Starlink Internet Services Limited: Decision on applications for six non-geostationary earth station gateway licences

Decision

Welsh overview available

STATEMENT:

Publication date: 10 November 2022

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Section

Annex

1. Overview

This document sets out our decision on applications by SpaceX for wireless telegraphy licences to operate six additional satellite gateway earth stations in the UK.

The gateway earth stations are intended to connect to SpaceX's Starlink constellation of non-geostationary orbit (NGSO) satellites, expanding the capacity of its existing satellite service and improving connectivity for UK citizens and consumers. SpaceX already operates three UK earth station gateway earth stations, so these applications increase the number to nine.

What we have decided – in brief

We have decided to grant SpaceX six new licences to operate UK gateway earth stations.

We set out our original assessment on the SpaceX applications in our June 2022 consultation in which we proposed to grant all six licences. In accordance with our licensing process, we have since assessed stakeholder responses regarding the ability of these additional gateway earth stations to coexist with other current and future NGSO licence holders and considered the competition issues raised in response to our consultation.

A number of additional concerns, such as coexistence with geostationary (GSO) services and environmental concerns, were raised by stakeholders and we have addressed these later in this document.

SpaceX has also provided us with additional information regarding their second-generation constellation and their ability to coexist with GSO networks, which we have published alongside our Decision today.

On coexistence, we continue to believe that the SpaceX system is capable of coexisting with other NGSO systems.

On competition, we assess the risks in this case are low: stakeholders agreed with our original assessment that alternative gateway earth station sites exist for others to operate, meaning SpaceX's nine gateway earth stations will not block future NGSO operators from placing gateway earth stations in the UK. Stakeholders also raised some additional competition concerns regarding vertical integration and a broader concern over the proliferation of SpaceX satellites in space.

We consider it is unlikely that granting these licences will affect competition as a result of SpaceX's vertical integration (i.e. that it would affect third party access to launch services). We have also considered broader competition concerns raised by stakeholders when making this decision, while noting that some of these sit outside of Ofcom's jurisdiction.

Our decision enables SpaceX to operate six additional NGSO gateway earth stations in the UK to increase the capacity for its direct-to-consumer satellite broadband services. We will now proceed to issue SpaceX with their new licences, subject to payment of the licence fee. Copies of the licences will be published in the "Existing licences" section of our website.

1.1 In December 2021 we set out our new NGSO licensing process, which was designed to encourage greater cooperation between NGSO licence holders, enhance our ability to

intervene if there was harmful interference and ensure greater transparency through a short consultation process.

1.2 In May 2022 we received applications from Starlink Internet Services Limited ("Starlink") - a subsidiary of SpaceX - for six NGSO earth station (gateway) licences (hereafter referred to as NGSO Gateway licence)[1].

1.3 SpaceX, through its subsidiary Starlink, is already authorised to operate terminals under an Earth Station Network licence (ESN). Three NGSO gateway earth stations are currently licensed to connect the Starlink system satellites to terrestrial networks. These NGSO gateway licences are held by Arqiva, Goonhilly, and Starlink.

1.4 In June 2022 we published a consultation (the "**Starlink consultation**"), in which we set out our initial assessment of the licence applications, including the coexistence and competition issues considered.

1.5 We took account of all responses to the consultation and additional material supplied by SpaceX in reaching our decision to grant the licences.

[1] The ITU definition for a gateway is a "gateway earth station".

2. Introduction and background

2.1 This document sets out our consideration of applications by SpaceX for wireless telegraphy licences to operate six additional NGSO gateway earth stations in the UK. NGSO gateway earth stations are hubs that connect NGSO satellite constellations to terrestrial networks or services including the internet, private networks, and cloud services. SpaceX already operates three such UK gateway earth stations and wishes to increase the total number to nine.

2.2 The applications were submitted to Ofcom on 27 May 2022 by Starlink Internet Services - a SpaceX subsidiary. We will use "SpaceX" in this document to mean the applicant and "Starlink" to mean the associated satellite system.

2.3 The applications were for NGSO gateway licences operating in the Ka band radio frequencies (27.5 – 27.8185 GHz, 28.4545 – 28.8265 GHz and 29.4625 – 30 GHz). SpaceX wants the new gateway earth stations to connect to its Starlink NGSO constellation, increasing the capacity for an existing system that already provides direct-to-consumer satellite broadband services.

2.4 We considered all six applications together and refer to them throughout this document as "the application". Our preliminary view - including our initial assessment of coexistence and competition issues - was set out in our Starlink consultation.

2.5 In response to issues raised by some respondents, we requested that SpaceX provide us with additional information regarding protection of GSO services, and information regarding the design of their second-generation constellation.

2.6 After taking account of the consultation responses and the further information provided by SpaceX, we have decided to grant the licence. The details of how we reached this decision are presented in this document as follows:

- In this section (**section 2**) we explain the operation of NGSO satellite systems, outline Ofcom's role in licensing NGSO earth stations, and summarise the process we follow in evaluating NGSO licence applications;
- In **section 3** we summarise the Starlink consultation and responses received;
- In **section 4** we consider in more detail the comments we received on NGSO coexistence and provide our assessment of these issues;
- In **section 5** we set out a summary of the responses related to the competition risks and benefits to consumers arising from the SpaceX licence applications and provide our assessment of these issues;
- In **section 6** we consider concerns raised in consultation responses related to potential impacts on GSO networks;
- In **section 7** we consider concerns on potential impacts of NGSO systems on the space environment;
- Finally, in **section 8** we set out our decision and next steps.

NGSO satellite systems

2.7 NGSO satellite constellations can deliver broadband services at lower latency, and often at higher speeds, than traditional GSO networks. They generally operate in low or medium Earth orbit (i.e. in lower orbits than most GSO networks) and connect a range of users to the internet or a private network via satellites which pass overhead.

2.8 The services they deliver typically have nationwide coverage and so have a vital role in connecting businesses and consumers in parts of the UK where terrestrial services are not currently available. They also provide additional choice for consumers in other parts of the UK. NGSO services can therefore play a role in delivering high-quality broadband and growth across the UK.

2.9 An NGSO satellite broadband system is made up of three components, as illustrated in figure 1 below:

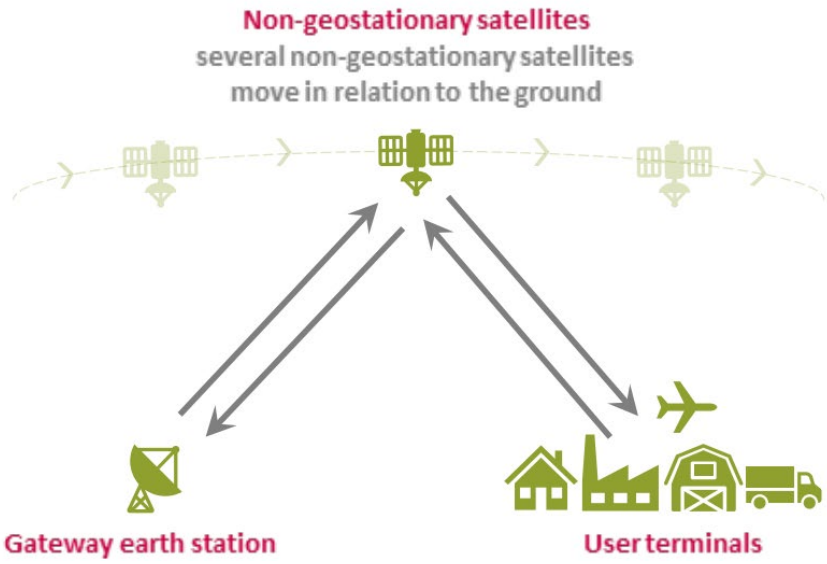
a) One or more gateway earth stations which connect the satellite broadband network to the internet or private networks. These earth stations can be located in the same country as the target users or could be located elsewhere.

b) Several satellites used to relay traffic between the gateway earth station and user terminals.

c) User terminals to provide broadband connectivity to end users, typically comprising of an antenna and user equipment. User terminals connect with an NGSO gateway earth station via one or more satellites, depending on the design of the constellation.

2.10 The Starlink application for NGSO gateway licences relates to the first component, the earth-based gateway earth stations in the UK that connect to its NGSO satellites.

Figure 1: Key elements of an NGSO system



Coexistence and competition issues

2.11 Satellite broadband services tend to operate in a small number of radio frequency bands (these are known as C band, Ku band, and Ka band).[2] Within these bands, different services use the same radio frequencies. The signals are coordinated – under international rules laid down in International Telecommunications Union (ITU) Radio Regulations – whenever the satellites appear close enough in the sky for their signals to be indistinguishable (typically within 2˚ relative to the observer on the ground).

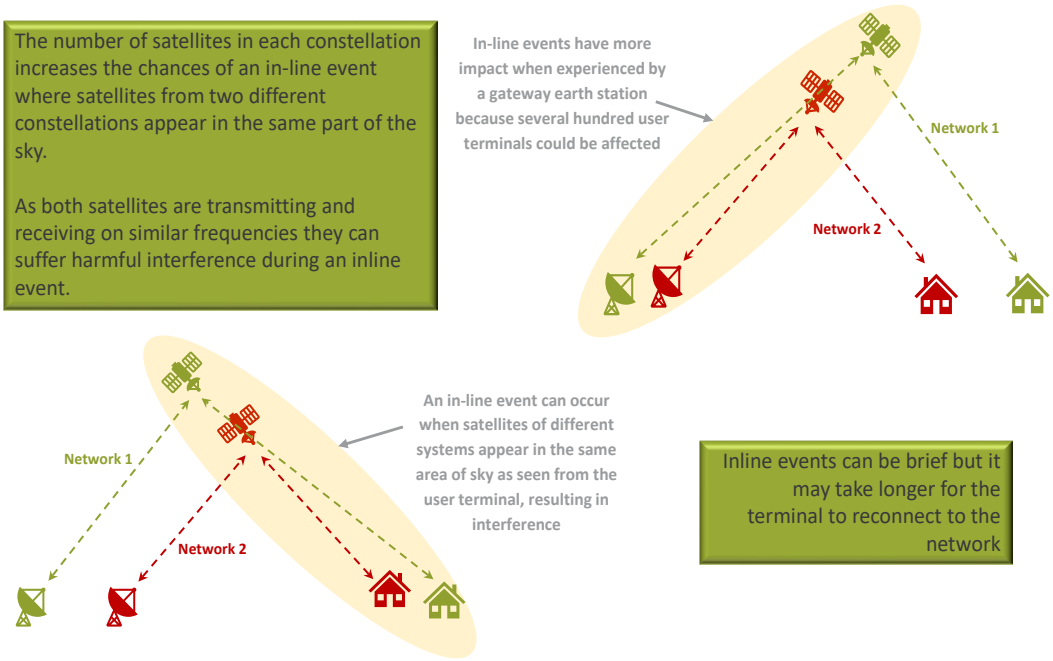
2.12 Traditional GSO satellites appear static in the sky to users on the ground, so the number of coordination agreements needed to operate without risk of causing or receiving harmful interference (such that one or both services are degraded) is relatively limited.

2.13 Proposed NGSO satellite constellations rely on large numbers of satellites that move position relative to the Earth. Gateway earth stations and user terminals must track these satellites in order to maintain a continuous connection. This creates a more dynamic spectrum management environment – both in space and on the ground – and so increases the risk of interference between NGSO systems compared to GSO networks (see Figure 2 below).

2.14 As this is a new and emerging market, operators are exploring different network designs (e.g. some will deploy a few hundred satellites, others will deploy many thousands of satellites; some will deploy in relatively low Earth orbits at an altitude of around 500 km, others at 1,000 km and still others in medium earth orbits at 8,000 km). In addition, operators are deploying satellites and services at different speeds as their projects mature.

[2] C band satellite services typically use 3.6 – 4.2 GHz for downlink and 5.85 – 7.075 GHz for uplink. Ku band satellite services typically use 10.7-12.7 GHz for downlink and 14.0-14.5 GHz for uplink. Ka band satellite services typically use 17.7-20.2 GHz for downlink and 27.5-30 GHz for uplink.

Figure 2: How interference can occur between two NGSO systems



2.15 NGSO operators are planning to deploy a range of different services with different business models. Some plan to focus more on business-to-business models, others plan to sell directly to consumers.

2.16 Table 1 provides examples of the range of the NGSO services which might serve the UK market. This is not an exhaustive list; Mangata Edge Ltd, for example has recently applied for an NGSO Earth Station Network licence, seeking to provide inflight connectivity, cloud services and backhaul using satellites in Medium Earth and Highly Elliptical orbits.

2.17 We are keen to enable NGSO satellite services in the UK and to foster a competitive market for several operators to provide services. However, we do not want those systems that deploy early to unduly constrain or block those that might come later.

