the GX10 system on the licensee would be minimal in terms of increased unavailability and decreased throughput.

b) Non-geostationary satellite systems for which an application has been made and which has been published for comment on Ofcom's website:

As of the date of submitting this application, there is an open NGSO network earth station applications from NSLComm Ltd (ref. number: BEETLESAT-NET-1). The ability to coexist with the recently-authorized Rivada Space Networks GmbH satellite network is demonstrated in ***Appendix 2*** and the ability to coexist with the NSLComm Ltd satellite network is demonstrated in ***Appendix 3***.

[1] IGL, through the use of software, manages the operations of the GX10 network but does not control the overall operation of the ASBM satellites or GX10 payloads.

c) Other specific co-frequency earth stations registered with the ITU

Concerning the applicable specific co-frequency earth stations registered with the ITU, Space Norway has coordinated its NGSO system with the relevant operator(s) for those earth stations under the applicable provisions of Article 9 of the Radio Regulations. Space Norway commits to take any necessary technical and operational measures required to avoid interference into those earth stations.

D.2 Coexistence with future systems

Coexistence between NGSO systems entails limiting the number of in-line events or lessening their impact. Where feasible in practice, methods like exclusion angles can be set in coordination discussions to reduce the number of in-line events – while dynamically allocating power and bandwidth can lessen their impact.

A system must be flexible, agile, and technically sophisticated to benefit from any of these methods for coexisting with future systems. The GX10 system satisfies all these criteria as explained in ***Section D.4***. New future operators can discuss the implementation of any of these methods during coordination meetings as deemed required. In conclusion, the GX10 system can dynamically assign capacity where and when needed by adjusting the spectrum and power allotted to beams.

D.3 Competitive impact (optional)

Explain the impact of issuing you a licence (combined with other non-geostationary satellite system licences held or applied for by you) in terms of:

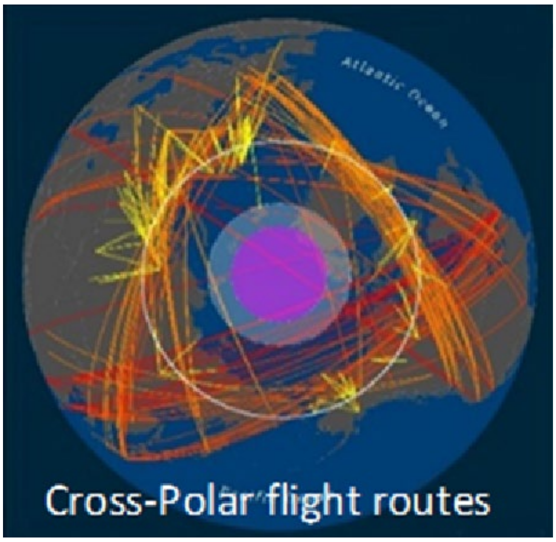
a) Any risks to competition in the UK. This may refer to the ability to coexist with other non-geostationary satellite systems.

As discussed in sections D1 and D2, theGX10 system has all the necessary capabilities to co-exist with current and upcoming non-geostationary satellite systems. As a result, there are no risks of coexistence.

b) Benefits for UK customers, end consumers, and/or citizens.

Having many satellite operators in the UK can bring several benefits to customers, end consumers, and citizens, including:

- Increased competition: Competition between satellite operators can lead to lower prices, better quality services, and more options for consumers. This can benefit both individual customers and businesses that rely on satellite services. Existing commercial satellite systems covering high latitude regions come from LEO constellations solutions. Enlarging the landscape with traditional GEO operators and expanding the commercial offer with highly reliable communications (usually required by government customers) is key to ensure a diverse satellite services portfolio to interested potential UK customers.
- Expanded coverage: With more satellite operators, coverage areas can be expanded, particularly in remote or under-served regions. This can provide communication, internet, and entertainment services to areas that might not have been previously served. The Arctic is 14.5 million square kilometres of frozen, desolate Earth. Inhospitable to man, it is the province of machines – ships, submarines, planes, and UAVs - and a natural buffer between antagonistic countries. With the rise in Earth temperatures, the rise in national tensions, and the discovery of natural resources locked beneath its ice floes, the Arctic is now one of the most sought-after prizes among nations, who are increasingly devoting strategic resources to protecting and exploiting it. It is also nearly devoid of communications. Inmarsat's core GX customer markets including maritime, aviation and government/military and all have increasing requirements for satellite broadband connectivity in latitudes above GEO coverage.



- Interoperability: GX10 would be seamlessly interoperable with existing GX commercial and mil-Ka band terminals, requiring only a firmware upgrade, and thus be an outstanding potential advantage for existing as well as future GX customers in UK.
- Job creation: The satellite industry is a significant source of high-tech jobs, and the presence of multiple operators can create more job opportunities in various fields, such as engineering, sales, and operations.
- Science and Innovation: More competition means more incentive to invest in new technologies and innovations to improve service quality and reliability. Scientific missions requiring broadband reliable communications can also benefit from the GX10 system.
- Defence: The UK MoD has Mil-Ka and X-band capabilities through the Skynet programme in GEO and is looking to extend these capabilities over the Arctic.
- Disaster response: In the event of natural disasters or other emergencies, satellite services can be critical for communication and coordination efforts. Having multiple satellite operators can provide redundancy and backup systems to ensure that communication services remain available during a crisis.

Overall, increasing the commercial and government offer for satellite communications services over the Arctic region will bring a range of benefits to UK customers and citizens, including: expanded coverage, increased network resilience, lower prices, strategic and scientific mission opportunities, improved services, a wider portfolio to address more diverse communities' needs on satellite connectivity, job creation, technology developments and increased resilience in times of crisis.

D.4 Protection of other services

The GX10 network will operate in the standard Ka frequency bands: 29.5-30 GHz Uplink and 19.7-20.2 GHz Downlink.

