Your response

Question	Your response
Question 1: Do you have comments on the overall approach to the review?	SpaceX appreciates the opportunity to respond to Ofcom's Consultation on "Supporting the UK's wireless future – Our spectrum management strategy for the 2020s" ("Consultation"). SpaceX supports Ofcom's goals of promoting wireless innovation, licensing to fit local and national services, and especially Ofcom's goal to promote spectrum sharing. SpaceX is leveraging its accumulated expertise in space system manufacturing, design, and operations, to develop Starlink, a constellation of satellites designed to provide high-speed, low-latency, competitively priced broadband service to locations around the world where access to the Internet has been unreliable, expensive, or completely unavailable. The first Starlink constellation consists of over 4,400 non-geostationary orbit (NGSO) satellites employing advanced communications and space operations technology. To date, SpaceX has launched 20 times to deploy more than 1,100 Starlink satellites. Starlink is now the largest operational satellite constellation. Since 2018, SpaceX has invested hundreds of millions of dollars in Starlink and is currently building 120 satellites per month, along with thousands of end-user terminals. SpaceX is currently testing Starlink with select communities in Canada, the United States, and the United Kingdom to demonstrate connectivity and has delivered speeds greater than 100 Mbps at low latency. The company plans to use this constellation to provide a wide range of broadband and communications services for residential, commercial, institutional, governmental, and professional users worldwide. Starlink has been designed to make efficient use of radio spectrum resources by prioritizing the ability to flexibly share spectrum with other licensed satellite and terrestrial users. The system uses advanced beam-forming and

	digital processing technologies to ensure compliance with regulations. It relies on frequency ranges that are aligned with international spectrum allocations identified by the International Telecommunication Union (ITU) and national allocations. Starlink links to the customer user terminals in the Ku-band for both uplink and downlink frequencies, with gateway links in the Ka-band. Upcoming versions of Starlink will connect satellites in space using optical intersatellite links to allow the network to exchange data between satellites in orbit, instead of connecting to the ground and consuming spectrum resources. Once SpaceX has these space lasers working consistently throughout the network, Starlink expects to become one of the fastest options available to transfer data around the world. By using phased array technology in space and on the ground, and multiple satellites in view from any point on the ground, SpaceX's system ensures efficient use of spectrum to maximize frequency reuse, a key consideration in providing diverse options available to UK citizens, consumers, and businesses. A focus on technologically advanced antennas, technologies, and operations also ensure that Starlink has the flexibility necessary to coordinate with other terrestrial and space-based spectrum users, while still delivering robust service, even in a crowded spectrum setting. Ofcom has granted SpaceX access to portions of the Ku- and Ka- bands that are critical for fixed satellite service constellations such as Starlink to bring broadband services to the UK. The 10.7 – 12.7 and 14.0 – 14.5 GHz bands forms the basis for the transmissions between satellite links and the User Terminal antennae located at individual customer homes and businesses that are required to connect to the internet. At this stage, Ofcom has granted Starlink access to 14.0 -14.25 GHz. Ofcom has shared that there may be a path to accessing the 14.25 -14.5 GHz band in the near future. SpaceX encourages Ofcom to consider allowing NGSO operators like SpaceX full access to this internationally harmonized band.

	The 27.5-29.1 and 29.5-30 GHz bands form the basis for the transmissions needed for the gateway earth stations that complete the satellite links that connect consumers to the Internet backbone. Portions of these bands are also allocated to fixed terrestrial users. SpaceX encourages Ofcom to maintain its current regime allowing both technologies to reach commercial arrangements to maximize the utility of these bands. SpaceX appreciates Ofcom's recognition of the need for increased spectrum access for all users and encourages the adoption of policies that reward those who develop and use efficient technologies. By driving spectrum users to develop efficient technologies, more users can share the spectrum, increasing competition and providing more choices for consumers. Conceptually, policies like these use the carrot of greater spectrum availability to reward efficient users and the stick of higher costs for inefficiency. This drive for efficiency is critically important for NGSO satellite operations, which must exist in a shared spectrum environment. SpaceX agrees with the International Telecommunications Union and other regulators that private coordination between operators is the most efficient means 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. Towards that end, SpaceX suggests Ofcom consider rules that provide the proper incentives for successful coordination that relies on spectrally efficient technology. For example, Ofcom should consider adopting a default band-splitting model in the event operators have interference events before they complete coordination. Ideally, operators will never actually split spectrum. Instead, because band splitting is a suboptimal approach for spectrum sharing, this default rule will encourage operators to quickly coordinate to meet their mutual interest to avoid this outcome. To further set the best incentives,