Table 1: Examples of different NGSO services which might serve the UK

Satellite System	Spectrum for gateways	Spectrum for user links	Initial No. satellites (1st Gen)[3]	Altitude (km)	Latency (ms)[4]	Coverage (latitude)	Type of service
Amazon[5]	Ka band[6]	Ka band	3,236	590 610 630	~30	57N-56S	Direct to home[7]
Kepler[8]	Ku band[9]	Ku band	140	575	20-40	global	IOT[10]
OneWeb[11]	Ka band	Ku band	648[12]	1,100-1,200	50	global	Backhaul[13] /mobility[14]
SpaceX[15]	Ka band	Ku band	4,408	540 550 570	20-40	global	Direct to home
Telesat	Ka band	Ka band	298	1,015 1,325	50	global	Backhaul /mobility

2.18 In addition to the different deployment timelines and constellation designs, we note that some NGSO gateway earth stations might require large separation distances (up to 100km) from their competitors in order to avoid interference.

2.19 Given the relatively small size of the UK, there may be a risk that the most suitable gateway earth station sites could be acquired early by one or more operators, preventing others from serving (or making it more difficult for them to serve) the UK market via a UK gateway earth station and constraining competition.

[3] Designs for first-generation architecture for these constellations are more certain. More satellites are expected for all these constellations and are indicated in the FCC references below. These may evolve.
[4] The latency figures are estimates based on the height of each constellation and the speed of light.
[5] FCC Authorizes Kuiper Satellite Constellation | Federal Communications Commission, 30 July 2020.
[6] Ka band satellite services typically use 18-20 GHz for downlink and 27.5-30 GHz for uplink.
[7] Direct to home indicates a broadband service sold directly to consumers.
[8] FCC Grants Kepler Communications Access to US Market | Federal Communications Commission
[9] Ku band satellite services typically use 10.7-12.7 GHz for downlink and 14.0-14.5 GHz for uplink.
[10] IOT denotes "Internet of Things", i.e. connecting wireless devices to each other and the internet.
[11] FCC Grants OneWeb U.S. Market Access for Expanded NGSO Constellation | Federal Communications Commission
[12] Size of initial OneWeb constellation: https://oneweb.world/media-center/oneweb-completes-its-five-to-50-mission
[13] Backhaul denotes a service provided to broadband and mobile telecommunications companies, helping them to extend their networks into hard-to-reach areas. This can sometimes include connectivity for towns and cities.
[14] "Mobility" here denotes a broadband service for air, maritime, rail or road companies, e.g. cruise ships, shipping, airlines.
[15] FCC Ruling on SpaceX Modification, FCC-21-48A1.pdf, April 2021.

Ofcom's role in licensing NGSO earth stations

2.20 All decisions taken by Ofcom are rooted in our statutory duties and obligations. These stem chiefly from the Communications Act of 2003 and the Wireless Telegraphy Act of 2006.

2.21 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.

2.22 The UK framework of rules for spectrum licensing is set out in section 3 of the Wireless Telegraphy Act 2006. It states that, in carrying out our spectrum functions, we have a duty to have particular regard to:

a) the extent to which the spectrum is available for use, or further use, for wireless telegraphy;

b) the demand for use of that spectrum for wireless telegraphy; and

c) the demand that is likely to arise in future for such use.

2.23 We also have a duty to have regard, in particular, to the desirability of promoting:

a) the efficient management and use of the spectrum for wireless telegraphy;

b) the economic and other benefits that may arise from the use of wireless telegraphy;

c) the development of innovative services; and

d) competition in the provision of electronic communications services.

2.24 As set out in our December 2021 statement on the NGSO licensing process, we have a specific process for considering applications for the following types of wireless telegraphy licence:

a) **Satellite (Earth Station Network)**: this authorises an unlimited number of user terminals[16] in the UK to connect to the NGSO system (subject to certain conditions). It also places certain conditions on the licence holder (typically a satellite operator) to coordinate with other licence holders and prevent interference. We refer to this licence in the rest of this document as the "NGSO network licence".

b) **Satellite (Non-Geostationary Earth Station)**: this individually authorises gateway earth stations[17] in the UK, which connect the NGSO system to the internet or to a private network. We refer to this licence in the rest of this document as the "NGSO gateway licence".

[16] User terminals connect the end user (e.g. the customer) to the satellite network; for example the dish and equipment installed at a customer's premises.
[17] Gateway earth stations are hubs that connect the satellite network to the internet and/or to private networks and cloud services.

2.25 In considering whether to grant or reject NGSO spectrum licence applications, we follow our published guidance. This includes consideration of technical coexistence with existing and future NGSO systems and any potential impacts on competition in the NGSO market. Details of existing licences can be found under the "existing licences" section of our website.

Our licensing process for NGSO applications

2.26 The national licensing process we introduced in December 2021 is designed to encourage greater technical cooperation between NGSO operators; help us manage interference; support a competitive market for NGSOs; and enhance transparency[18].

2.27 As such, the process focuses on measures to support the coexistence of NGSO services. Other conditions in our NGSO gateway licences deal with how an NGSO system needs to operate in order to coexist with other services (e.g. GSO services). We explain these conditions in paragraphs 2.38-2.43 below.

Figure 3: New NGSO licensing Process

2.28 The main steps in the NGSO licensing process are outlined in figure 3 above. An overview of this process can be found on the NGSO licensing page of our website. This page also includes the details of NGSO systems that new applicants should take account of when applying (i.e. existing NGSO licence holders, co-frequency earth stations and earlier applicants).

2.29 Under the UK process for licensing NGSO systems we ask those applying for a gateway licence to supply information on the following issues:

[18] Satellite operators need to submit filings for their constellations to the ITU and coordinate with all NGSO operators who hold an older or "more senior" satellite filing. However, due to the complexity and cost of developing and launching NGSO satellite networks, not all satellite filings come to fruition in the order in which they were filed. The UK process for licensing NGSO systems is not designed to circumvent the international regulatory regime as laid out by the ITU's Radio Regulation but it encourages those who are ready to deploy to cooperate in such a way that services can coexist.

- how they will ensure that the applied-for gateway earth station(s) can coexist with existing NGSO licence holders;
- how they will ensure that the applied-for gateway earth station(s) can coexist with future NGSO systems;
- the benefits that the applied-for gateway earth station(s) can bring to UK citizens and consumers; and whether they pose any risks to competition in the market.

2.30 We publish a short consultation on applications – along with a preliminary assessment – and invite stakeholders to comment on that and on the information supplied by the applicant. The questions we ask of stakeholders are based on the criteria above, with an option to provide comments on any additional concerns.

2.31 Upon receipt of consultation responses, we may ask the applicant for additional information to help us address concerns raised in the consultation responses. Our final assessment considers all of the information supplied by the applicant and all of the comments gathered from stakeholders.

How we assess applications

2.32 A summary of our published assessment process for each of the requested inputs follows.

2.33 **Demonstration of coexistence with other NGSO systems**:

a) We prefer for applicants to have an agreement with other relevant licence holder(s) already. This would ideally be an ITU coordination agreement, but it could also be a local cooperation agreement allowing the systems to coexist in the UK.

b) 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.

2.34 **Demonstration of the ability to coexist with future systems:** We do not expect licensees to foresee the characteristics or the number of future systems that will apply for a licence in the UK, or how other systems may evolve. Our intention is for licensees to:

a) explain how their existing network design and operating model might facilitate coexistence with other NGSO satellite systems and any limits to that flexibility;

b) outline any additional measures, which would allow improved coexistence with other systems (for example, planned roll out of ground equipment, future network designs); and

c) be aware that they may be expected to take reasonable measures to accommodate such future applicants, in order to avoid material degradation to services in the UK.

2.35 Potential impact of their application on competition in the UK. We expect applicants to describe:

a) the benefits that the NGSO system can bring to UK people and businesses. Possible benefits might include:

   i) improvements to an existing NGSO service;

   ii) greater choice and/or allowing the applicant to compete more effectively in the UK; and

   iii) how the NGSO system may benefit its customers (e.g. a communications provider that uses the NGSO system for backhaul) as well as end consumers (e.g. the ultimate users of that communication provider's services) and possibly citizens more generally (e.g. if that communication provider's services are of wider benefit to society).

b) any risks to competition in the UK. This may refer to how the applicant intends to mitigate any risks to competition, including, but not limited to, their ability to coexist with other NGSO satellite systems or giving a sense of the scale of any costs of coexistence for other operators' systems.

2.36 It is worth noting that a new applicant for a UK network or gateway licence may hold a senior (earlier) ITU international satellite filing than a competitor holding an existing UK licence. Under the ITU's Radio Regulations, the burden to ensure coexistence falls on the operator with the junior (later) ITU filing. In this scenario, consistent with the ITU Radio Regulations, existing UK licensees with deployed NGSOs may be reasonably expected to make changes as required to accommodate the new UK applicant. Most should have already designed their systems in such a way that this is possible.

Relevant NGSO Earth Station (Gateway) licence terms and conditions

2.37 We expect all licence holders to meet the conditions of their licence(s) and we have a range of monitoring and enforcement powers to ensure they do so. Most of the conditions in the NGSO gateway licence are the same as those for the Permanent Earth Station licence (the licence for gateway earth stations operating to GSO satellites). However, there are some additional conditions that are specific to NGSO operators relating to the protection of GSO services. We have also introduced some other specific licence conditions as part of the NGSO licensing process to enable us to take action in the event that one NGSO system causes harmful interference to another NGSO system, resulting in a material and recurring degradation of service, which in turn can cause competition risks. A copy of the standard NGSO gateway licence can be found in Annex A1.

Protection of GSO services

2.38 The licence already contains provisions for the protection of GSO satellite services using the same frequencies. Specifically, condition 3.1 (d) of our NGSO gateway licence states:

> *"earth stations operating with non-geostationary satellites shall ensure compliance with the equivalent power flux-density limitations specified in Article 22 of the ITU Radio Regulations"*

2.39 As this licence covers the transmissions from NGSO gateway earth stations, this condition ensures the gateway earth stations do not cause interference from Earth to space transmissions (in the uplink) into GSO satellites.

2.40 For space to Earth transmissions (in the downlink) all satellite operators must comply with the relevant sections in the ITU Radio Regulations. The administration who holds their satellite filings is responsible for ensuring the satellite operator complies with the ITU Radio Regulations.

2.41 Article 22 of the ITU Radio Regulations covers (amongst other things) the protection of GSO services from NGSO services. We explain the details of the limits included in Article 22 of the ITU Radio Regulations and their relevance to the licensing process in Section 6 of this document.

2.42 There are some bands where those protections do not apply, as indicated in No. 5.523A of the Radio Regulations, which states that for certain frequencies, GSO networks and NGSO systems have to coordinate their use of spectrum on a first-come, first-served basis, based on the date of their ITU filings. As stated in Note 1 of the licence conditions:

> *"This Licence does not remove any other obligations that the Licensee may have in relation to satellite filings made under the ITU Radio Regulations"*

2.43 In addition, some bands may be subject to special restrictions and conditions. One example is the band 29.1 – 29.5 GHz, for which No. 5.535A stipulates its use to be limited to GSO networks and feeder links to NGSO systems in the mobile-satellite service. This is reflected in condition 3.1 (g) of the NGSO Earth Station (Gateway) licence:

> *"use of the band 29.1 – 29.5 GHz shall be in compliance with ITU Radio Regulations 5.535A;"*

Coexistence with other NGSO services

2.44 In our **NGSO licensing process**, we introduced six conditions for holders of NGSO gateway licences under section 5 of the licence (see below).

> "*1. The radio frequencies authorised by this Licence must be used in common with other non-GSO satellite systems authorised under wireless telegraphy licences granted by OFCOM. The names of these licensees shall be notified by Ofcom to the Licensee from time to time, and together with the Licensee are described as the "NGSO Licensees".*
>
> *2. The radio frequencies authorised by this Licence must only be used to communicate with a satellite system which has transmissions authorised under a Satellite (Earth Station Network) wireless telegraphy licence granted by Ofcom.*
>
> *3. In the event that –*
>
> *• one (or more than one) of the NGSO Licensees suffers a material and recurring degradation of services to its users at a specific region or location in the United Kingdom; and*
>
> *• the degradation of services is resulting from radio transmissions from the earth stations, the satellite or any other part of the satellite system operated by another of the NGSO Licensees, including the Licensee; Ofcom may instruct the Licensee to cease or change the use of particular equipment or particular radio frequencies which are authorised under a wireless telegraphy licence (including but not limited to radio frequencies authorised under this Licence) and are used by any part of the satellite system.*
>
> *4. Any such cessation or change must be for the purposes of ensuring that such interference is avoided and the degradation of services to users at the particular regions or locations is resolved.*
>
> *5. Following receipt of such notice, for such period of time as may be specified in the notice, the Licensee may only operate in accordance with the terms and conditions of the notice.*
>
> *6. The Licensee must establish, install and use the Radio Equipment to commence regular wireless telegraphy transmissions in accordance with the provisions of this Licence within twelve months of the date that this Licence is issued, and maintain such transmissions thereafter."*

2.45 These licence clauses give us additional powers of enforcement should one or more NGSO systems suffer material and/or recurring degradation of service.