1. Protection of geostationary satellite systems

The GX10 satellite system fully complies with the equivalent power flux-density (epfd) limits in Article 22 of the ITU Radio Regulations. The primary mission of the GX10 network is to provide arctic coverage and will implement a GSO arc avoidance angle, therefore, there will be a large separation between any GX10 transmissions and the geostationary satellite orbit (GSO) arc. Compliance with the epfd limits has already been demonstrated by the publication of ITU filing SLEIPNER-1 with favourable findings. Therefore, GSO services are adequately protected in the Ka band to which these limits apply.

2. Protection of fixed links in the 17.7-19.7 GHz band

GX10 only operates user links in the adjacent band 19.7-20.2 GHz. To protect fixed links, the ITU has established power flux density limits for NGSO systems in Article 21 of the Radio Regulations which apply in the frequency bands 17.7-19.3 MHz and 19.3-19.7 MHz. Any out of band emissions from the GX10 satellite network in adjacent bands to the 19.7-20.2 GHz band will comply with Article 21 of the radio regulations.

3. Protection of Radio Astronomy in the 10.6-10.7 GHz band

GX10 does not operate in the 10 GHz band and therefore there is no risk of interference to radio astronomy operating in the 10.6-10.7 GHz band.

D.5 GX10 System

In this section, Inmarsat introduces the GX10 network including the system overview, architecture, data connectivity, and other important technical and performance features. The last section discusses the system applications that are beneficial for UK customers and citizens.

1. **System Overview**

The GX10 space segment system consists of two Ka-band payloads (GX10A and GX10B) on board Heosat’s Arctic Satellite Broadband Mission (ASBM). The two payloads will be exclusively used by Inmarsat and are envisioned to deliver GX capacity over the Polar region (extending the GX GEO coverage above higher latitudes).

The orbit selected for ASBM is a triple apogee (TAP) highly elliptical orbit (HEO) with two HEO (Highly Elliptical Orbit) satellites having an orbital period of approximately 16 hours, each satellite being spaced 8 hours apart on the same orbital plane. These two satellites allow for continuous coverage over 65N with each of them alternating active service every eight hours. Coverage below 65N, and specifically over the United Kingdom is intermittent. From one of the apogees, all of the United Kingdom is covered- while from the other two, it covers Scotland. The figures below illustrate this initial coverage set up; at the same time, thanks to the flexibility of the GX10 network and system, coverage of the UK can be further improved and adapted to address customer demand and specific needs.

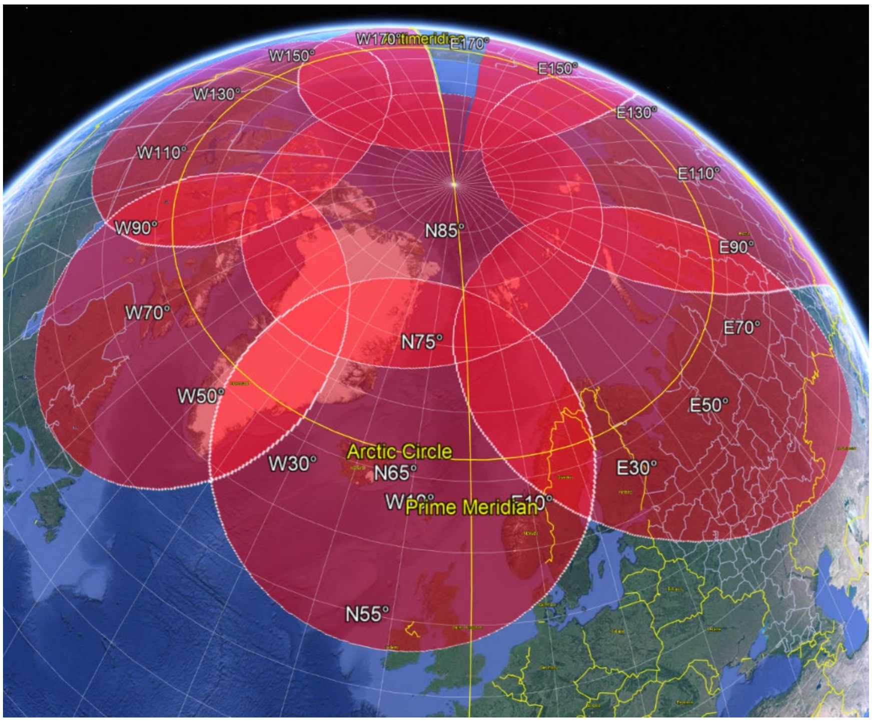
The Heosat’s gateway stations supporting feeder and TCR communications with the satellites are located on two ground sites in Norway (Bardufoss and Tromso).

