D1 Coexistence with existing systems

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

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

SpaceX Response

Starlink commercial broadband service is live in over 30 markets and is providing consumers around the world with reliable, high-speed, low-latency broadband Internet access. Starlink connects people and businesses wherever they may be, including in unserved and underserved areas traditionally left on the wrong side of the digital divide. Since launching in the UK, Starlink has connected thousands of customers and invested millions of pounds into the UK economy to develop and support our ground stations.

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.

SpaceX's Starlink system can coexist with other non-geostationary satellite gateways in close proximity by leveraging several important design and operational techniques. These techniques, which SpaceX views as fundamental to responsible non-geostationary operations, include:

- directional antennas designed to maximize transmissions towards the SpaceX satellite system and minimize power directed elsewhere;
- multiple beams with very narrow transmit and receive beam widths;
- steerable beams on satellites, which can point in a different direction in advance of an in-line event to avoid interference;
- multiple satellites in view to provide options to serve users while avoiding in-line events;
- the ability to dynamically split spectrum (cease transmitting on certain channels) in the case of in-line events;
- low gateway height above ground level (less than two meters above ground level), to make use of shielding fences and other physical obstructions ("ground clutter") to protect adjacent users from interference

With regard to coexistence with NGSO systems already filed or licensed in the UK, SpaceX's coordination discussions are ongoing and affirm the benefits of the responsible spectrum sharing techniques described above. SpaceX is committed to its ongoing, good faith coordination with the two existing NGSO network earth station licenses, Network Access Associates Ltd and Kepler Communications Inc. Based on our understanding, neither of those systems will operate user terminals in the Ka band, so our discussions for this spectrum have centered around gateway earth stations.

D2 Coexistence with future systems

State what flexibility your Gateways have to coexist with future non-geostationary satellite systems. You should include measures you would be able to put in place if another non-geostationary satellite system were to enter the market in the future, and the expected benefits of such measures. Also state what measures future non-geostationary satellite systems could reasonably be expected to put in place to coexist with your Gateways.

SpaceX Response

SpaceX has designed its Starlink system in anticipation of a vibrant, competitive space landscape and implements important threshold technologies and techniques to promote coexistence. 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. SpaceX would encourage new operators—and operators in the midst of deploying their satellite networks—to employ technologies and techniques that use spectrum efficiently, including but not limited to those mentioned in the response to Question D1 above, and to negotiate in good faith to timely resolve coordination discussions.

While Starlink has been designed in a flexible manner, SpaceX expects other systems to employ spectrum management techniques such that they bear equal responsibility and burden for managing interference. One system should not suffer because another is designed or operated inflexibly. This is why coordination between operators continues to be the preferred approach for managing coexistence. In the event that is approach fails, there should be regulatory certainty and a well-defined process to ensure constructive cooperation.

SpaceX urges Ofcom to proceed with skepticism in instances where an operator has not employed responsible spectrum sharing technologies and techniques. Caution should be exercised for systems that are authorized, but not fully defined, and for systems that can only operate with massive keep-out zones between gateway sites

D4 Competitive Impact
Explain the impact of issuing you a licence (combined with other non-geostationary satellite system licences held or applied for by you) in terms of: • Any risks to competition in the UK. This may refer to

the ability to coexist with other nongeostationary satellite systems. • Benefits for UK customers, end consumers and/or citizens.

SpaceX Response

In order to provide broadband service, Starlink satellites must connect with gateway earth stations that are connected to the Internet. The 53-degree inclination orbit occupied by most Starlink satellites means that there are a larger number of satellites above the UK in comparison to other latitude bands.

A Starlink gateway site is comprised of eight or more parabolic antennas, each of which tracks a satellite across the sky and delivers data between the satellite and the internet point of presence. Our plans for gateway earth stations are based on a number of factors, including the number of satellites that are in view of the UK – both now and as the system grows, user throughput demand and fiber capacity at each site.

To date, SpaceX has launched over 2,000 of the 4,400 satellites in this first-generation constellation. As more satellites are launched and more users are added, our ground systems will require more gateway antennas and fiber bandwidth than SpaceX has at its existing sites. Additionally, SpaceX plans its gateway earth stations for weather diversity. This means that SpaceX requires a sufficient variety of locations such that if one site is experiencing connection problems due to weather, other sites can provide back-up. For example, during Storm Eunice, Starlink was able to provide service throughout the UK despite record-breaking weather conditions. We attribute Starlink's resiliency during the storm to the geographic diversity SpaceX has at other gateway sites in the region. This ensured that whenever the weather was the worst in one area, there was another site that was available. Additionally, in the rare event that a gateway site is taken down due a power or fiber outage, multiple gateway sites are able to serve as a redundancy to ensure that SpaceX can continue to provide quality service to customers in the UK and throughout Europe. SpaceX estimates that with additional gateway sites we will be able to meet demand, and make available the weather diversity and network resiliency needed to provide high-speed, low-latency Starlink service to consumers in the UK.

As noted in response to question D2, SpaceX does not require any specific geographic separation between its gateway earth stations and those of other co-frequency systems, but rather undertakes coordination assessments based on the proposed locations and operating parameters of each system. Given our experience in coordinating with other co-frequency systems around the globe, we do not believe our proposed gateway earth stations will have a preclusive effect on other NGSO systems.

Starlink was developed to bring high-speed, low-latency internet service to rural and remote areas. In the latest quarterly report released by Ookla[1], Starlink service is rivaling – and in some cases exceeding – the speeds of fixed broadband. In Belgium, for example, Ookla reports that Starlink's median download speed of 155.15 Mbps was much faster than the fixed broadband speed of 76.94 Mbps. Starlink is already serving [redacted] users in the United Kingdom, with a waiting list that will be fulfilled when capacity (both gaining access to additional spectrum for user terminals and approval for gateway earth stations) supports it.

[1] https://www.ookla.com/articles/starlink-hughesnet-viasat-performance-q4-2021

Starlink operates principally as a direct-to-consumer service and in addition to standard commercial deployment, Starlink is able to provide emergency service to villages in Tonga after the recent volcanic eruption and tsunami and to the government and citizens of Ukraine during the recent attacks by Russia.