2.46 Further, condition 5.2 of the NGSO Earth Station (Gateway) licence requires the gateway earth station to only connect to an NGSO network that holds an Earth Station network licence in the UK. This is because the requirement to cooperate with other NGSO earth station network licence holders is explicitly laid out in the NGSO ESN licence:

> *"7.2 The Licensee shall cooperate with all NGSO Licensees such that each satellite system (comprising the satellites, earth stations and user terminals) can co-exist and operate within the United Kingdom without causing harmful radio interference to each other, such that network services can be provided to end users."*

Ofcom may take a range of monitoring and enforcement actions where licence conditions are not met

2.47 Alongside the specific requirements for NGSO licence, the Wireless Telegraphy Licence Conditions Booklet (the general conditions booklet) places a number of conditions on all spectrum licence holders. It outlines some of the actions we may take in the event that conditions in our licences are not met. This includes the power to access and inspect sites (condition 5); modify, restrict and closedown (condition 6) services; and revoke a licence (condition 1).

2.48 In addition, we have the legal power to take enforcement action in relation to breaches of conditions in wireless telegraphy licences through criminal law prosecution. Similarly, section 42 of the Wireless Telegraphy Act 2006 gives us the power to fine companies which are in breach of the conditions in wireless telegraphy licences.

2.49 The type of enforcement action we would take in any circumstance would be appropriate and proportionate.

3. The Starlink consultation and response summary

3.1 As set out in sections 1 and 2, in June 2022 we published a consultation (the "**Starlink consultation**"), in which we set out our initial assessment of the six licence applications for NGSO gateway licences operating in the Ka band frequencies (27.5 – 27.8185 GHz, 28.4545 – 28.8265 GHz and 29.4625 – 30 GHz). We said we would assess the six applications together, including the coexistence and competition issues involved as set out in our NGSO licence application process. We also set out our preliminary view that we proposed to grant all six licences.

3.2 We invited comments on the application and on our preliminary views and said we would take into account all comments received, and that we were open to changing those views depending on responses and evidence submitted to us as part of this process.

3.3 We explained that SpaceX provides satellite broadband services direct to consumers in the UK and currently operates three NGSO gateway earth stations in the UK. We also set out SpaceX's description of their system and a rationale for why they require the additional gateway earth stations they are applying for: "Starlink was developed to bring high-speed, low-latency internet service to rural and remote areas…. In order to create a fully redundant and reliable system, Starlink needs multiple gateway sites to ensure that our satellites can always establish a reliable connection with a gateway. Moreover, because our satellites use a low orbit to achieve improved space sustainability and better network performance, SpaceX's constellation requires sufficient gateway sites on the ground to ensure connection."

3.4 We explained that when issuing new licences, one of Ofcom's objectives is that all authorised systems are capable of coexisting (in bands they are using in common), such that they are all able to provide services to their users without experiencing harmful interference. We outlined the coexistence criteria we asked applicants to demonstrate, and how SpaceX proposed to meet these criteria. Our initial view was that Starlink's coexistence plans provided sufficient comfort that the Starlink systems would be capable of coexisting with existing and future NGSO gateway earth station and terminal operators. We sought stakeholder views on this and any potential coexistence concerns regarding the proposed gateway earth stations.

3.5 On competition, we explained that, as outlined in Annex A3 of our statement on updates to NGSO licensing, our starting position with any competition check is to authorise applications, where possible. We outlined that we would take into account four factors: a) the extent of the likely risks to competition; b) the potential benefits from granting NGSO licences; c) ensuring that time and resources devoted to the licensing process are proportionate to the risks and benefits; and d) that NGSO services are currently in their infancy. Following consideration of the information provided by SpaceX, our preliminary assessment was that there are few competition risks associated with this application, as (a) future entrants would be able to access infrastructure in the UK, including preferential sites, or could choose to serve UK customers from gateway earth stations outside the UK;

and (b) we did not believe that granting the licences would prevent or restrict entry. We sought stakeholder views on whether granting one or more of these licences might prevent their service from operating in the UK or make it less attractive or more costly to enter the market.

3.6 We also noted the potential benefits of granting the licences. In our Connected Nations 2021 report, we stated that: "Satellite remains an option for a fixed broadband connection, particularly for premises without the alternative of a fixed provider. However, the number of customers accessing satellite services remains low in comparison with traditional broadband provision".[19]

3.7 We noted that SpaceX stated in the application that it had a backlog of customers waiting to connect to its service and that the additional gateway earth station sites would help to meet user demand and provide the weather diversity and network resiliency needed to provide highspeed, low-latency Starlink service to consumers in the UK. Further, SpaceX referred to a study by OOKLA which they had commissioned earlier in the year, comparing their service to other satellite services and terrestrial broadband in fifteen countries. They claimed that Starlink deployed a broadband service with speeds of over 100Mbps and latency of 20- 40ms and stated that this could be faster than the median speeds from terrestrial broadband services and other satellite broadband services.

3.8 Our preliminary assessment was therefore that granting these licences would increase the availability of high-quality broadband services, which would be beneficial for UK consumers.

3.9 We maintained that coexistence and competition were the two issues on which we expected to make our licensing decisions (as set out in the NGSO licensing updates Statement) but also asked if stakeholders had any additional concerns or comments regarding this application.

Overall summary of responses

3.10 We received eight responses to the Starlink consultation. This included: three non-confidential responses from consumers; two non-confidential responses from satellite operators; one response from a satellite operator that contained some confidential information; and two wholly confidential responses. All non-confidential responses have been published on our website.

3.11 The responses from consumers were wholly supportive of SpaceX's application and noted the benefits they felt the Starlink service would offer. Satellite stakeholders provided more varied responses: some had no concerns, while others raised concerns about potential interference to NGSO systems.

3.12 GSO satellite operators expressed the most concerns, raising questions about the potential risks of interference to their services; the potential impact of the Starlink constellation on the global space environment, and potential risks to competition in the market. In

[19] See page 20.

response to some points raised by respondents, we requested SpaceX to provide us with additional information regarding protection of GSO services and information regarding the design of their second-generation constellation. This additional evidence has been published alongside our decision and can be found on the NGSO site on our webpages. We have referred to this material where relevant throughout the rest of this document.

3.13 We note that some stakeholders raised similar issues in their response to different questions.

3.14 In sections 4-7 we consider the responses we received to the Starlink consultation and set out our assessment of the arguments with respect to NGSO coexistence, competition issues, and additional issues presented in submissions. In addressing consultation responses, we have grouped comments together under the most relevant topic.

4. Consultation responses on NGSO coexistence

4.1 As part of its licence assessment process Ofcom looks to evaluate applications on their ability to coexist both with existing licensed systems and future systems.

Coexistence with existing NGSO licensed systems

4.2 The Starlink consultation set out our preliminary view that SpaceX would be able to coexist with existing NGSO licence holders because none of them use the frequencies to which the application relates. That is:

a) there are no other NGSO Gateway licences in the Ka band which would overlap with the frequencies applied for by SpaceX.

b) none of the NGSO Network licence holders currently operates terminals which use the Ka band.

c) this was the first application through our new process, so there were no other NGSO applications at the time of the consultation.

4.3 In the consultation we asked the following question:

Consultation question 1

Do you anticipate one or more of the NGSO gateways in these applications will pose coexistence challenges to existing services?

Please provide evidence of the impact of any likely interference in terms of throughput and unavailability.

Consultation responses and assessment regarding coexistence with existing NGSO licenced systems

4.4 We received no responses from existing NGSO gateway licence holders raising coexistence concerns (noting that SpaceX is the only existing NGSO gateway licence holder operating in the Ka band in the UK).

4.5 Similarly, since no existing NGSO network licence holders in the UK operate terminals in the Ka band, we received no coexistence concerns on their part either.

Coexistence with future NGSO systems

4.6 The Starlink consultation detailed how SpaceX proposed to manage coexistence with future NGSO systems. Our initial view was that SpaceX had provided sufficient information to demonstrate that its system is capable of coexisting with future NGSO gateway earth station and terminal operators in the UK.

4.7 We noted that in its application SpaceX outlined how it would cooperate with future applicants in the following way:

"SpaceX selects low altitude orbits for Starlink satellites, driving down transmission power requirements and promoting coexistence with other systems. In NGSO systems like ours, where there are multiple satellites in view and transmitter beams are dynamic and finite, the duration and extent of interference to other operators is minimized.

SpaceX agrees with the International Telecommunications Union and many regulators that private coordination between operators is the most efficient means (the "gold standard") for two NGSO satellite operators to manage shared spectrum. Because operators themselves are best positioned to understand the capabilities of their systems and their business objectives, successful coordination ensures the most efficient use of shared spectrum.

Where agreements cannot be reached, if spectrum bands are to be split, as is the case under the US Federal Communications Commission rules, the Starlink system is able to operate on parts of the spectrum bands during inline events and expects other systems to be similarly flexible in managing interference."

4.8 As part of the consultation, we sought views and evidence from interested parties on future coexistence challenges related to SpaceX's NGSO gateway licence applications. We asked the following question:

Consultation question 2

Do you consider that the measures to enable coexistence with future systems, as set out by the applicant, are reasonable? If not, what are your concerns and to which specific gateway sites do your concerns relate?

Consultation responses regarding coexistence with future NGSO systems

4.9 One respondent said it did not foresee any challenges with the proposed locations of the gateway earth stations.

4.10 Mangata considered that SpaceX had not provided sufficient technical detail on their strategy to co-exist with future NGSO systems. It said: *"We note that SpaceX has offered a generic narrative on some measures available to achieve coexistence with future NGSO systems but without providing any technical assessment on the deployment of such measures and the level of coexistence that can be achieved (in terms of meeting long term and short term interference criteria)."*

4.11 One respondent had concerns about SpaceX placing its gateway earth stations in or near major conurbations, which it claimed could restrict or prevent the deployment of Ka band user terminals in such conurbations by other operators.

4.12 Viasat also submitted a view that the increase in the number of gateway earth station sites "*would result in a high number of 'active' SpaceX satellites operating over the UK*". It claimed that the size of SpaceX's large LEO system can consume significant portions of the "look angles" toward space, and essential LEO orbits, which would have the effect of

"*preventing use of the sharing tools that have been employed successfully for decades among NGSO systems*." It suggested that look angle splitting should be used to mitigate this risk.

4.13 Viasat argued that SpaceX, therefore, would have *"no incentive to avoid in-line interference events, and every incentive to maximise them; large numbers of in-line interference events would impede competition from smaller NGSO systems without materially impacting SpaceX's operations".*

Ofcom assessment regarding coexistence with future NGSO systems

Requirement for technical detail

4.14 The criteria for our assessment regarding coexistence with future NGSO systems has been set out in the NGSO Licensing Guidance document (and summarised in section 2). There we explained that we do not expect licensees to foresee the characteristics or the number of future systems that will apply for a licence in the UK, or how other systems may evolve. Instead: *"Applicants should state what flexibility their system has to achieve coexistence with future networks. This could include the measures they would be able to put in place if another network comes along in the future; it could also suggest measures future networks could reasonably be expected to put in place in order to coexist".*

4.15 While some applicants have chosen to provide more technical details regarding the operation of their system and the level of coexistence that can be achieved with existing licensees, this is not a requirement for the test regarding future systems (as explained above). Technical coexistence is difficult to demonstrate without knowing what the future systems will be: some future NGSO systems may not even have been designed yet. It would therefore be unreasonable to expect an applicant to demonstrate technical coexistence with such a system or to speculate which of the other planned NGSO networks might wish to operate in the UK. Our aim with the future coexistence test is to check the ability and willingness of applicants to accommodate future operators.

4.16 We are satisfied that SpaceX has provided the necessary level of detail to reassure us that their network has the necessary flexibility. Specifically:

a) SpaceX has a wide choice for which satellites connect to each gateway earth station. This means that it can anticipate in-line events by choosing to connect to satellites which are in a different part of the sky from the satellites of other operators (as the satellites appear to the user or gateway earth station on the ground).

b) Active antenna technology in the earth stations means beams can more easily be steered (and avoid in-line events). The same technology on the satellite widens the number of satellites that can transmit data to the same Earth Station.

c) Minimisation of power levels decreases the risk of harmful interference, especially to constellations operating at higher altitudes even if the satellites appear to be in the same part of the sky to the user on the ground.

Risk of blocking other services

4.17 We have considered the potential for SpaceX Ka band gateway earth stations to create no-go areas for Ka band user terminals of other operators in or nearby major UK conurbations, by causing harmful interference to potential future user terminals within proximity of the gateway earth station. We assess that the risk of this occurring is low, given the different ways in which SpaceX declared that Starlink can mitigate interference.