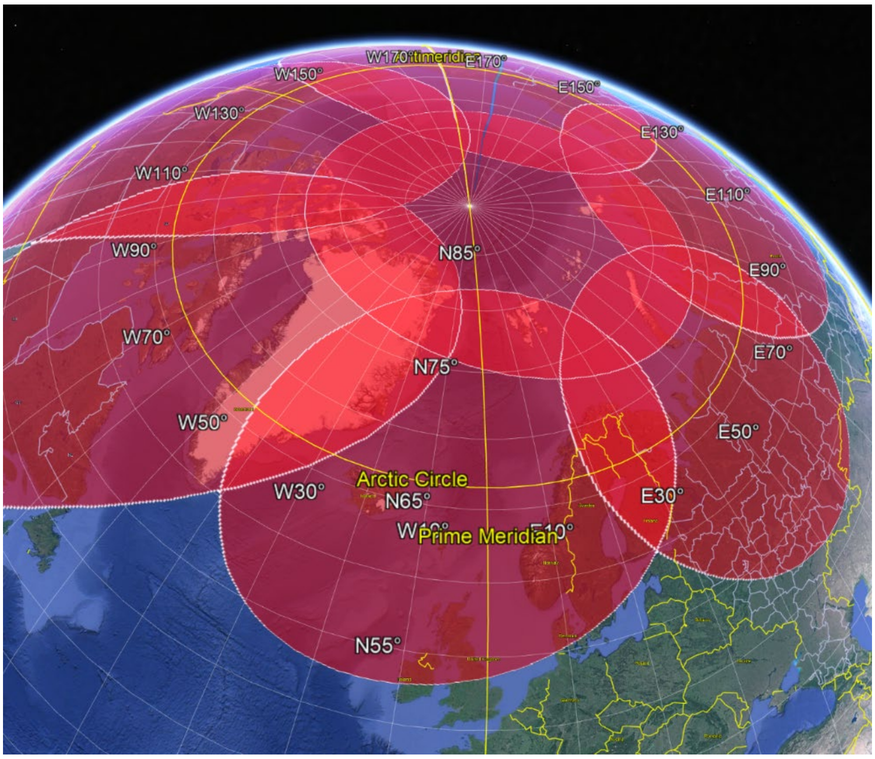
The coverage area is comprised of 7 contiguous polygon beams for each satellite, and each satellite has an active period of 10 hours per orbit. This allows for a period of up to 2 hours of overlap between the two satellite’s coverage at each transition between the active and inactive arc.

Multispot Coverage

- Multi-spot antenna with seven GX beams covering the entirety of the region above 65° N (Arctic Circle). The total potential capacity is above 2GHz.

- Using digital processor and distributed amplification techniques, capacity can be dynamically shared among beams according to demand and can operate in both Commercial and Military Ka-bands simultaneously.





Steerable Spot Beams

- Two steerable spot beams provide very high throughput links in Mil-Ka Band.

The on-board processor provides high-value confidential commanding. The transponders provide up to 80 MHz Forward bandwidth and 160 MHz Return bandwidth per beam to support high-value intelligence, surveillance, and reconnaissance (ISR) missions and fibre restoration for critical facilities. Meshing capability is also supported. Each satellite supports one "global" beam covering the entire Polar region that will be used for signalling and is envisaged to be used to provide a Global Signalling Channel (GSC) for both commercial and government customers, as in GX GEO operations. GX10 network will be fully integrated into the Inmarsat GX network allowing terminals to freely move from GX GEO coverage to GX10 coverage and vice versa ensuring seamless service to address specific service demands as well as outages in the overlapping GX GEO coverage for UK customers across all sectors (maritime, aviation, government etc.)

2. Network Architecture and Components

This section describes GX10 network architecture and components. Figure 1 illustrates the system architecture and its components. Each component in Figure 1 has a label that refers to the corresponding descriptions in Table 1.

The main components of the GX10 network are:

- GX10A and GX10B arctic payloads;
- Radio Frequency Subsystem (RFS);
- Radio Access Network (RAN);
- Inmarsat Network;
- User Terminals; and
- Payload configuration & control tools.

All these components are interlinked and need to be synchronised to fully operate and guarantee the service to Inmarsat Users. The architecture is the same for both gateway sites (Bardufoss - 2 Antenna/RFS/RANs and Tromso - 1 Antenna/RFS/RAN), both satellites (ASBM-1 and ASBM-2), and all terminal types.