	the policy should also allow the more spectrally efficient to select spectrum first during a split. Allowing first choice based on efficiency, will create a race to the top to build systems that are best equipped for sharing. This incentive arises because not all spectrum is fungible and the operator that chooses second could be left with more encumbered spectrum. But again, ideally this outcome never arises because this default rule of band-splitting with a preference for efficiency will drive all operators to coordinate effectively. Underlying such proposals is a straightforward principle: regulators should set aggressive performance metrics, and allow industry to compete to meet that metric. In this case, the metric is spectral efficiency. By driving industry to strive to find the best way to meet performance metrics like efficiency, these policies lead to more competition, ultimately serving consumers who accrue the benefits of more choices and lower costs. Given the rapid development of all wireless technologies—terrestrial and satellite—performance-based policies like the one described above will drive more competition than a tax-based system that risks deterring competition and becoming quickly outdated.
Question 2: Have we captured the major trends that are likely to impact spectrum management over the next ten years?	SpaceX applauds Ofcom's recognition of these key trends: ○ "Changing external context" ○ "Changing technology and net-work architectures" (including satellite broadband) ○ "Changing application de-mands" SpaceX's next-generation satellite constellation is poised to offer unprecedented satellite broadband service to UK customers as these trends emerge, in even the most remote corners of the country. The need for connectivity has never been starker, whether to support children doing homework, parents working from home, doctors providing

telehealth services, first responders coordinating activities to address emergencies, or any number of other important activities. While existing networks have stood up admirably during the COVID pandemic, the current crisis is laying bare the true cost for those stuck on the wrong side of the digital divide.

To address this surging demand, terrestrial providers are densifying their networks. While 4G networks required roughly ten times as many cells as 3G networks, 5G networks will require yet another tenfold increase. Wireless operators are planning to deploy thousands of cells across the country over the next several years, while wireline operators have deployed fiber to millions of residences and businesses that can both deliver services direct to customers and also support 5G expansion. Together, these investments will provide essential services to those living in urban, suburban, and even some rural areas. But they cannot bridge the gap in the near term for the millions of citizens who live in the most rural and remote areas. Without an infusion of new tactics and capabilities, reaching the rest of the population—and providing a choice to millions more who have limited options—could take years or even decades, assuming it is ever achieved.

Fortunately, dramatic improvements in launch services and satellite technology can help meet the growing need for innovation. This revolution in space has enabled satellite providers to plan systems for the first time at the scale necessary to meet not just current demand, but also future calls for truly high-speed, low-latency broadband even to underserved and unserved areas. Just as large deployments of new densified 5G networks are helping those in more urban environments, the densified satellite constellation SpaceX is deploying will substantially increase capacity and drive up the number of consumers even in rural and remote areas with access to truly robust broadband. While SpaceX's next-generation constellation will use only a small fraction of the number of antennas being deployed for terrestrial technologies, its spectrally efficient designs and intensive

	spectral reuse will allow it to bring to rural areas the type of services and prices previously reserved only for urban customers. By operating at low and very low altitudes, SpaceX will enable smaller spot beams and greater satellite diversity, achieving the intensive frequency reuse needed to heighten capacity available anywhere in the world. And by guaranteeing multiple satellites in view for every customer located at any point on the ground, SpaceX's system incorporates the flexibility necessary to coordinate with other spectrum users while still delivering robust service, even in a crowded spectrum setting. Extending true broadband connectivity to those on the wrong side of the digital divide—especially those in remote areas—will not be easy and necessitates innovative approaches and cutting-edge technologies that complement existing infrastructure. Terrestrial broadband providers are taking this on by deploying fiber to millions of locations and thousands of new densified 5G small cells to serve urban, suburban, and some rural areas. SpaceX is complementing these efforts by investing in a constellation that operates at the scale necessary to provide high-capacity, low-latency broadband service to reach even those in rural and other underserved areas. Critically, SpaceX will achieve this goal by making efficient use of spectrum that does not cause harmful interference to other licensees, ensures safety of the orbital environment, and preserves the wonder of the night sky.
Question 3: Could any of the future technologies we have identified in Annex 6, or any others, have disruptive implications for how spectrum is managed in the future? When might those implications emerge?	With regard to "Automated Spectrum Management Tools", SpaceX cautions Ofcom on the use of these systems with regard to NGSO satellite systems. Use of automated spectrum management tools like a SAS are untested and likely inappropriate for managing spectrum the NGSO context. Regarding "Spectrum in the 3000 GHz and above range ("Tremendously High Frequency"), Ofcom should take a "light touch" regulatory