4.18 In addition, we reiterate our expectation that all operators coordinate in good faith. SpaceX has also set out in its application its willingness to coordinate with other operators to manage interference risks. Indeed, in its additional response, SpaceX confirmed: *"SpaceX has already been engaging in good-faith coordination with other licence-holders regarding the system. In fact, SpaceX already reached an historic NGSO-NGSO coordination agreement with OneWeb with regard to both companies' Gen1 and Gen2 systems."*

4.19 Viasat expressed a concern that SpaceX - as an operator of a large constellation through its future Gen 2 system - would have no incentive to avoid in-line interference events, and every incentive to maximise them. In theory an operator with many satellites might have a reduced incentive - in the absence of regulation - to avoid in-line events, particularly if they have a higher priority filing. Similarly, a smaller constellation with a more junior filing to SpaceX risks not being able to transmit their own signals in space because they (the junior filing) may cause interference into the terminals of the larger constellation.[20] As the junior filing, it is their responsibility to protect the constellation of the more senior filing. However, in each of these scenarios the larger operator would also have flexibility to avoid in-line events (as mentioned by SpaceX in their application). As regards a potential lack of incentive to avoid in-line events, Ofcom's licensing process addresses this risk. Applicants need to demonstrate how they can coexist with other NGSO systems, as well as how they can be flexible to coexist with future NGSO systems. Licence holders are obliged to cooperate with other licence holders, and as noted above Ofcom has options for enforcement action in relation to breaches of licence conditions.

4.20 On the concern regarding 'look angles', NGSO systems are required - under Ofcom's ESN Licence conditions - to cooperate with each other in good faith regardless of their size. This licensing framework states that bilateral cooperation is the preferred way to achieve an efficient use of spectrum, and we do not set specific fall-back conditions such as look angle splitting or spectrum splitting. Our licensing conditions give us powers to enforce against licensees who refuse to coordinate in good faith and who cause harmful interference to others.

Conclusion on NGSO coexistence

4.21 We have considered stakeholder responses on whether one or more of the NGSO gateway earth stations in these applications would pose coexistence challenges to existing services,

[20] In addition, the earth stations of the junior filing operator may cause interference into the satellites of the larger constellation.

and whether the proposed measures to enable coexistence with future systems are reasonable.

4.22 The applications would not be expected to affect other existing NGSO gateway or NGSO network licence holders as there are none which operate in the Ka band in the UK.

4.23 In relation to coexistence with future systems, our aim is to check the ability and willingness of applicants to accommodate future operators. We have noted the points raised by respondents in respect of the level of detail provided on potential coexistence measures. However, technical coexistence is difficult to demonstrate without knowing what the future systems will be. On balance, we are satisfied that SpaceX has provided the necessary level of detail to reassure us that their network has the necessary flexibility to coexist with future systems.

4.24 We have also considered the concerns raised around the potential for additional SpaceX Ka band gateway earth stations (and/or satellite connections to them) to block other NGSO services from operating in a number of ways. Overall, we consider that these risks are low, taking account of the information provided by SpaceX and Ofcom's licence conditions, which require NGSO licence holders to cooperate with other licence holders in good faith regardless of their size to avoid interference. We note that Ofcom has options for enforcement action in relation to breaches of licence conditions.

4.25 We therefore confirm our initial view, as set out in the Starlink consultation that SpaceX has provided sufficient information to demonstrate that its system is capable of coexisting with future NGSO gateway earth station and terminal operators in the UK.

5. Assessment of competition issues

5.1 In this section we assess the competition risks, and benefits to consumers, arising from SpaceX's NGSO gateway licence application. We cover several competition issues: availability of gateway earth station sites, interference into other systems because of gateway earth station site proximity, access to launch services, and a broader concern over proliferation of satellites in space.

5.2 We assess these competition issues using the counterfactual method. That is, we compare the competitive conditions which we expect to result from granting the application (the factual) against the conditions which would have prevailed without the application (the counterfactual). We take as our counterfactual the status quo. Specifically, we assume a situation in which SpaceX does not hold the six NGSO gateway licences it is applying for. We assume that SpaceX's Gen 1 satellite launches will proceed without these additional NGSO gateway licences. This is a reasonable assumption because the UK is a relatively small market for satellite broadband, and it is global demand which SpaceX is seeking to meet with its Starlink constellation.

5.3 We also assume that any decisions regarding the design and launch of Starlink's Gen 2 satellite constellation are taken independently of any Ofcom licensing decision related to the number of additional gateway earth stations in the UK. Again, this is because the size of the UK market is relatively small such that it is unlikely to influence SpaceX's global satellite launches. It also reflects the situation that operators seeking to compete in the UK are not limited to using UK gateway earth stations to provide their services to customers, and therefore a denied NGSO gateway licence application would not necessarily lead to lost or fewer UK services but may instead lead an alternative system configuration being deployed.

5.4 The rest of this section is structured as follows:

a) A summary of Ofcom's consultation position on competition.

b) Consultation responses related to competition.

c) Ofcom's assessment of these consultation responses.

d) Conclusion on competition matters arising from the gateway application.

Summary of Ofcom's consultation position on competition

5.5 In our Starlink consultation we set out four potential competition risks which we envisaged might arise in relation to an NGSO operator applying for a gateway licence, along with our preliminary assessment of each of these in respect of SpaceX's application. The risks we identified were informed by our statement on non-geostationary satellite systems.

5.6 The first risk identified was that SpaceX could occupy all or most of the available gateway earth station sites, which could potentially block future entrants from accessing the market. We noted in our initial assessment that, if SpaceX's gateway licence applications were granted, there would remain up to nine existing UK teleports available for

development by potential entrants.[21] In addition, we noted that NGSO operators can develop their own teleport sites, as SpaceX plans to do. This would increase the number of usable gateway earth stations in the UK. Finally, we noted that gateway earth stations do not need to be in the UK to serve UK customers.[22]

5.7 The second risk was that SpaceX could occupy 'preferential' gateway earth station sites, raising the cost of entry for subsequent entrants. In our Starlink consultation we noted that a gateway earth station site might be preferable if it has access to spectrum, suitable infrastructure (such as high-quality fibre links), and proximity to a customer base. If new entrants could not access such gateway earth stations, this could diminish future competition on the market. Our preliminary assessment was that, as SpaceX is planning to develop new gateway earth station sites for most of their gateway earth stations, there would remain a range of suitable gateway earth station sites for future NGSO operators.

5.8 The third risk related to the distance between gateway earth stations required to avoid interference. That is, SpaceX potentially requiring large separation distances between its gateway earth station(s) and that of others, thereby blocking potential sites to future entrants. In the Starlink consultation we noted SpaceX's view that it does not need geographic separation between its gateway earth stations and those of other operators.

5.9 The fourth risk related to SpaceX making a strategic licence application for gateway earth station sites which it does not plan to use, in order to deliberately block future entrants. In the consultation we noted that Ofcom's NGSO licence conditions would be expected to ensure that such strategic behaviour is unlikely to occur.[23]

5.10 Overall, our preliminary view was therefore that there were no significant competition risks directly associated with SpaceX's application. In particular, future entrants will be able to access infrastructure in the UK, including preferential sites, or could choose to serve UK customers from gateway earth stations outside the UK. Accordingly, granting the licences would not prevent or restrict entry.[24]

5.11 In the consultation we also noted the potential benefits of granting SpaceX a licence. Satellite connectivity is an option for a fixed broadband connection, particularly for premises without the alternative of a fixed provider.[25] We also referred to SpaceX saying that additional gateway earth station sites would help it to meet user demand and provide the weather diversity and network resiliency needed to provide high-speed, low-latency services. Consequently, our preliminary view was that the additional six gateway earth stations in SpaceX's application had the potential to increase the availability of high-quality broadband services for consumers in the UK.

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[21] A teleport is a site already developed for the hosting of multiple NGSO gateway earth stations with the relevant IT, fibre and power infrastructure.

[22] For example, OneWeb [Licence: Network Access Associates Ltd (ofcom.org.uk)] is currently serving UK customers from gateways outside of the UK. In addition, we have granted a licence for a network earth station licence to Telesat [Application: TELSAT-NET-1 application (ofcom.org.uk)] which plans to serve UK customers using an NGSO system without a UK gateway.

[23] For example, we require all licence holders to commence transmissions within 12 months of receiving a licence. See paragraph 3.56 of the NGSO Licensing Updates Statement.

[24] See paragraph 2.31 of the Starlink consultation.

[25] See paragraph 2.32 of the Starlink consultation.

5.12 As part of the consultation, we sought views and evidence from interested parties on competition concerns related to SpaceX's NGSO gateway licence application:

Consultation question 3

Could the granting of one or more of these licences prevent your service from operating in the UK or make it less attractive or more costly to enter the market? If yes:

- Please outline your proposed services, including locations, and indicate when you are planning to start deploying your services.
- Please also explain the reasons why granting these licence applications would affect or restrict (i.e. make more costly or less attractive) your future service in the UK.
- Please state which of the proposed gateway applications would affect your deployment (if relevant).

Consultation responses related to competition

Responses received relating to the risks identified in the consultation

5.13 We set out below the responses received that relate to the four risks identified in the consultation.

Risk of SpaceX occupying all or most of the available gateway earth station sites, potentially blocking future entrants from accessing the market

5.14 One respondent's view was that, given the number of teleports under consideration in this application, there is a risk that issuing these licences could make it harder for other competitors to access these teleports for the Ka band in the future. Other respondents did not express competition concerns in relation to this first risk. In addition, in the course of our normal duties we have discussed this issue with other stakeholders, including those who are considering placing a gateway in the UK, and they did not raise this as a concern with us.

Risk of SpaceX occupying preferential sites, raising the cost of entry to subsequent entrants

5.15 In addition to the responses summarised above, one respondent had concerns about SpaceX placing their gateway earth stations in or near major conurbations, which they claimed could prevent the deployment of Ka band customer terminals by competitors.

Risk of SpaceX's potential requirement for large separation distances between its gateway earth station(s) and that of others, thereby blocking potential sites to future entrants

5.16 Respondents either did not raise this as an issue or stated that the locations of the proposed SpaceX gateway earth stations would be of sufficient geographic separation from their proposed sites.

Risk of strategic licence application for gateway earth station sites which an operator does not plan to use, in order to deliberately block future entrants

5.17 Stakeholders did not express any views in relation to this fourth risk.

Consultation responses related to other competition matters

5.18 We also received responses on other competition matters. These fell into two broad categories: (a) a broader concern over the global number of satellites in space and foreclosure of other satellite operators, and (b) concerns related to SpaceX's vertically integrated satellite launch and satellite broadband businesses. We address these in turn.

Global number of satellites and foreclosure in space

5.19 Some respondents suggested that the planned global expansion of the SpaceX system (via its Gen 2 configuration) would substantially increase the number of satellites operating in space. These respondents stated that the impact of such a global expansion could be to prevent potential entrants deploying smaller, lower priority[26] constellations in space in the future. This would be because these new entrants may not be able to protect or operate around such a large constellation.

5.20 Some respondents also said that the size of the expanded constellation would mean it may be difficult to access certain orbital resources which SpaceX plans to use for their Gen 2 configuration. Taken in combination with challenges around scarce and shared spectrum, Viasat's view is that the planned global expansion of satellites by SpaceX could foreclose other satellite operators.

5.21 Further details on the responses we received are set out below.

5.22 Viasat stated that SpaceX's global plan to deploy 42,000 satellites combined (through Gen 1 and a future Gen 2) would harm competition in space because it would preclude *"safe and reliable access to approximately 86% of the altitudes between 300km and 700km, regardless of frequency bands".*

5.23 Viasat also warned of a larger "race to the bottom", in which LEO systems deploy many more satellites than are needed, "utilising large numbers of spectrally-inefficient satellites and rejecting reasonable approaches that otherwise would enable spectrum sharing among all NGSO system types – even those operating at other altitudes". Viasat suggested that SpaceX's proposal to "blanket the sky" would have direct and harmful consequences for other NGSO systems and operators – and would foreclose competition and harm the broader public interest. This could easily leave only one or two NGSO systems with the ability to serve UK.

5.24 Viasat expressed concerns about the wide orbital tolerances within which SpaceX proposes to operate "thus effectively filling up hundreds of kilometres of orbits to the exclusion of other NGSO systems that otherwise could operate safely in nearby orbits. This forecloses

[26] As set out in sections 2 and 6, NGSO systems in the bands under discussion have to coordinate their use of the spectrum under the provisions of Article 9.12 of the ITU Radio Regulations on a first-come, first-served basis, based on the date of their ITU filings, and later systems will be expected to take into account earlier systems.

those other NGSO systems from using LEO to provide competitive and innovative services to the public and distorts the competitive balance in LEO".

5.25 It claimed that SpaceX has not identified the parameters necessary to safely allow other LEO satellites or constellations to occupy, or overlap, the orbits SpaceX plans to occupy. It stated that other operators (Amazon/Kuiper and Iridium) "have asserted to the contrary that other LEO constellations cannot safely share the same orbits." It suggested one mitigation would be to require SpaceX "to maintain an orbital tolerance of +/- 2.5 km for the apogee and perigee of each satellite, and a 0.5 degree tolerance for each orbital inclination it employs."