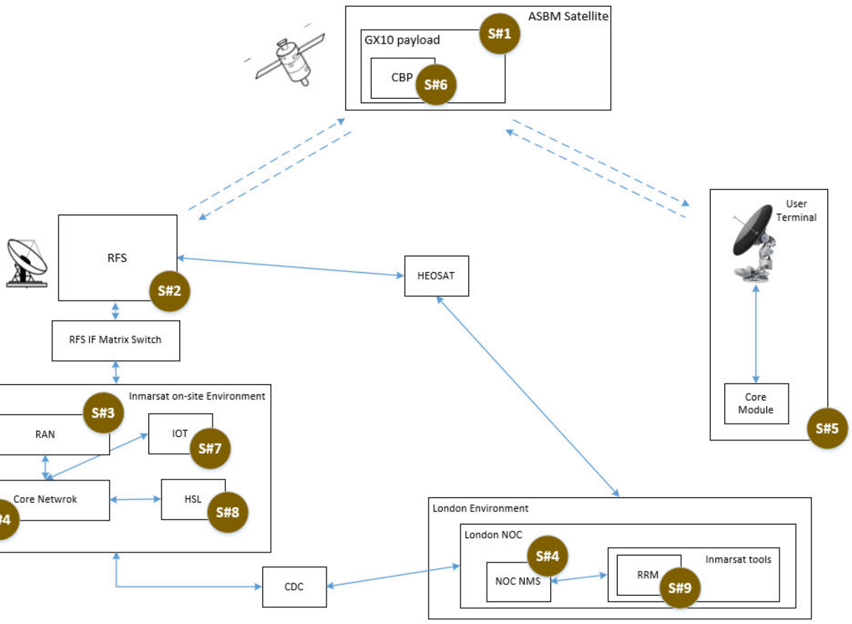


Figure 1: GX10 network architecture and components

Table 1: Description of GX10 system components and their features

Component	Description
S#1: payload	The satellite system is composed of two satellites, named ASBM-1 and ASBM-2, placed in Highly Elliptical Orbit (HEO) so they can provide broadband connectivity at latitudes beyond where geostationary satellites can reach. Whereas geostationary satellites provide coverage from over the equator, the ASBM satellites will use their unique orbits to cover the Arctic Circle, specifically 65 degrees north and above.
S#2: RFS	The GX10 network is based on three RFS antennas installed in Bardufoss and Tromso. Bardufoss hosts two Primary RFS systems completely separated and independent but sharing the same equipment room. Tromso hosts the Backup Antenna.
S#3: RAN	The solution to be delivered will be built based on the current GX RAN solution, with additional features to be designed and implemented to cope with the specific HEO and with the ground architecture differences concerning the other GX satellites. The main changes implemented are focused on Timing control, Doppler compensation, dynamic Beams updates, acquisition, and User terminal interfaces.
S#4: GX10 Network	The GX10 Network consists of a core network, backbone, and NOC. Limited Core Network equipment is installed at each Radio Frequency Gateway (RFGW). Additional Core Network equipment is installed in each CDC to receive/transmit the traffic from/to Bardufoss and Tromso. The terrestrial link will provide the infrastructure required to cover the physical distance from each equipment room and both primary and backup CDCs. The NOC is the place where the whole GX network is maintained, key events are managed, critical data is analysed, and important decisions are made.
S#5: User Terminals	A user terminal (UT) in the Global Xpress (GX) system is the end-user equipment responsible for providing the user with an interface to the GX network. A GX UT will work in all Inmarsat GX satellite constellations including GX10. At the heart of the GX system is the STE Core Module (CM) which is the modem. A user terminal integrator integrates the CM into a UT, together with other components and subsystems to: • Establish an efficient and uninterrupted communication link between the CM and GX RAN. • Provide a user interface that will enable and support all the market-specific features and services. Within GX UTs, the CM is responsible for the configuration of the RF link, including modulation and demodulation, power control, terminal authentication, configuration, initiating tracking, and beam switching. The CM is also responsible for providing IP access to an end user connected to the GX satellite network.

c) Operational Aspects and Performance

The GX10 system will extend the current Inmarsat GX global network over the Arctic region, ensuring seamless commercial Ka and mil-Ka connectivity for communication services above 65º N. The GX Arctic payloads (GX10A & GX10B) will ensure continuous coverage above 65º North and will have the ability to direct capacity in real-time to the areas of highest demand including part of the UK territory. The system is scheduled to be operational for at least 15 years with users being able to switch between current geostationary GX satellites and the new HEO satellites. All terminals based on Supported GX10 Core Module Types will be able to move from the Inmarsat GX GEO Network to the GX10 Network and from the GX10 Network to the Inmarsat GX GEO Network based on position and traffic loading. This creates the concept of an inter-orbit link i.e. a radio link between a transmitting earth station and a receiving earth station through two or more satellites operating on different orbits, without any intermediate earth station.

The system can dynamically assign capacity where and when needed by modifying the spectrum and power allotted to the user spots. These dynamic capabilities ensure efficient use of the satellite resources and the scarce spectrum. Indeed, the dynamic assignment of spectrum and power to each beam makes the GX10 system comply with local spectrum regulatory requirements and policies. Additionally, all terminals based on Supported GX10 Core Module Types will be able to switch between GX10A beams and between GX10B beams during periods of dual visibility. These capabilities indicate the flexibility of the system to co-exist and coordinate with other NGSO satellite systems efficiently as well as to address the specific needs of certain customers like UK-based government users and so forth.

The RFS is a fundamental segment of the overall GX10 network. Through the RFS, the signal is captured and transmitted. Concepts of operations (CONOPS) have been agreed upon between Inmarsat, Heosat, and KSAT to define how the RFS systems are operated and maintained. All sites are sized to handle the same traffic load (number of channels) per RFS antenna. In a nominal scenario, during most of the active arc, only one satellite will be visible, therefore all traffic will be transmitted/received from one RFGW at any given time. During the transition between active and inactive arc for each satellite, there will be an overlap period of 1-2 hours where both satellites are visible. During this period traffic may be load balanced between 2 RFGWs, with two antennas being active simultaneously (one on GX10A and one on GX10B). In case of failure, maintenance, or rain, redundancy procedures will be enforced. Therefore, redundancy is mandatory to ensure a continuous and reliable service.

The RAN is configured, operated, and monitored through the NOC Network Management System (NMS) located in London (primary) and Burum (backup). The NMS offers all the features required to monitor multiple network segments at the same time, manage individual tasks, and integrate all the systems related to the GX network. Through the NMS, it is possible to ensure that all the teleports are online, through a multi-site distributed architecture that provides critical redundancy and data backup support.

Inmarsat will maintain a point of contact available on a 24/7 basis with the authority and ability to cease transmissions from the network through a suitable gateway facility that will interface with Inmarsat's Network Operations Center (NOC) located in London, in the United Kingdom. The NOC will monitor the GX10 network to ensure that operations are within the prescribed operational parameters.

d) System applications that are beneficial for UK customers, end customers, and citizens

Inmarsat, the world leader in global mobile satellite communications, in a partnership with Space Norway and its subsidiary Space Norway HEOSAT AS, will operate a satellite network dedicated to the Artic region.

The new Global Xpress (GX10A & GX10B) payloads support the rapidly growing demand among both commercial and government users for seamless, reliable, high-speed mobile broadband services in the Arctic and throughout the world.

- Commercial markets: The GX Arctic payloads are designed to specifically address the needs of merchant fleets, fishing vessels, commercial airlines, and the energy market, where high-speed mobile broadband connectivity is driving both major operational and efficiency improvements and supporting the introduction of new business models. In the maritime sector, UK shipping and shipping management companies will significantly benefit from the commercial opportunity provided by increased coverage over the Artic region for onboard connectivity solutions, in addition to the existing

GX portfolio. Vessels sailing in and out of the UK will also take advantage of increased network resilience resulting from the GX10 coverage over the UK.

In the specific sector of Commercial Aviation, Viasat, which Inmarsat is now part of, has several UK based customers that have committed or will commit long range aircrafts. These fleets currently have no service of connectivity when flying their northernmost routes (to US West coast for instance) and the introduction of GX10, through the use of compatible hardware, will provide them service on this currently unserviceable area. This will represent a few percentage points of their flight time for affected aircrafts.

