Your response

Question	Your response
Question 1: Do you have comments on the overall approach to the review?	ESOA very much welcomes Ofcom's recognition of the importance of the satellite sector. ESOA notably commends Ofcom for acknowledging that satellites have already transformed lives of people and concurs that emerging satellite constellations will widen the range of services to be offered by satellites. The satellite communications sector is going through several major innovation trends. Non-geostationary (NGSO) constellations have deployed with MEO systems relying on High-Throughput and Very High-Throughput Satellites (HTS and VHTS) such as O3b and mPOWER operated by SES, whilst LEO systems ventures such as Telesat's Lightspeed or OneWeb are deploying to provide broadband or narrowband services all over the world. These state-of-the-art systems are capable of providing unprecedented connectivity levels, including for very high Gigabit capacity, low-latency applications. Geostationary platforms have been also subject to strong capacity enhancements driven by a systematic digitisation of space technologies, the 'softwarisation' of satellite operations and other virtual network functions. Combined with the advent of new ground antennas and reliance on steerable spot beams using Ku, Ka and now Q/V frequency bands, these progresses have increased flexibility in geographical coverage and spectrum use by a new generations of satellite systems operated by several companies such as Viasat, Echostar, Inmarsat, Intelsat or SES.[1] Large geographical are coverage is still provided from wide-beams footprints relying on HTS satellite systems using C-band (e.g. Intelsat EPIC or AMOS-17). These satellite systems are now offering speeds of 100 Mbps and beyond. As Ofcom raised in their report on Technology Futures: "In satellite telecommunications, large geostationary satellites remain important. Here, technologies adopted from the mobile sector such as small cell spectrum frequency reuse have enabled higher capacity satellites providing lower cost services. This trend is set to continue with mobile edge computing enhancing both network performance and the user experience (…) The next generation of satellites will be all-electric, software-defined satellites, providing operators with greater flexibility over either the frequencies the satellite operates and/or the capacity delivered in different locations over the lifetime of the spacecraft." The satellite community has also multiplied its efforts to ensure its integration into the 5G ecosystem, inter alia through its active participation in research and standardisation activities such as with the 5G-PPP, 3GPP (SA and RAN groups), ETSI and ATIS (NTN group). This evolution has led to a much-increased ability of satellite and terrestrial systems to operate seamlessly within the 5G ecosystem and thus accelerate the deployment of 5G services to end-users in all geographical areas, whether urban, sub-urban or rural.

[1] See ESOA membership from: https://www.esoa.net/about/members/full-members.asp

	When Ofcom writes: “Satellites have global coverage so can be used to overcome the economic challenges of rolling out terrestrial networks in remote areas. To date, satellites have provided backhaul for 3G and 4G services, helping mobile network operators to serve some of these communities. The additional commonality between satellite and terrestrial networks offered by 5G standards should make that easier still,” ESOA wants to emphasise that there is no reason that satellite communications should be confined to remote areas or to backhaul connectivity: in fact, satellite services have been and will continue to enable communications on the move, direct to premises connectivity in rural and urban areas, direct connectivity to end user devices or video content / big data delivery worldwide. Another important evolution is the adoption of cloud technology by satellite operators. Big players such as IBM, Microsoft Azure or Amazon are counting on satellite to extend the reach of direct access to the Core or access to the Edge using the cloud. The same players are relying on cloud technology and artificial intelligence to help process the large databases of imagery and other sensing data: big data from Space Earth Observation, Navigation and other scientific activities are downloaded from ground stations or teleports co-located to data centres and cloud access points, in joint operations with satellite players. Satellite communications platforms also benefit from much enhanced network agility and security coming out of the cloud functionalities. In particular, cloud technology combined with software designed networks and the expected advent of quantum technology are creating new ways of increasing cyber-security by using space technology, without deploying dedicated and expensive physical infrastructure. All in all, industry’s implementation of technology advances and integration into the 5G and future 6G ecosystems make satellite usage of radio spectrum even more essential. This is leading regulators to deal with a multiplication of satellite players, which share the same spectrum amongst themselves, to respond to a wide variety of connectivity needs. Finally, ESOA has observed the trend identified by Ofcom of communications moving to higher frequencies. However, similar to terrestrial networks, satellite networks have different use cases for different frequency ranges. While the satellite industry is in progress of deploying services in the Q/V-band, as Ofcom also stated, high frequencies are not suitable for all applications. More traditional L-, C-, Ku- and Ka-band frequency resources will remain vital to satellite communications for the foreseeable future.
Question 2: Have we captured the major trends that are likely to impact spectrum management over the next ten years?	ESOA concurs with trends identified by Ofcom related to the external context, especially the increasing importance of more resilient and dispersed connectivity. The current COVID-19 pandemic has emphasized the need for connectivity everywhere. As people are encouraged to work from home, the need for connections in places unserved or underserved by terrestrial networks has increased. As acknowledged in several international fora, satellites also play an important role in fostering the 5G service roll out in urban, suburban and these unserved or underserved areas. Additionally, satellite networks are vital during natural disasters and other emergencies, as they enable establishing rapid and reliable communications.