5.26 Inmarsat also stated that the "large scale use of certain orbital regions could result in a de facto exclusion of other players from those regions." According to Inmarsat, this issue, and its impact on both competition and innovation, is poorly understood and needs further study. It warned that such orbital exclusion "could violate the 1967 Outer Space Treaty." Inmarsat also warn it could create "space-based dominant 'platforms' that restrict competition in space similar to the impact of dominant digital platforms on Earth".

SpaceX's vertically integrated business

5.27 Viasat expressed a concern regarding SpaceX's ambition to "design and manufacture its satellites and user terminals in-house, to launch the Starlink constellation on its own rockets and to market its services directly to the end customers, thereby bypassing the entire existing ecosystem and keeping 100% of the value of the project for itself". Viasat said that this strategy could have a negative impact on the space and telecom industry in the United Kingdom that could result in a tremendous "loss in value for the British economy and the corresponding negative impact on jobs."

Views regarding the consumer benefits of SpaceX's application

5.28 Three consumers who responded to our consultation urged us to act with speed to increase the availability of satellite broadband (via SpaceX in this case) in their area. We have additionally received a further 26 requests for access to the Starlink service via our spectrum roadmap consultation.

Ofcom assessment of consultation responses relating to competition

Responses relating to risks identified in the consultation

5.29 We received two responses which related to those potential competition risks set out in the consultation: that SpaceX's gateways would limit the availability of gateways for other operators, and that SpaceX's gateways might block competitors' Ka band terminals in the future.

5.30 On the concern that the number of gateway earth station licences under consideration could make it harder for other competitors to access these teleports for the Ka band in the future, no respondents raised any points[27] which challenged the assessment below:

a) there would remain up to nine existing UK teleports available for development by potential market entrants;

b) operators can develop their own sites as a way to increase the number of suitable gateway earth stations in the UK; and

c) gateway earth stations do not need to be in the UK to serve UK customers.

5.31 On the concern that SpaceX's placement of gateways in or near major conurbations could prevent the deployment of Ka band terminals by rivals in future, our assessment set out in the 'coexistence with future NGSO systems' section above (see section 4) concluded that the risk of this occurring is low, given the inherent flexibility of the SpaceX constellations. Since the competition concerns here would stem from there being an inability to coexist with future systems (which would create interference issues), our assessment is that the flexibility built into SpaceX's system (see section 4) means that SpaceX can avoid causing harm to competition.[28]

5.32 As discussed above, we also received responses relating to other competition matters. We assess these below.

Responses concerning the number of satellites and the size of orbital resources

5.33 Ofcom's competition assessment of a NGSO gateway licence application follows the principles set out in our December 2021 statement. In particular, we assess the potential effect on competition to supply satellite broadband to UK customers from issuing the additional six NGSO gateway licences to SpaceX. We compare this potential effect against the counterfactual (i.e. not granting these licences) set out at paragraphs 5.2-5.3.

5.34 The relevant focus of our competition assessment is the effect of granting the application on competition in the supply of satellite broadband services to UK customers. For the application to raise competition concerns in the UK, and in the manner expressed by Viasat and Inmarsat, it would need to be the case that (a) granting the six additional UK NGSO gateway licences to SpaceX drives the deployment of a sufficient proportion of SpaceX's planned additional c. 30,000 global satellites (its Gen 2 system), and (b) this deployment leads to harm to competition in the UK.

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[27] Further, as noted in paragraph 5.14, in the course of our normal duties we have discussed this issue with other stakeholders, including those who are considering placing a gateway in the UK, and they did not raise this as a concern with us.

[28] We also note that the conditions which apply to these licences seek to ensure such coexistence on an ongoing basis. See paragraph 5.9 of the NGSO Statement: "On the general point of compliance and enforcement, we note the general licence conditions which also apply to these licences, as set out in the Wireless Telegraphy Licence Conditions Booklet (the general conditions booklet). It stipulates a number of general licence conditions that also apply to satellite licensees and give general enforcement powers for Ofcom to act where it is deemed appropriate. This includes the power to revoke (condition 1), access and inspect (condition 5), and modify, restrict and closedown (condition 6) services (see Annex A6). Furthermore, we have the legal power to take enforcement action in relation to breaches of conditions in wireless telegraphy licences through criminal law prosecution. It also has power in section 42 of the Wireless Telegraphy Act 2006 to fine companies which are in breach of the conditions in wireless telegraphy licences."

5.35 Our assessment is that the link between granting six UK NGSO gateway licences and SpaceX's planned incremental launches is unlikely to be strong. This is because:

a) First, the UK represents a small market compared to global demand for satellite broadband, and it is global demand which SpaceX's Gen 2 system of satellites seeks to meet. Accordingly, denying the application is unlikely to materially affect the number of satellites launched by SpaceX.

b) Second, if the licences were not granted to SpaceX, it is likely that (a) their plan to launch satellites would not be significantly changed, and/or (b) SpaceX's NGSO gateway earth stations could be deployed in countries neighbouring the UK as an alternative means to provide services to UK customers.[29] Accordingly, if the licences were not granted the number of additional global satellites launched by SpaceX is likely to be similar to the number that would be launched if the licences were granted.

5.36 Therefore, our assessment is that in both the counterfactual (SpaceX operates in future without the additional six UK gateway earth stations) and factual (granting the licences) SpaceX would likely deploy the c. 30,000 additional global satellites or at least the vast majority of them, which is the source of concern for Viasat and Inmarsat. As a result, we consider that granting the licences is unlikely to make a material difference to competition in the UK through the mechanism of potential foreclosure in space from satellite proliferation and access to orbital resources.

5.37 Notwithstanding the above, we recognise the importance of satellite operators continuing to coordinate in good faith in the event of significant changes to systems, or the launch of a new generation of satellites. In paragraph 3.42 of our NGSO Licensing Updates Statement, we said: *"We recognise that second or third generations of NGSO satellite systems might be substantially different from earlier generations. As discussed in Section 5, operators will have an ongoing requirement to cooperate with others to ensure their systems can coexist. Major modifications to a system might significantly change the interference environment for other operators. In such situations, operators will need to cooperate with other licensees ahead of that change in order to avoid causing harmful interference and impacting the services provided by other licensees".*

5.38 Indeed, SpaceX has confirmed in its additional material provided to Ofcom that it has already completed a coordination agreement with another NGSO operator that covers the first and second generations of both parties (see paragraph 4.18 above).

Response concerning the effect of SpaceX's vertical integration strategy

5.39 Viasat stated a concern that SpaceX's vertical integration could have a negative impact on the space and telecom industry in the United Kingdom that could result in a tremendous "loss in value for the British economy and the corresponding negative impact on jobs". As discussed in section 2, Ofcom is keen to enable NGSO satellite services in the UK and to foster a competitive market for several operators to provide services. Enabling multiple NGSOs to operate in the UK is likely to be beneficial for the UK. In addition, in principle,

[29] For example, alternative architectures could be used to in-fill SpaceX's UK capacity through using inter-satellite links.

vertical integration can result in efficiencies and can, in some cases, be viewed as beneficial for competition and therefore beneficial for people in the UK. These efficiencies can include reduced costs, and improvements to product or service quality.[30]

5.40 However, there is at least a theoretical possibility that SpaceX's vertical integration could affect competition in the supply of satellite broadband to UK customers. For completeness, we have therefore considered the likelihood of actual harm to competition from 'input foreclosure'. Input foreclosure refers to a situation where an upstream division of a vertically integrated firm either stops supplying inputs to rivals of its own downstream division or continues to supply the inputs but at higher prices.[31]

5.41 Unlike many satellite operators, SpaceX provides satellite broadband directly to consumers. It also builds the satellites and the terminals and can use its own launch services. This means it is more vertically integrated than other operators and it also provides launch services to its competitors. In this case, the downstream division is satellite broadband services and the upstream division is launch services. SpaceX's plan to increase its capacity to supply satellite broadband services in the UK could, in principle, increase SpaceX's incentive to engage in input foreclosure.[32]

5.42 Hypothetically, the benefit from input foreclosure for the vertically integrated firm – in this case SpaceX – would be that downstream customers switch from (or are prevented from) purchasing from its downstream rivals to instead purchasing from its own downstream division. This would arise if SpaceX denied its rivals access to inputs, such as launch services, or charged high prices to make these services *de facto* inaccessible. This conduct has the potential to cause harm by impeding the ability of rival firms to compete effectively such that end customers face higher prices or lower quality. This would represent a weakening of competition in the provision of services to UK consumers.

5.43 The standard assessment of input foreclosure follows a three-part framework, which asks whether:[33]

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[30] "Efficiencies may include, but are not limited to, a reduction or elimination of transaction costs (i.e. costs associated with contract writing and monitoring between firms at different levels of the supply chain and costs associated with ex ante investment and ex post performance); greater economies of scope; the elimination of double marginalization; improvements to product or service quality; better innovation from coordination in product, design and innovation efforts; the elimination of free-riding from the harmonization of incentives; and the creation of a maverick" – see paragraph 7 of OECD publication 'Vertical mergers in the technology, media and telecom sector – Note by BIAC', June 2019: pdf (oecd.org).

[31] Input foreclosure is typically considered as part of merger control when there is a vertical merger. Analytically, SpaceX's gateway licence application can be treated as being similar to a vertical merger, in which an upstream division (SpaceX's rocket and satellite launching business) purchases a potential rival downstream firm (as represented by several available teleport locations and the associated licences to use Ka band spectrum), thereby allowing the merged entity to expand its market share in the downstream market: the supply of satellite broadband services to UK customers.

[32] We note that in our counterfactual we consider that a) the Starlink system proceeds anyway without these UK gateway earth stations, and/or b) these gateway earth stations might instead be deployed in other neighbouring countries as an alternative means of providing capacity for the system to provide services to UK customers. In this situation, SpaceX may be able to deploy a similar capacity to serve the UK in both the factual and the counterfactual. As a result, the input foreclosure concern assessed here is likely to be even less of a direct concern to our decision, because irrespective of our licencing decision the incentive to engage in input foreclosure is the same.

[33] See CMA merger assessment guidelines: Merger Assessment Guidelines (CMA129) - GOV.UK (www.gov.uk)

a) a firm would have the ability to use its control of inputs to harm the competitiveness of its downstream rivals;

b) a firm would have the incentive to actually do so, i.e. it would be profitable; and

c) the foreclosure of these rivals substantially lessens overall competition.

5.44 The tests are cumulative. That is, all must be met for there to be a competition concern.

5.45 For SpaceX to have the ability to foreclose rivals it would need to have upstream market power and the input (satellite launches) must be important to rivals' ability to provide services to their customers. While satellite launches are certainly important for commercial satellite operators, our current view is that other launch operators such as Arianespace, ILS, Indian Space Research Organisation's Polar Satellite Launch Vehicle, Virgin Orbit and Rocket Lab provide services to third parties in competition with SpaceX.[34] There is also potentially a range of future competitors, such as ABL and UK companies such as Skyrora and Orbex.

5.46 Given the availability of an alternative satellite launch providers, we conclude that at this stage SpaceX is unlikely to have the ability to engage in input foreclosure.

5.47 Since the relevant framework for assessing input foreclosure is a cumulative test, we have not proceeded to assess whether SpaceX would have the incentive to engage in input foreclosure. We note though that the additional incentive from a larger presence in the UK from the application being granted is likely to be small when compared against the potential 'cost' of such a strategy, which is the loss of global sales of satellite launches to its downstream rivals.

5.48 Overall, our assessment is that it is that there is no realistic prospect that granting these gateway licences would increase the likelihood of SpaceX engaging in input foreclosure.

Conclusion on competition matters arising from the gateway application

5.49 In view of the above, our overall competition assessment is that granting the licences is unlikely to prevent or restrict future NGSO systems from deploying UK gateway earth stations, should they require it. Accordingly, the risk of harm to competition in the supply of satellite broadband to UK customers, and in particular to the direct-to-consumer segment, is low. We also note that there is potential for consumer benefits which could arise from granting the licences, which are discussed in paragraph 5.11.

[34] Analysis by other competition authorities supports the view that there are other credible launch providers. See for example Table 1 of the European Commission's merger decision on ASL / ARIANESPACE (Case M.7724): m7724_2310_7.pdf (europa.eu).

6. Additional concerns raised regarding potential impacts on GSO networks

Consultation summary

6.1 In our Starlink consultation, as well as our statement on non-geostationary satellite systems, we explained that coexistence with existing and future NGSO systems and competition are the main issues on which we expect to make our licensing decision. However, we also provided space for stakeholders to raise any additional concerns or comments.

> **Consultation question 4**
>
> Do you have any additional concerns or comments regarding this application?

6.2 Stakeholders raised two additional issues:

a) Protection of GSO networks from interference from NGSO systems- which we consider in this section; and

b) Environmental concerns- which we consider in section 7.

Interference from NGSO systems into GSO networks

6.3 Our NGSO licensing process focuses on the mitigation of interference between two NGSO systems. This is because NGSOs are dynamic by nature, creating a complex spectrum management environment – both in space and on the ground – and so increases the risk of interference. Whilst there is also the potential for interference between NGSO and GSO services which use the same frequencies, international rules and our licence conditions are intended to prevent this, and also address the management of any issues should they arise. We discussed these briefly in the annex to our Statement on NGSO Licensing Updates and will explain them in more detail here.