- Government: the new GX payloads will provide continuous, assured communications to tactical and strategic government users operating in the Arctic region, including customers in the USA, Canada, Scandinavia and other territories in the region. Importantly, these payloads will also provide KA Gov steerable capacity through service beams and high-capacity steerable beams, complementing military satellite resources, cost-effectively, for optimal redundancy, protection, scalability, and global portability.

- UK Defense: the High North, Baltic and Arctic regions are of increasing importance in protecting and advancing UK security interests. The UK MoD has invested heavily in a range of military platforms and task forces dedicated to the region – with significant contributions from the Joint Expeditionary Force, Littoral Response Group (North), as well as the recent deployment of dedicated equipment and aircraft[2]. With this renewed focus on the High North, the MoD will require a broad range of multi-domain capabilities to support these security aims, including the need for highly reliable communications and connectivity across a complex operating environment. The GX 10 network would aim to support existing capability gaps by ensuring long-range, seamless wideband connectivity and coverage, thereby offering key support to UK Defense aims across the region.

Overall, connectivity in the Arctic region is growing in importance as aircraft fly more northerly routes, merchant ships transit new high-value waterways and the region becomes of increasing geo-political importance for diverse governments. Inmarsat's GX network will always seek to be ahead of where customers are going and what they demand. This enhancement is fully backward compatible and will strengthen coverage over the Arctic to provide the connectivity needed by the customers now and into the future. As part of the existing Inmarsat GX network, customers will now have seamless, high-quality mobile broadband services as they travel in and out of the Arctic region.

Additionally, Inmarsat's new Arctic capabilities will further increase network flexibility and efficiency through multi-beam, and the high-throughput capacity that can be fully dialed up and down depending on customer demand in the region.

Furthermore the GX10 (intermittent) coverage over the UK will result in overspill capacity that the advanced satellite system will use to ease congestion in the overlapping GX GEO coverage for UK customers across all sectors (maritime, aviation, government etc.) when the GX10 satellite are in view from the UK. On this note the system design also allows for multiple coverage configurations resulting in coverage of most of the UK territory up to 80-90% of the time to meet the needs of specific groups of customers.

Today, the Arctic Circle represents a rapidly growing connectivity region for high-quality mobile broadband with increasing requirements from government, maritime, and aviation customers. Building on Inmarsat's current capabilities up to and beyond 65º North, the new GX Arctic payloads will improve network

[2] https://assets.publishing.service.gov.uk/media/6241cd63d3bf7f32b2e52515/The_UK_s_Defence_Contribution_in_the_High_North.pdf, https://www.army.mod.uk/news-and-events/news/2023/03/joint-expeditionary-force-a-new-era-of-military-cooperation/

performance in very high latitudes by flying directly overhead, providing GX antennas with much higher elevation angles to optimise throughput.

The new GX Arctic payloads (GX10A & GX10B) will be placed into Highly Elliptical Orbits (HEO), ensuring continuous coverage above 65º North, and will have the ability to direct capacity in real-time to the areas of highest demand.

They represent the world's first and only mobile broadband payload dedicated to the Arctic region and will integrate seamlessly into the current and planned GX network. The new GX payloads will be fully compatible with current and future GX terminals, ensuring that current Global Xpress customers can benefit from a further extension of the network.

This enhancement of GX is further validation of the success of the network, first designed by Inmarsat in 2010, and now seen as the gold standard for high-speed broadband connections wherever customers need them in the world. Inmarsat's diverse network strategy ensures the highest hot-spot capacity, optimal coverage, excellent 'look-angles' between the terminal and the satellite, zero blockage, and deep resilience for GX customers.

Inmarsat's GX network began global services in 2015 and it remains the world's first and only seamless global mobile broadband network. Inmarsat has since grown GX revenues strongly and established leading positions in the emerging global Maritime, Aviation, and Government mobile satellite broadband markets. GX is the most successful network for global mobility. Inmarsat will be the sole provider of the mobile broadband connectivity our customers need in the Arctic region.

Appendix 1: GX10/Mangata Edge Ltd Coexistence study

1. *Study Overview*

This appendix outlines technical analysis that shows the GX10 satellite network can coexist with existing licensees with which a prior coordination agreement has not been obtained, namely, Mangata Edge Ltd. The analysis focuses on the impact to the victim network with respect to an increase in unavailability and a decrease in average spectral efficiency that would be caused by operation of GX10 user terminals in the UK should the license be granted. The analysis shows that coexistence between GX10 and Mangata Edge Ltd is possible, and that the resulting interference, expressed in terms of decrease in average spectral efficiency and increase in unavailability, would be minimal.

The study presented is a dynamic simulation of both the Mangata Edge Ltd and GX10 NGSO satellite networks. It looks at User-User interference on both the uplink and downlink when both networks user terminals are co-located in the north of England. Interference statistics are computed in the form of C/N and C/N+I and compared to the given C/N requirements and these are used to derive statistics for measuring the impact on the Mangata Edge Ltd satellite network. A conservative satellite tracking method is selected for both networks where the satellite with the highest elevation for each respective network is chosen as the transmitting satellite at each time step. All study parameters can be seen in ***Tables 1, 2, 3 and 4***. Parameters for the emissions of the Mangata Edge Ltd network are taken from the ARISTARCHUS filing. Carriers are chosen based on previous application submitted by Mangata and represent a realistic operating scenario. Two sets of results are presented, a worst-case analysis, and an approach that considers a more realistic C/N requirement for the Mangata link when calculating the decrease in average spectral efficiency.