	approach to providing access to these frequency bands. This approach should focus on encouraging experimentation and innovative spectrum use cases.
Question 4: Do you agree that there is likely to be greater demand for local access to spectrum in the future? Do you agree with our proposal to consider further options for localised spectrum access when authorising new access to spectrum?	SpaceX appreciates Ofcom's recognition of the trade-offs that must be made when making decisions regarding the appropriate license size for a particular use of spectrum. While the concept of "local licensing" has its place, given the ubiquitous nature of NGSO satellite services nationwide licensing is the most appropriate regime. Ofcom should instead focus on encouraging efficiency and spectrum sharing rather than geographic license sizes in its rules as the best way to maximize the utility of spectrum.
Question 5: Do you agree with the actual and perceived barriers identified for innovation in new wireless technologies, and our proposed ways of tackling those?	
Question 6: Do you agree with Ofcom's proposals to improve our outreach and reporting activities, and spectrum information tools? • **Are there additional ways that Ofcom could better engage with existing and future users and providers of wireless communications?** • **Please explain any specific areas where you believe more or better provision of information could provide value to stakeholders**	
Question 7: Do you agree that it is important to make more spectrum available for innovation before its long-term use is certain? Do you have any comments about our proposed approach to doing this?	Ofcom calls out five principles it uses use to try to balance the need for promoting innovation in the use of spectrum with the rights of incumbents to have some certain in the licenses they hold. Three of these are particularly important: - Make spectrum available in a variety of ways including for innovation and trials

- Make spectrum rights as flexible as they can
- Promote an appropriate level of international harmonization

SpaceX also appreciates Ofcom's understanding that spectrum users require sufficient certainty necessary to make the level of investment necessary for communications networks, such as next-generation satellite systems. But Ofcom also correctly recognizes the difficult in predicting how technology will evolve over time. Unfortunately, these two dynamics can create a difficult tension in policy making.

To help balance these two principles, Ofcom should consider adopting a policy of sunsetting certain technical rules and the license conditions over time as new technologies and innovative uses of spectrum emerge. Many regulatory protections for incumbents become stale over time as they are overcome by changes in the market and technology. These regulations can gradually turn from protections necessary to encourage investments, to deterrents to developing and using new more efficient technology. By setting dates under which protections sunset over time, incumbents will be driven to periodically evaluate whether they are putting their resources to the highest and best use.

Of course, Ofcom could also extend the life of these protections if it deems them still necessary, but an upfront and transparent sunset provision would force an affirmative decision. By sunsetting protections afforded incumbent licensees, Ofcom can ensure protections for initial licensees do not inadvertently lead to anti-competitive behavior that entrenches incumbents.

SpaceX also appreciates Ofcom's recognition that the "international harmonization of spectrum – where particular bands are made available in similar ways in different countries in order to enable similar use across those countries - can significantly influence the benefits from use of those bands." In the NGSO context this is critically important to ensure the

	benefits of global operators like SpaceX can bring the benefits of affordable broadband access to every country its system covers. As Ofcom exercises its authority representing the UK before international bodies like the European Conference of Postal and Telecommunications ("CEPT") and the International Telecommunications Union ("ITU") it should promote international harmonization of spectrum allocations whenever possible.
Question 8: Do you agree that it is important to encourage spectrum users to be 'good neighbours' to ensure more efficient use of the spectrum? Do you agree with our proposals to: **a) increase realism in coexistence analysis at a national and international level?** **b) encourage spectrum users to be more resilient to interference?** **c) ensure an efficient balance between the level of interference protection given to one service and the flexibility for others to transmit?** **Do you have any comments on which of these will be the most important?**	SpaceX encourages Ofcom to set the right incentives for the efficient use of spectrum. In the NGSO satellite context, the spectrum-splitting proposal we share above is a relevant example. By setting appropriate incentives, Ofcom can avoid having to predict technological or market changes and inadvertently adopting regulations that could harm innovation. SpaceX wholeheartedly supports Ofcom's intention to encourage users to be more resilient to interference. Because satellite providers operate in a shared spectrum environment, too often NGSO satellite operators design systems that are spectrally inefficient and overly sensitive to interference in an effort to limit spectrum access for competitors. Ofcom should adopt policies that drive licensees to develop and use technologies that are spectrally efficient and resilient. For example, adopting the band-spitting regime described above will encourage efficient use of spectrum. But by combining those polices with sunsets for protections for incumbents will also create incentives to use technology that is more resistant to interference. For instance, if certain interference protections for incumbents will sunset overtime, the incumbents will have incentives to ensure their systems can continue to function in a more crowded spectrum environment. SpaceX applauds Ofcom's recognition of the ongoing explosion in demand for both satellite and terrestrial wireless services that are driving technological development and demand for spectrum. A successful spectrum policy will

	encourage operators, terrestrial and satellite, to design and deploy systems that increase efficiency and better share limited spectral resources. Ofcom's licensing practices should capture the actual spectrum use and the efficiency of satellite constellations. It should encourage the use of cutting-edge antenna technology such as beam forming and steering and advanced filtering techniques, that make it possible for different users and different services to work more precisely and closer together without adding significant interference.
Question 9: Are there any other issues or potential future challenges that should be considered as part of this strategy?	
Question 10: Do you agree that continued use of our existing spectrum management tools (as set out in sections 4-7) will be relevant and important for promoting our objectives in the future, in light of future trends?	
Question 11: Is there anything else we should be considering doing, or doing differently, to promote our objectives?	