6.4 There are two potential sources of interference from NGSO systems into GSO: interference from the NGSO earth station(s) uplink into the GSO satellite (as illustrated in Figure 4) and interference from the NGSO downlink into the GSO earth station(s) (see figure 5).

Figure 4: Demonstration of interference from NGSO services into a GSO network in the uplink

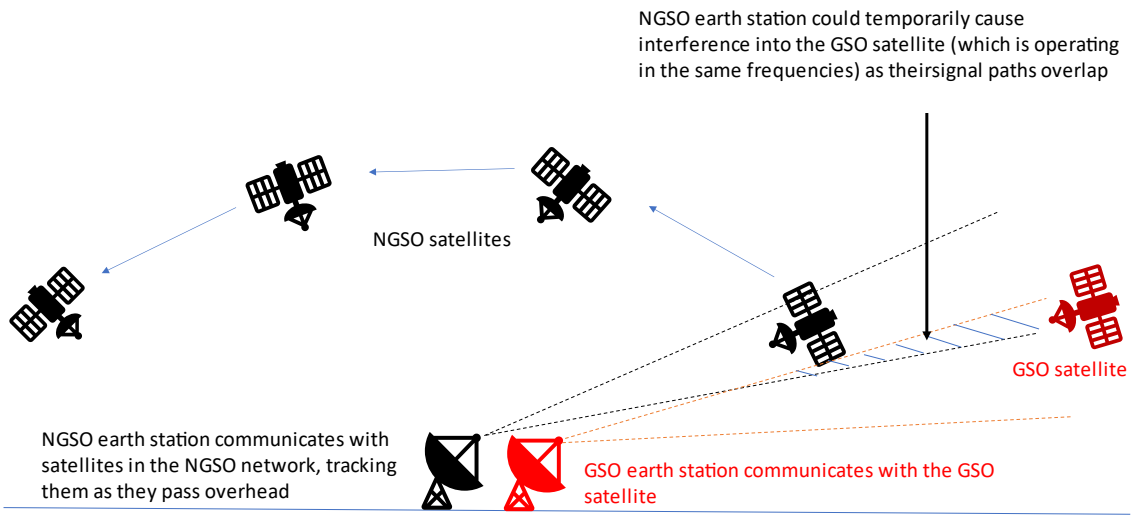
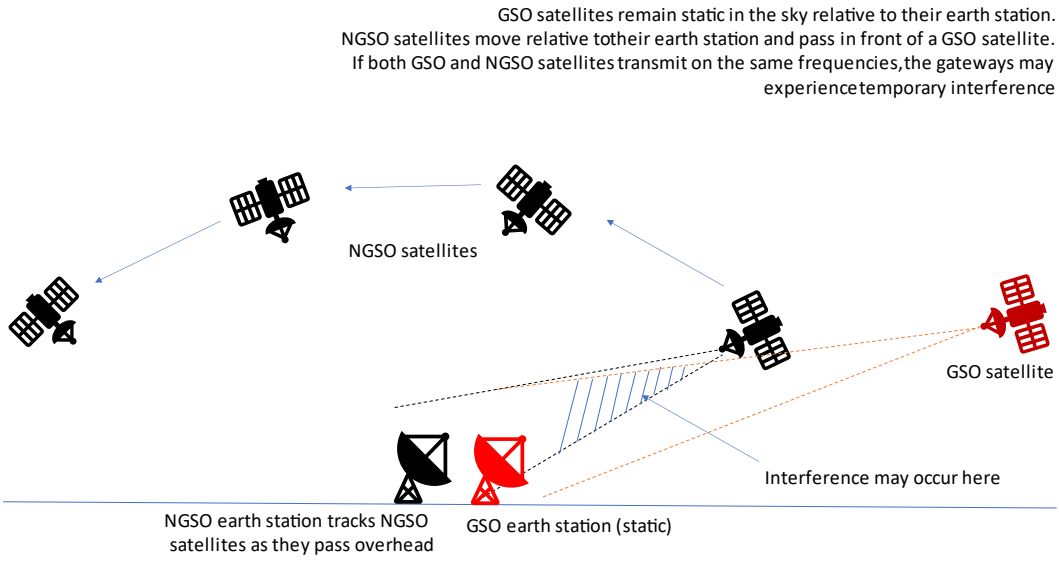


Figure 5: Demonstration of interference from NGSO services into a GSO network in the downlink



6.5 In the NGSO uplink scenario, Ofcom is responsible for licensing NGSO earth stations to transmit in the UK and for managing associated interference issues (see figure 6).

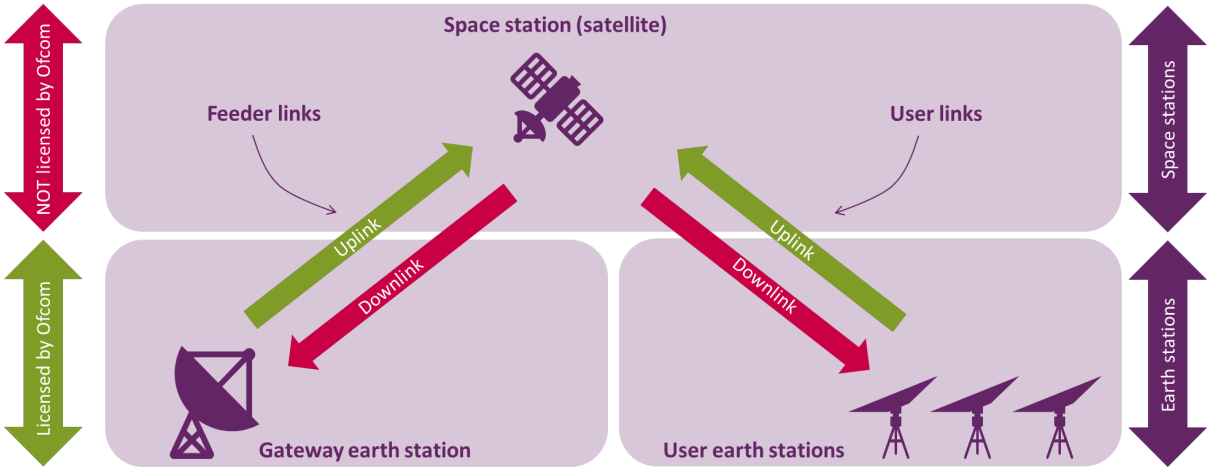
6.6 In the NGSO downlink interference scenario, GSO earth stations could experience two forms of interference from NGSO networks:

a) Single entry interference: interference caused by satellites from one NGSO network;

b) Aggregate interference: interference caused by the combined signals of satellites from multiple NGSO systems, all operating in the same frequencies as the GSO earth station.

6.7 Ofcom does not license signals transmitted by a space station (satellite) into the UK. Interference in the downlink scenario is managed through international rules on coexistence as described in the next subsection below.

Figure 6: Description of a typical satellite service and the regulations that govern their use



International rules on coexistence between NGSO systems and GSO networks

6.8 The way NGSO systems and GSO networks coexist is primarily managed through the ITU Radio Regulations. The Radio Regulations are part of an international treaty that is binding to ITU Member States (including the UK), "who shall operate their radio stations so that they do not cause harmful interference to the radio services of other Member States operating in accordance with the provisions of this treaty".

6.9 Unless there is another specific agreement in place, the UK in its authorisation and spectrum management processes will take into account (and if necessary, take steps to protect) stations of other national administrations[35], following the provisions of the Radio Regulations. Here, the term "station" can refer to a satellite in space or an earth station on the ground. In turn, we expect that other administrations will operate their stations in accordance with the Radio Regulations and protect UK stations accordingly. Article 15 of the ITU Radio Regulations sets out the process for resolving cases of harmful interference between member states.

6.10 The ITU Radio Regulations stipulate that, in most frequency bands, NGSO systems shall operate without causing harmful interference to, or claiming protection from, GSO networks (Article 22.2). The Radio Regulations also define a set of interference limits, called equivalent power-flux density (EPFD) limits, used to check whether NGSO systems meet this non-interference condition or not in certain bands.

6.11 These EPFD limits are defined in the Radio Regulations articles 22.5C (limits on Earth for emissions from NGSO satellites), 22.5D (limits on the geostationary orbit for emissions

[35] The ITU Radio Regulations define an administration as "any governmental department or service responsible for discharging the obligations undertaken in the Constitution of the International Telecommunications Union, in the Convention of the International Telecommunications Union and in the Administrative Regulations."

from NGSO earth stations) and 22.5F (limits on the geostationary orbit for emissions from NGSO satellites).

6.12 Upon reception of a new satellite filing, the Radiocommunications Bureau runs a calculation to see if the proposed new system would conform with the stated limits. Further, tables 22-4A, 22-4A1 and 22-4B in the Radio Regulations contain additional limits that must be met when measured at any operational GSO fixed-satellite service earth station. A NGSO system that complies with all these limits is deemed to be not causing unacceptable interference to GSO networks (see Article 22.5I). In the event that the ITU Radiocommunications Bureau concludes that the limits are exceeded, the filing will receive an unfavourable finding and will not have full international recognition for the use of its orbits and frequency bands.

6.13 The Radio Regulations also set limits on the aggregate interference caused by all co-frequency NGSO systems into GSO networks in Article 22.5K and Resolution 76. This resolution states that, "in the event that aggregate interference exceeds the prescribed limits, administrations operating NGSO systems shall take all necessary measures expeditiously to reduce the aggregate interference levels".

6.14 Article 22.2 does not apply in the bands at 18.8-19.3 GHz (space-to-Earth) and 28.6-29.1 GHz (Earth-to-space), which are subject to Article 5.523A of the Radio Regulations instead. GSO networks and NGSO systems in those bands have to coordinate their use of the spectrum on a first-come, first-served basis, based on the date of their ITU filings, and later systems will be expected to take into account earlier systems regardless of their type.

6.15 It is reasonable for us to expect that NGSO satellite operators will comply with the Radio Regulations and protect GSO networks according to the relevant provisions. The administration which holds the filing(s) for a specific NGSO system is ultimately responsible to ensure such compliance.

6.16 Ofcom acts as the UK notifying administration under ITU procedures in relation to international management of the radio spectrum and orbit resources. Accordingly, it is responsible for ensuring that these filings (and the satellite networks operating under these filings) comply with the ITU's Radio Regulations. This covers the submission of satellite filings on behalf of companies registered in the UK, British Overseas Territories, the Channel Islands and the Isle of Man.

6.17 Ofcom is not the notifying administration responsible for the satellite filings under which Starlink's system shall operate.

What our licensing framework requires

6.18 In our NGSO licensing statement[36] we said that at this time we did not think that there was a material risk to GSO networks, given the existing international regulations as set out in paragraphs 6.7 to 6.14. Therefore, our process for considering NGSO licence applications focused on requiring applicants to demonstrate that they can coexist with other NGSO systems.

[36] Paragraph A2.6 in the annexes to our NGSO statement.

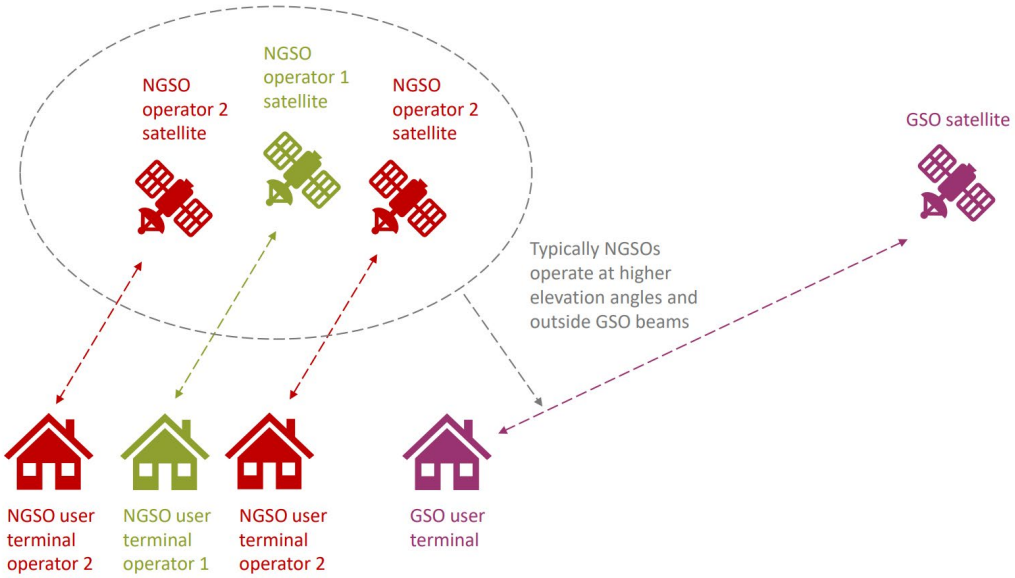
6.19 It is a requirement of our licence conditions that all satellite operators operating in the UK under this licence must comply with the relevant sections in the ITU Radio Regulations, including the provisions relating to GSO networks as detailed above.