2. *Study Parameters*

Table 1: GX10 Orbital Parameters

Parameter	Value
Number of planes	1
Number of satellites per plane	2
Semi-major axis (km)	32177.644531
Eccentricity	0.55
Inclination (deg)	63.4

Table 2: GX10 Emission Parameters (a) uplink and (b) downlink

Table 2a: Uplink

Parameter	Value
Tx Frequency (GHz)	29.5
Carrier Power (dBW/Hz)	-57
Occupied Bandwidth (MHz)	1
UT Gain	43.6
UT tx antenna pattern	Rec 465-5
Satellite Rx Gain	36
Satellite Rx Gain Pattern	S.1528
Satellite noise temp (k)	600
Tracking Strategy	Highest Elevation
C/N Required	12.5

Table 2b: Downlink

Parameter	Value
Tx Frequency (GHz)	19.7
Carrier Power (dBW/Hz)	-68
Occupied Bandwidth (MHz)	1
Satellite Tx Gain	36
Satellite Tx Antenna Pattern	S.1528
UT Rx Gain	40

UT Rx Antenna Pattern	S.580-6
UT Noise temperature (k)	100
Tracking Strategy	Highest Elevation
C/N Required	13.6

Table 3: Mangata Orbital Parameters, (a) MEO constellation and (b) HEO constellation

Table 3a: MEO Constellation

Parameter	**Value**
Number of planes	27
Number of satellites per plane	21
Apogee (km)	6400
Perigee (km)	6400
Inclination (deg)	45, 50, 52.5

Table 3b: HEO Constellation

Parameter	**Value**
Number of planes	32
Number of satellites per plane	7
Apogee (km)	11585, 9800, 9000, 11024
Perigee (km)	1215, 3000, 3800, 1776
Inclination (deg)	63.4

Table 4: Mangata Emission Parameters, (a) uplink and (b) downlink

Table 4a: Uplink

Parameter	**Value**
Tx Frequency (GHz)	29.5
Carrier Power (dBW/Hz)	-70
Occupied Bandwidth (MHz)	50
UT Gain	43.6
UT Tx Antenna Pattern	Rec 465-5
Satellite Rx Gain	46.7
Satellite Rx Gain Pattern	S.1528
Satellite Noise Temp (k)	600

Tracking Strategy	Highest Elevation
C/N Required to Maintain Link	-3
C/N Required to Meet Performance Objective	17

Table 4b: Downlink

Parameter	Value
Tx Frequency (GHz)	19.7
Carrier Power (dBW/Hz)	-87.2
Occupied Bandwidth (MHz)	900
Satellite Tx Gain	43.2
Satellite Tx Antenna Pattern	S.1528
UT Rx Gain	40.2
UT Rx Antenna Pattern	S.580-6
UT Noise temperature (k)	290
Tracking Strategy	Highest Elevation
C/N Required to maintain link	-3
C/N Required to Meet Performance Objective	12

3. Results

The above parameters were used to simulate the interference in Visualyse. The following graphs show the C/N and C/N+I statistics for the Mangata uplink and downlink.

Figure 1: Mangata downlink degradation.

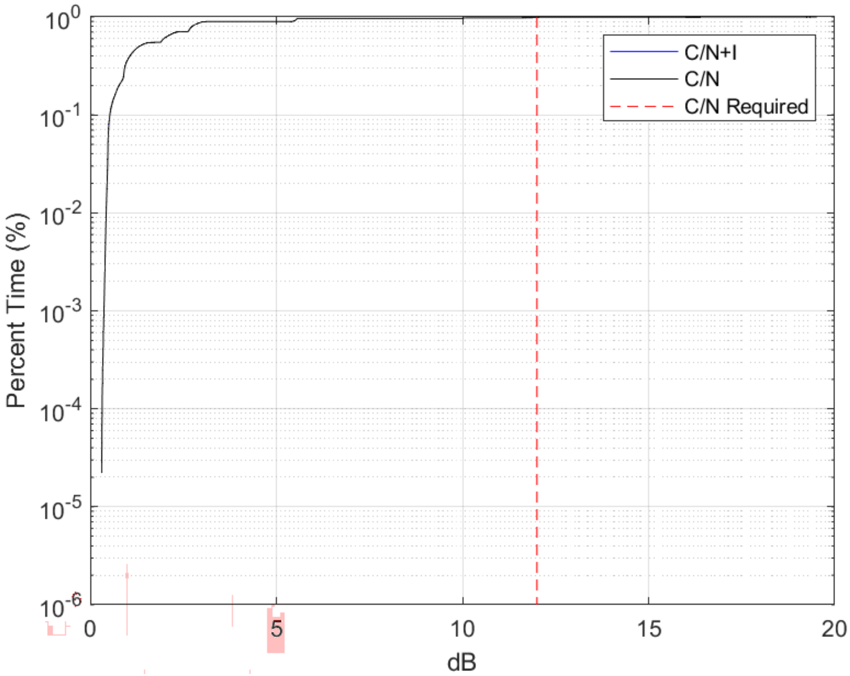
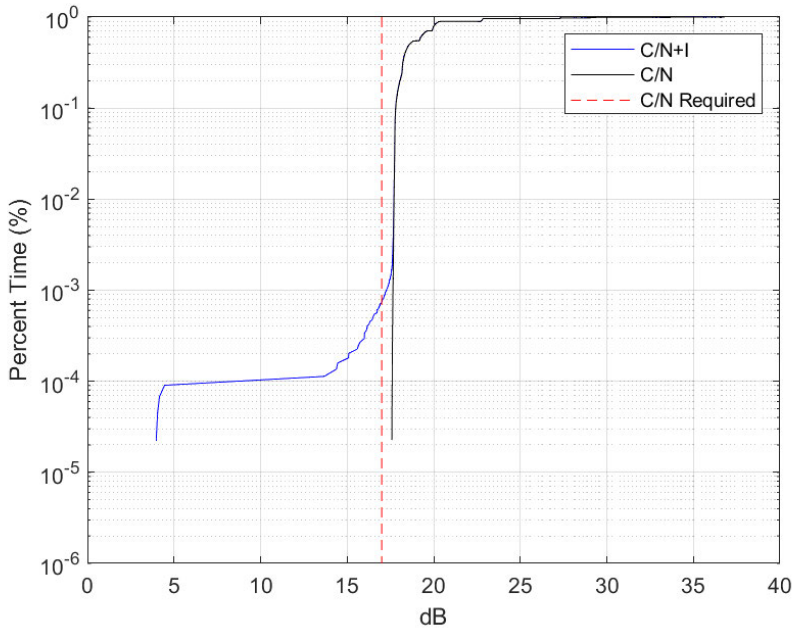


Figure 2: Mangata uplink degradation.