NGSO systems can use mitigation techniques to coexist with GSO networks

6.20 We consider that NGSO systems have a range of mitigation techniques at their disposal that allow them to provide services while meeting the above conditions to protect GSO networks; examples are the use of a suitable GSO arc avoidance angle, or the selective reduction of transmit power at certain times.

6.21 Given the static positioning of GSO satellites, protecting GSO networks is typically easier than protecting another NGSO system. For example, for a non-GSO system serving the UK, the elevation angle of earth stations will often be higher than the elevation angle of the GSO arc, as shown in Figure 6. When this is the case, NGSO earth stations will radiate most of their power away from the GSO arc.

Figure 7: Angular Avoidance between GSO and NGSO



6.22 There are bands where Article 22.2 does not apply, as explained in para 6.13 above. In practice, the same technical measures used by NGSO systems to protect GSO networks in other bands would be available and could be used to support coordination in the 18.8-19.3 GHz and 28.6-29.1 GHz bands. Thus, we do not foresee major difficulties in achieving coexistence in the bands.

Consultation concerns on interference into GSO networks

6.23 While our process for considering NGSO licence applications only requires applicants to demonstrate that they can coexist with other NGSO systems, we have considered the consultation responses received on the potential risk of NGSO systems causing interference into GSO networks. We have also further reviewed SpaceX's capabilities to

coexist with GSO networks, including the capability of their satellites to protect GSO earth stations providing services to the UK.

Consultation responses

6.24 Viasat and one confidential respondent expressed concern about the potential for NGSO interference into GSO networks and the subsequent impact on quality of service. They considered that the interference generated by SpaceX's system would likely exceed certain limits stated in Article 22 of the ITU Radio Regulations and breach the international requirement for them to operate without causing harmful interference to, or claim protection from, GSO networks Article 22.2 of the Radio Regulations. They asserted that SpaceX had not provided sufficient technical analysis to suggest otherwise, and that Ofcom had not set out how it would monitor and act upon such interference.

6.25 According to Viasat, the Starlink system would exceed both "single-entry" and "aggregate" EPFD limits in the Radio Regulations in the UK, including at all six proposed gateway earth station locations, and would consume more than an equitable share of the aggregate amount of interference that all NGSO systems (combined together) may generate into GSO networks.

6.26 Viasat argued that this exceedance of the limits was not immediately obvious because of the way in which the ITU assesses expected EPFD levels from NGSO operators. Viasat also considered that the ITU had no way to effectively check the ability of a system operator to try to "game" the system, by contriving EPFD inputs in a way designed to "pass" the ITU's spot checks regarding EPFD without reflecting how the NGSO system actually would operate.

6.27 Viasat also considered that, unless Starlink's communication links were angularly separated from the GSO arc by a sufficient amount, they could easily degrade service levels and cause capacity losses to the GSO networks with which Starlink seeks to compete, including those that serve UK and Europe. Viasat believed angular separation to be a relatively simple operational technique in which the NGSO satellites would avoid operating within a suitable angular separation around the GSO arc.

6.28 Viasat proposed a number of further conditions for the licence, should it be granted. For example, Viasat requested that either SpaceX or Ofcom calculate the minimum GSO arc avoidance angle that would ensure that the Starlink system would protect GSO networks serving the UK and Europe from interference. Viasat also requested that Ofcom make any authorisation it may grant subject to the condition that "SpaceX not use more than one satellite beam from any of its satellites in the same frequency in the same or overlapping areas at a time", a condition which they mentioned applies to Starlink's FCC-authorised earth station operations.

Ofcom assessment of concerns about the potential for NGSO interference into GSO networks

6.29 We have considered the different potential scenarios in which an NGSO system might cause interference to a GSO network, followed by what action we or others could take in the event of each scenario arising or being suspected.

Protection of GSO networks from uplink interference

6.30 The NGSO Gateway licence contains provisions for the protection of GSO satellite services using the same frequencies. Specifically, condition 3.1 (d) states:

> *"earth stations operating with non-geostationary satellites shall ensure compliance with the equivalent power flux-density limitations specified in Article 22 of the ITU Radio Regulations"*[37]*;*

6.31 Additionally, we have sought additional information from SpaceX on its capabilities to meet the relevant limits in Article 22. It has stated that: *"Compliance with the uplink* EPFD *limits of No. 22.5D is assured by the following two means, which are employed simultaneously: 1. All uplink spot beams on each satellite are independently steerable. 2. The maximum transmit carrier power and power spectral density levels will only be used for uplink beams from gateway earth stations that are angled sufficiently away from the geostationary orbit (GSO) such that the angular separation between the main beam of a transmitting gateway earth station antenna in the system and the GSO arc provides the required attenuation of the Earth-to-space transmissions towards any GSO satellite. For transmitting gateway earth stations uplink beams pointed closer to the GSO arc, for which the maximum transmit carrier power and power spectral density levels would cause an exceedance of the uplink* EPFD *limits in Article 22, the levels are correspondingly reduced such that the system fully meets the corresponding uplink* EPFD *limits."*

6.32 We are therefore satisfied that Starlink is capable of meeting the Article 22 limits in the Earth-to-space (uplink) direction.

6.33 At this point we do not think it would be proportionate to add more specific technical conditions to the licence, such as imposing a specific angle avoidance or a maximum number of co-frequency beams that licensees should comply with, beyond the obligation to meet the relevant limits in Article 22. Doing so would be a significant departure from the way we usually licence space systems; for example, when licensing GSO earth stations we do not impose specific technical conditions to ensure the protection of other co-frequency satellites.

[37] The use of the word "earth stations" means this relates to transmissions from NGSO gateway connecting to satellites in space.

Enforcement in the event of harmful uplink interference

6.34 In the scenario of a NGSO system causing uplink interference to a GSO network, the interference would arise from transmitting earth stations. Ofcom is responsible for licensing NGSO earth stations to transmit in the UK and for managing associated interference issues.

6.35 In the event of suspected interference from UK-licensed NGSO Earth Station(s) into space stations, this can be raised through the space station's responsible administration.

6.36 Should we receive a report of suspected harmful interference being caused to a GSO satellite receiver by a UK licensed earth station, we would use our investigation and enforcement powers and, if needed, instruct the licensee to mitigate or remove the interference. [38]

Protection of GSO networks from (single entry) downlink interference

6.37 The presence of Starlink gateway earth stations in the UK results in SpaceX needing to place a downlink beam (that is, to transmit signals from their satellites towards the earth) in Ka band in the gateway earth station area. As a consequence, the licensing of additional gateway earth station equipment would be expected to result in additional downlink emissions in the area. In the technical annex to their response, Viasat has claimed such emissions could exceed the limits permitted by the Radio Regulations for interference to GSO networks in parts of the UK.

6.38 We are aware of some concerns with respect the accuracy of the current version of the ITU examination software[39], and whether some limits could be exceeded in specific locations even if the non-GSO system were to be operated as declared to the ITU. We recognise the importance of ensuring the ITU examination process achieves accurate results, and we intend to play an active role in discussions of this matter in the ITU, for example in ITU Working Party 4A.

6.39 We have reviewed the information presented in Viasat's technical annex and have sought further information on this point from SpaceX. In their response, SpaceX has stated that: *"The maximum transmit carrier power and power spectral density levels will only be used for space station downlink beams that are angled sufficiently away from the boresight of GSO receiving earth stations such that the angular separation, as viewed from a GSO receiving earth station located at the beam center, between the direction towards the space station and the direction towards the GSO arc, provides the required attenuation of the space-to-Earth transmissions. For space station downlink beams that are angled closer to the boresight of GSO receiving earth stations, where the maximum transmit carrier power and power spectral density levels would cause an exceedance of the downlink* EPFD

[38] In considering the appropriate course of action, we would take into account a number of factors including the extent and impact of the interference and the international regulatory framework that would apply in the circumstances.
[39] This software is used by the ITU Radiocommunications Bureau to examine NGSO filing and determine if they comply with the relevant limits in Article 22.

limits of in Article 22, the levels are correspondingly reduced such that the system fully meets the corresponding downlink EPFD *limits."*

6.40 As a consequence, we are satisfied that SpaceX is capable of meeting the Article 22 limits in the space-to-Earth direction.

Enforcement in the event of harmful (single-entry) downlink interference

6.41 In a NGSO downlink single entry interference scenario, a GSO earth station would experience interference caused by satellites from one NGSO network.

6.42 It is reasonable for us to expect that SpaceX will comply with the relevant Article 22 limits and protect GSO networks according to the relevant provisions; as we indicated above, the national administration responsible for a NGSO system is ultimately responsible to ensure such compliance.

6.43 Ofcom operates a Spectrum Monitoring Centre to investigate interference issues. Issues of harmful interference to UK licensed earth stations can be raised directly to the Centre by the GSO operator or its responsible administration. Upon receiving a report we will use our investigation powers and, if needed, reach out to the relevant filing administration in order to have the interference removed.

6.44 In the interests of proportionality, we would normally use our investigation powers in the event of material and recurring degradation to the victim's service, and that is not necessarily the same as one of the limits in Article 22 being breached.

6.45 It is worth noting that the ITU Radio Regulations set out the rules governing how spectrum should be managed between member states. National administrations are responsible for the management of spectrum within their own borders. Thus, the limits in the space-to-Earth direction as set out in the Radio Regulations apply unless a national administration decides to less stringent limits in their territory. In the strictest sense, it is therefore for Ofcom to decide whether less stringent limits would be acceptable in the UK and act accordingly.

6.46 In our space spectrum strategy, we state that we consider the existing approach to protecting GSO earth stations from harmful interference to be sufficient. However, we will also consider whether introducing a new licence condition (into the NGSO Earth Station Network Licence) in relation to the downlink would enable us to enforce more quickly and directly against a UK NGSO licensee (under the new licence condition) if there was harmful interference to GSO receivers in the UK. This could give Ofcom added enforcement options beyond reaching out to the administration responsible for the system causing the interference.

Protection of GSO networks from aggregate downlink interference

6.47 In their response, Viasat raised concerns that SpaceX alone would exceed the aggregate EPFD limits in Resolution 76 (see paragraph 6.24-6.25). It also raised concerns that SpaceX planned to operate various elements of its integrated Starlink system under a variety of ITU filings, and that the overall contribution of these parts could exceed the existing permissible limits.

6.48 As explained in paragraph 6.39 we have sought further information from SpaceX and we are satisfied they can meet the single-entry limits in the Radio Regulations, and therefore also the aggregate limits. We expect SpaceX to meet such limits regardless of the number of filings under which they operate their system, which should ensure that they consume only an equitable share of the aggregate amount of interference that all co-frequency NGSO systems may generate.

Enforcement in the event of harmful (aggregate) downlink interference

6.49 In a NGSO downlink aggregate interference scenario, a GSO earth station would experience interference caused by the combined signals of satellites from multiple NGSO systems, all operating in the same frequencies as the GSO earth station.

6.50 As with the single-entry limits, should we receive reports from a GSO operator that they are experiencing harmful interference (as a consequence of the aggregate interference limits being breached), we would use our investigation powers and, if needed, reach out to the responsible administrations in order to have such interference removed in accordance with Resolution 76.

Monitoring and enforcement of interference from NGSO systems

6.51 A respondent queried how Ofcom would monitor possible interference from NGSO systems into GSO networks.

6.52 We have explained above in paragraphs 6.35-6.36, 6.42-6.46 and 6.50 the mechanisms available should any satellite operator suspect harmful interference from an NGSO system. If interference from any NGSO system is suspected, UK licensed operators should contact our Spectrum Monitoring Centre. At that stage we would expect victim operators to provide evidence of the degradation they have experienced.

6.53 Our approach to handling interference will depend on the type of interference scenario:

a) In the case of suspected interference arising from NGSO satellites to a GSO receiving earth station, we will seek evidence of harmful interference from measurements conducted at the victim earth stations (i.e. at the user or operator's site), and we may also use our satellite monitoring facility at Baldock.

b) In the case of suspected NGSO interference to a GSO satellite receiver we would rely on evidence of harmful interference provided by the victim satellite operator, as monitoring stations on the ground cannot measure interference to satellite receivers.

6.54 We are taking steps to further develop the UK's capabilities to detect and handle NGSO interference to GSO receiving earth stations. At our Baldock monitoring station we are developing methodologies and processes to collect evidence of harmful interference to satellite receivers, in close collaboration with NGSO and GSO operators. These methodologies will be used to support investigations when required.

Conclusion regarding potential impacts on GSO networks

6.55 Whilst our process for considering NGSO licence applications only requires applicants to demonstrate that they can coexist with other NGSO systems, we have considered the consultation responses which raised concerns over the potential for NGSO interference into GSO networks and the subsequent impact on quality of service. We have further reviewed SpaceX's capabilities to coexist with GSO networks, including the capability of their satellites to protect GSO earth stations providing services to the UK.

6.56 We recognise that the licensing of additional gateway earth station equipment for six sites would be expected to result in additional emissions in those areas. Nonetheless, in view of the information provided in the initial applications, and in response to our subsequent request for further information, we are satisfied that Starlink is capable of meeting the Article 22 limits for both uplinks and downlinks.

6.57 There is an existing framework to protect GSO networks from harmful interference from NGSO systems, should they arise. At an international level, all satellite operators must comply with Article 22 in the ITU Radio Regulations which mandates that NGSO systems shall not cause interference to, or claim protection from, GSO networks. This applies to both satellites and Earth Stations.

6.58 Further, in the UK our NGSO gateway licence explicitly requires the operator to comply with Article 22 when transmitting in the UK. In the event of suspected harmful interference from a NGSO system, there are a number of options available to Ofcom and GSO operators to take action in relation to these provisions.

6.59 We will continue to support the principles of the current ITU framework for NGSO systems, including the need for later filed systems to seek agreement from earlier filed systems, and the obligation for all operators to negotiate coordination in good faith. Further, we will work within international bodies to promote improvements to the international framework for NGSO systems.

6.60 In view of the above our conclusion is that it is unlikely that a decision to grant a licence for six additional gateway earth stations would result in harmful interference to GSO networks.[40] However, in the event that this were to occur we would look to take action to address this.

[40] In reaching this conclusion we have also taken account of our assessment in paragraph 5.35 that the link between granting six UK gateway licences and SpaceX's planned incremental launches is unlikely to be strong.

7. Concerns regarding the potential impact of NGSOs on the space environment

Consultation responses regarding the potential impact of NGSOs on the space environment

7.1 Respondents raised a number of concerns centred on the risk of collisions in space; space debris; and the impact of releasing large amounts of vaporised aluminium into the atmosphere.

7.2 One respondent questioned the efficacy of SpaceX's auto-manoeuvre procedure for avoiding collisions, arguing that it might not prove effective at scale, particularly if SpaceX proceed with the launch of their 30,000 satellite second generation network. It claimed the SpaceX collision avoidance algorithm has not been peer-reviewed and is not in the public domain.

7.3 Respondents also expressed concern about the amount of space debris that the Starlink constellation could create through defunct satellites. Concerns were raised that naturally deorbiting satellites could pose a risk to human life because they might interfere with human missions. Viasat warned of the risk of the Kessler syndrome, where too many collisions lead to a belt of debris around the Earth which becomes self-sustaining, which would make certain orbits unusable for critical civil, military and commercial space services.

7.4 Several respondents also highlighted uncertainty surrounding the impact of the amount of aluminium vaporised into the atmosphere by SpaceX's generation 2 satellites. It was claimed that damage could be caused to the chemistry of the upper atmosphere and that light pollution could obscure optical astronomy. Respondents requested that more research be carried out before the launch of these additional satellites.

Our assessment of responses on space environment

7.5 In the UK, policy on safe and sustainable use of space is determined by UK Space Agency and the Department for Business Energy and Industrial Strategy. Further, the UK regulator with responsibility for issues concerning the safety of space, including space launch and space debris is the Civil Aviation Authority, as outlined in the Space Industry Act 2018. As outlined in section 2, our duties and powers come from separate legislation.

7.6 As discussed in section 5, we assess that granting UK NGSO gateway licences is unlikely to influence or impact the number of satellites that SpaceX puts into space. Starlink is a global system serving a global market.

7.7 We recognise the role spectrum will play in enabling safe and sustainable use of space. We will consider appropriate access to spectrum for radars to track the movements of objects in space. We will also seek to understand whether changes to international spectrum allocations are needed to support in-orbit servicing and other safe space initiatives.

7.8 We have shared the concerns raised in the consultation with our responsible counterparts in the CAA and the UK Space Agency for their consideration.

Conclusion on issues regarding space environment

7.9 We recognise the importance of safe and sustainable use of space. However, we assess that granting six additional UK gateway licences is unlikely to influence or impact the number of satellites that SpaceX puts into space.

8. Summary and next steps

Decision

How we decide whether to grant a licence

8.1 In our NGSO statement we set out how we would decide whether to grant a licence. In this, we referred to our statutory duties, with our principal duty being to further the interests of citizens and consumers in relation to communications matters. In accordance with these statutory duties, when deciding whether to grant a licence we said that we would be mindful that our objective is to enable citizen and consumer benefits arising from innovative satellite services, such as improved connectivity, and would take all relevant factors into account including in particular:

- (in the case of NGSO gateway licence applications) the availability of gateway earth station sites within the UK;
- any risks to competition for UK consumers; and
- the ability of networks to coexist in terms of radio interference management.

8.2 We confirmed that in reaching our decision we would thus take account of both our technical check, our competition check, and our statutory duties and objectives. In achieving our aim, we would also take account of the available relevant evidence, including responses to the Invitation to Comment.

Our decision

8.3 **We have decided to grant six NGSO gateway licences to Starlink Internet Services Limited** in light of the evidence presented by SpaceX, stakeholder responses and the reasoning set out in this document on the risks and benefits to citizens and consumers of granting these licences.

8.4 This will authorise Starlink/SpaceX to operate six additional gateway earth stations in the UK, expanding the capacity of its existing satellite service and improving connectivity for UK citizens and consumers.

Next steps

8.5 On payment of the appropriate licence fee, we will issue the six licences to Starlink Internet Services.

8.6 A copy of the licences will also be made available under the “Existing licences” section of our website.

A1. Satellite (Non-geostationary Earth Station) Licence

Wireless Telegraphy Act 2006

Satellite (Non-Geostationary Earth Station)

Sector/class/product	
Licence number	
Licensee	
Licensee address	
Licence first issue date	
Licence version date	
Payment interval	

1. This Licence is issued by the Office of Communications ("Ofcom") on **<Date>** and replaces any previous authority granted in respect of the service subject to this Licence by Ofcom or by the Secretary of State.

2. This Licence authorises **COMPANY** ("the Licensee") to establish, install and/or use radio transmitting and/or receiving stations and/or radio apparatus as described in the schedule(s) (hereinafter together called "the radio equipment") subject to the terms set out below and subject to the terms of the General Licence Conditions booklet (Version OfW 597).

ISSUED BY OFCOM

Satellite (Non-Geostationary Earth Station)

SCHEDULE 1 TO LICENCE NUMBER XXXXXXX

TERMS, PROVISIONS AND LIMITATIONS COVERED BY THIS LICENCE

This schedule forms part of Licence **XXXXXXX**, issued to **COMPANY** the Licensee on **<Date>**, and describes the terms and equipment specifications covered by this Licence.

1. The Licensee may establish and use:

1.1. A permanent sending and receiving earth station ("the station") at the location specified in the attached schedule for the purpose of providing wireless telegraphy links between the station and non-geostationary satellite(s).

2. Limitations on use

2.1. The stations shall use only:

a) the classes of emission specified in the emission code column of the attached schedule;

b) the frequencies specified in the transmit frequency and receive frequency columns of the schedule;

c) a power not exceeding that specified in the antenna I/P power column of the schedule;

d) the antenna type specified in the antenna type column of the schedule;

e) a power density not exceeding that specified in the spectral power density column of the schedule; and

f) the station shall be operated only from the location specified on the schedule.

3. Apparatus

3.1. The Licensee shall ensure that:

a) the wireless telegraphy apparatus comprised in the station(s) (“the apparatus”) is so designed constructed, maintained and operated, that it does not cause any undue interference to other users of the spectrum;

b) the apparatus complies with (and is maintained in accordance with) the relevant performance specification(s) published by the operator of the satellite;

c) the earth station antenna shall not be employed for transmission at elevation of less than 3 degrees measured from the horizontal plane to the direction of maximum radiation as specified in Article 21.14 of the ITU Radio Regulations;

d) the earth stations operating with non-geostationary satellites shall ensure compliance with the equivalent power flux-density limitations specified in Article 22 of the ITU Radio Regulations;

e) the component of effective isotropic radiated power directed towards the horizon and the minimum elevation angle above the horizontal must comply with ITU Radio Regulations and not exceed those limits specified in Articles 21.8-21.15 of the ITU Radio Regulations;

f) in the band 13.75-14 GHz, earth stations with an antenna diameter of less than 4.5 m operate in compliance with the pfd limits in ITU Radio Regulations 5.502, that the e.i.r.p. of any emission from an earth station in the fixed satellite service does not exceed 85 dBW and that the e.i.r.p. density of emissions in the band 13.77-13.78 GHz complies with ITU Radio Regulations RR 5.503;

g) use of the band 29.1-29.5 GHz shall be in compliance with ITU Radio Regulations 5.535A;

h) the apparatus used for transmission complies with the Radio Equipment Directive (Directive 2014/53/EU) and all appropriate National Interface Requirements (IR) for satellite earth stations in force within the UK; and

i) the antenna radiation pattern envelope meets the minimum performance specified by the operator of the satellite.

3.2. Where appropriate, Ofcom may require that the Licensee provide additional screening at the installation as a condition of the Licence.

4. National and international obligations

a) the earth station must undergo national coordination and site clearance for operation at the specified location;

b) the relevant satellite data shall have been submitted to ITU in accordance with established ITU procedures;

c) all transmissions in the fixed-satellite service must be terminated prior to any change of location; unless operating under a specific exemption authorised by Ofcom;

d) the Licensee shall comply with any notice given by Ofcom under section 9A of the Wireless Telegraphy Act 2006 requiring the Licensee to cease or suspend the uplinking by means of the licensed apparatus of any service specified in such notice by such date as may be specified.

e) the Licensee shall provide such information as Ofcom may request by notice in writing for the purpose of determining whether section 9A of the Wireless Telegraphy Act 2006 applies in relation to a service for which the Licensee provides uplink facilities using the licensed apparatus or for any purpose connected with the giving of a notice by Ofcom under section 9A of the Act.

5. Additional conditions

5.1. The radio frequencies authorised by this Licence must be used in common with other non-GSO satellite systems authorised under wireless telegraphy licences granted by Ofcom. The names of these licensees shall be notified by Ofcom to the Licensee from time to time, and together with the Licensee are described as the “NGSO Licensees”.

5.2. The radio frequencies authorised by this Licence must only be used to communicate with a satellite system which has transmissions authorised under a Satellite (Earth Station Network) wireless telegraphy licence granted by Ofcom.

5.3. In the event that –

a) one (or more than one) of the NGSO Licensees suffers a material and recurring (or ongoing) degradation of services to its users at a specific region or location in the United Kingdom; and

b) the degradation of services is resulting from radio transmissions from the earth stations operated by the Licensee;

Ofcom may by notice instruct the Licensee to cease or change the use of particular equipment or particular radio frequencies which are authorised under this Licence.

5.4. Any such cessation or change must be for the purposes of ensuring that such interference is avoided and the degradation of services to users at the particular regions or locations is resolved.

5.5. Following receipt of such notice, for such period of time as may be specified in the notice, the Licensee may only operate in accordance with the terms and conditions of the notice.

5.6. The Licensee must establish, install and use the radio equipment to commence regular wireless telegraphy transmissions in accordance with the provisions of this Licence within twelve months of the date that this Licence is issued, and maintain such transmissions thereafter.

6. Interpretation

6.1. In this and subsequent schedule(s):

a) “earth station” means a radio transmitter located on the surface of the earth and intended for communication with one or more satellites;

b) “non-geostationary satellite” means a satellite that does not remain fixed relative to a position on the surface of the earth; and

c) “uplink” and any cognate expression refers to a transmission in the earth-to-space direction

Notes

1. This Licence does not remove any other obligations that the Licensee may have in relation to satellite filings made under the ITU Radio Regulations.

2. This Licence does not affect the requirement, where necessary, to obtain licences or authorisations under other Acts. Some satellite television or radio broadcasting services also require licences under the Broadcasting Act 1990, and some installations require local authority planning approval.

3. Advice can be sought from Ofcom using the contact details on page 1 of this Licence and the appropriate local authority planning department.

4. The Licensee must apply for a variation of the Licence from Ofcom before making any changes which may contravene the Licence.
5. Technical terms used in clause 2 shall have the meanings assigned to them in the ITU Radio Regulations.

SCHEDULE 2

Licence No		Licence version date	<Date>	Payment Interval	1 year

Licensing Centre Point	

Earth Station Deployment	Earth Station Name	Earth Station NGR	

			Transmit		Receive		
Antenna Centre Height AGL (m)	Antenna Type	Dish Size	Tx Gain (dBi)	Tx Beamwidth (deg)	Rx Gain (dBi)	Rx Beamwidth (deg)	System Noise Temperature (K)

Satellite Name	ES Azimuth from (deg)	ES Azimuth to (deg)	ES minimum Elevation (deg)	ES maximum Elevation (deg)

Transmit Frequency	Receive Frequency	Associated Authorised Bandwidth (MHz)	Associated Emissions

Emission reference code	Emission Type	Emission Code	Polarisation	Antenna I/P Power (dBW)	Spectral Power Dens (dBW/Hz)