The simulation output data used to create the above plots can be used to calculate the increase in unavailability and decrease in average spectral efficiency.

The decrease in average spectral efficiency is calculated using methodology outlined in ITU-R S.2131-1. The results are shown in table 5. It demonstrates that the operation of GX10 user links will have minimal effect on the availability of Mangata links as well as their spectral efficiency. This study considers a number of conservative assumptions and with proper coordination, the interference in realistic operational scenarios will be much lower. Therefore, this study demonstrates that GX10 and Mangata Edge Ltd can coexist without overly constraining either network.

Table 5 - Statistics.

	Uplink	**Downlink**
Increase in Unavailability (%)	0.0747	<0.0001
Decrease in Average Spectral Efficiency (%)	0.0666	<0.0001

Appendix 2: GX10/Rivada Space Networks Coexistence study

1. *Study Overview*

The study set-up is the same as in Appendix 1. The required parameters are taken from the Rivada Space Networks earth station license application and the 3ECOM filings. Only the worst-case statistics are presented as these are sufficient in showing co-existence is possible.

2. Study Parameters

Table 1: Rivada Orbital Parameters

Parameter	Value
Number of planes	24
Number of satellites per plane	24
Apogee (km)	1050
Perigee (km)	1050
Inclination (deg)	89

Table 2: Rivada Emission Parameters, (a) uplink and (b) downlink.

Table 2a: Uplink.

Parameter	Value
Tx Frequency (GHz)	29.5
Carrier Power (dBW/Hz)	-73
Occupied Bandwidth (MHz)	10
UT Gain	49
UT Tx Antenna Pattern	Rec.580-6
Satellite Rx Gain	30
Satellite Rx Gain Pattern	S.1528
Satellite Noise Temp (k)	600
Tracking Strategy	Constellation Avoidance (20 deg), Highest Elevation
C/N Required (from filing)	20

Table 2b: Downlink.

Parameter	Value
Tx Frequency (GHz)	19.7
Carrier Power (dBW/Hz)	-81.6
Occupied Bandwidth (MHz)	125

Satellite Tx Gain	30
Satellite Tx Antenna Pattern	S.1528
UT Rx Gain	49
UT Rx Antenna Pattern	Rec.580-6
UT Noise temperature (k)	190
Tracking Strategy	Constellation Avoidance (20 deg), Highest Elevation
C/N Required (from filing)	20

3. Results

The above parameters were used to simulate the interference in Visualyse. The following graphs show the C/N and C/N+I statistics for the Rivada uplink and downlink.

Figure 1: Rivada uplink degradation.

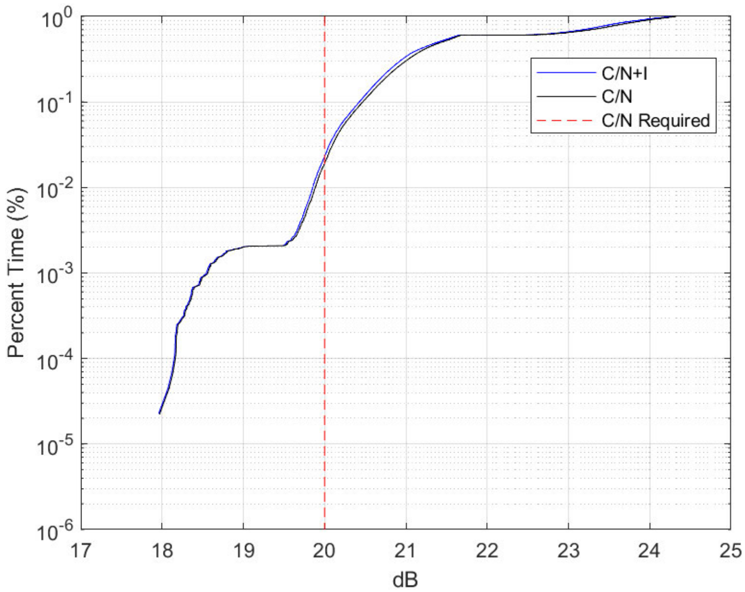
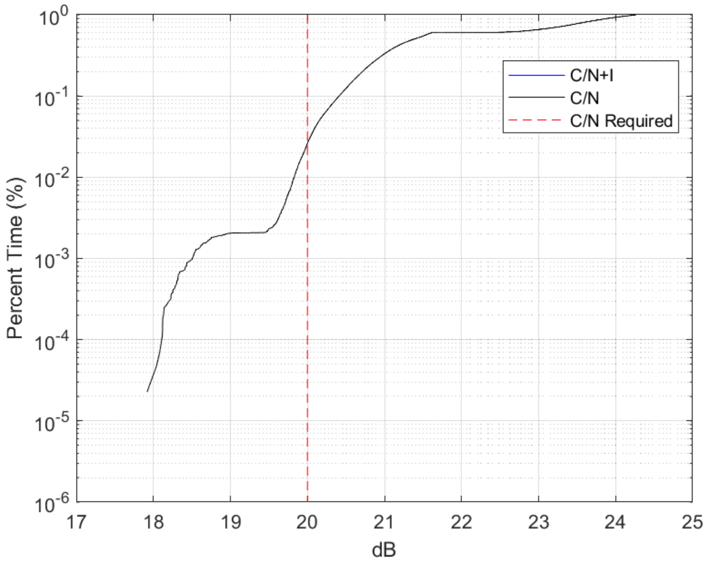


Figure 2: Rivada downlink degradation.



As with Appendix 1, the simulation output data can be used to calculate the increase in unavailability and decrease in average spectral efficiency. The results in this study are very conservative. The highest filed parameters have been used for GX10 and the parameters used for Rivada are provided in their license application. The powers used in the Rivada license application are much lower than the majority of their filed parameters. It is likely that in an operational scenario the degradation would be less than shown here. Table 3 shows that the degradation, due to transmissions from the GX10, on the availability and spectral efficiency of the Rivada satellite network will be minimal, despite conservative assumptions. This demonstrates co-existence is possible.

Table 3 – Increase in unavailability and decrease in average spectral efficiency.

	Uplink	**Downlink**
Increase in Unavailability (%)	0.3959	<0.001
Decrease in Average Spectral Efficiency (%)	0.0976	<0.001

Appendix 3: GX10/NSLComm Ltd Coexistence study

1. *Study Overview*

The study set-up is the same as in Appendix: 1. The required parameters are taken from the NSLComm earth station license application and the BEETLESAT_LEO filings. Only the worst-case statistics are presented as these are sufficient in showing co-existence is possible.

2. *Study Parameters*

Table 1: BeetleSat Orbital Parameters

Parameter	**Value**
Number of planes	25
Number of satellites per plane	22
Apogee (km)	720, 700
Perigee (km)	720, 700
Inclination (deg)	53, 97, 0

Table 2: BeetleSat Emission Parameters, (a) uplink and (b) downlink.

Table 2a: Uplink.

Parameter	**Value**
Tx Frequency (GHz)	29.5
Carrier Power (dBW/Hz)	-84.6
Occupied Bandwidth (MHz)	10
UT Gain	49.6
UT Tx Antenna Pattern	Rec 580-6
Satellite Rx Gain	42.5
Satellite Rx Gain Pattern	S.1528
Satellite Noise Temp (k)	500
Tracking Strategy	Constellation Avoidance (90 deg), Highest Elevation
C/N Required (from filing)	15

Table 2b: Downlink.

Parameter	**Value**
Tx Frequency (GHz)	19.7

Carrier Power (dBW/Hz)	-81.5
Occupied Bandwidth (MHz)	10
Satellite Tx Gain	25
Satellite Tx Antenna Pattern	S.1528
UT Rx Gain	46
UT Rx Antenna Pattern	Rec 580-6
UT Noise temperature (k)	290
Tracking Strategy	Constellation Avoidance (90 deg), Highest Elevation
C/N Required (from filing)	15

3. Results

The above parameters were used to simulate the interference in Visualyse. The following graphs show the C/N and C/N+I statistics for the BeetleSat satellite network uplink and downlink.

Figure 1: BeetleSat uplink degradation.

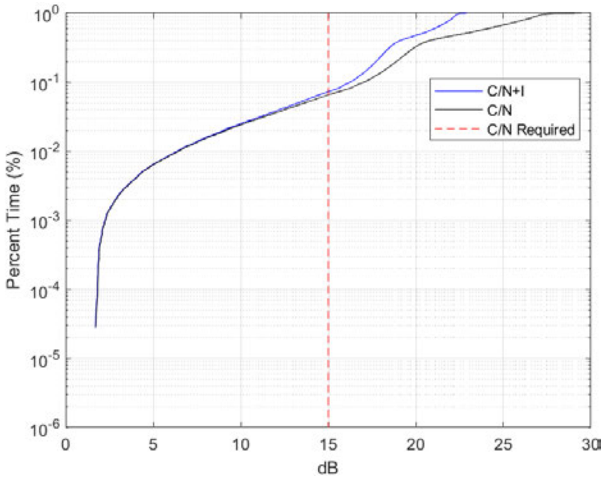
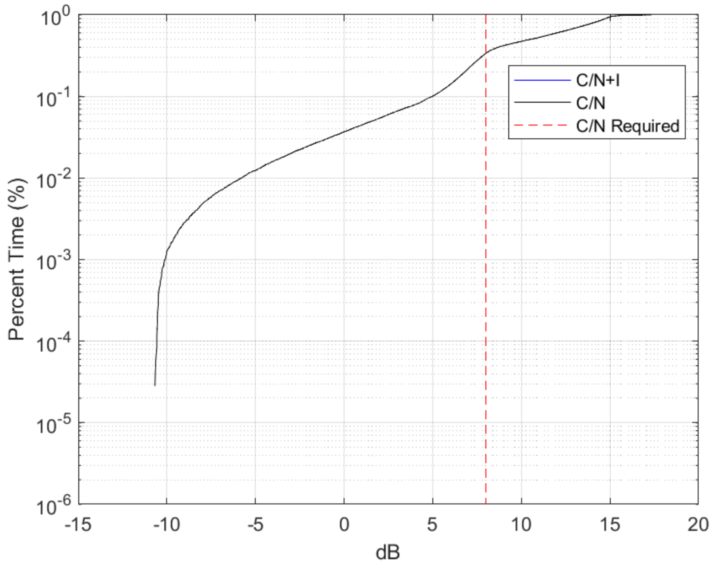


Figure 2: BeetleSat downlink degradation.



The interference statistics are present in table 3 below. It is clear that the dominant interference mechanism is in the uplink. Even in this case, the effect of GX10 on BeetleSat uplink carriers is minimal and should be consider acceptable. It is likely in an operational scenario with coordination in place, any effect on BeetleSat carriers will be reduced. This study demonstrates coexistence is possible between the BeetleSat satellite network and GX10.

Table 3 – Increase in unavailability and decrease in average spectral efficiency.

	Uplink	**Downlink**
Increase in Unavailability (%)	0.7482	<0.001
Decrease in Average Spectral Efficiency (%)	1.6284	<0.001