The use of satellite networks in 5G will reinforce service reliability of terrestrial networks by providing service continuity to users. To reduce power consumption, satellite networks are able to scale 5G networks through the provision of efficient multicast/broadcast resources for data delivery towards the network edges, or directly to the user equipment. Once launched, satellites are essentially carbon neutral as they rely on solar power. However, when spectrum availability is reduced such as in C-band, additional satellites need to be launched to maintain the same capacity levels. Therefore, the most environmentally friendly option is to allow the launched satellites to utilize the frequency ranges of the designed payload to the extent possible for the entirety of their life span.

Importance of the international framework

ESOA commends Ofcom for its extensive recognition of the importance of the ITU Radio Regulations.

ESOA very much appreciates that, in this ITU-RR context, "a specific aspect of [Ofcom's] role is to manage 'filings' for satellite orbital positions and radio frequencies on behalf of the UK." We also appreciate that Ofcom "take[s] a leading international role in relation to satellite communications, including new satellite services that can help deliver improved broadband services to people in locations that are hard to serve with other networks" and would very much welcome that Ofcom further pleads for the role of satellites in contributing to acceleration and extension of 5G networks, as largely referenced in ITU, 3GPP, CEPT or EU documents.[2]

Harmonisation work achieved by the CEPT and by ETSI on spectrum usage and standards are also essential to take into account. This harmonisation effort in Europe is useful in setting up similar conditions on spectrum use, licensing regimes and equipment usage across many different countries, which is critical for the deployment of services spanning territories covered by the footprint of our satellites. It is especially important that the UK continues to participate to the telecommunications standardisation efforts conducted in ETSI, CEN and CENELEC post-Brexit, considering the trade flows between the UK and the rest of Europe.

ESOA notes Ofcom's intention to "continue to be active in promoting 3.4-3.8 GHz, 26 GHz, 40 GHz (40.5-43.5 GHz) and 66-71 GHz as 5G bands in CEPT and in ITU" but wishes to remind Ofcom of the necessity of adapting the approach to the realities and needs of the regional level: the 3.6-3.8 GHz band is extensively used by FSS in several parts of the world, and the split of the 40 GHz band is reversed in ITU Region 2 - with 5G IMT to use the lower part of the band (37.5-40.5 GHz).

ESOA welcomes the UK's intention to "continue to monitor the work [of the EU's RSPG and RSC] and cooperate with them as appropriate following the UK's exit from the European Union," as it can only benefit all wireless players active in the European region.

[2] See https://docdb.cept.org/download/e1f5f839-ba17/ECCRep280.pdf, and https://www.itu.int/en/ITU-R/space/workshops/2019-SatSymp/PublishingImages/Pages/Programme/R-REP-M.2460-2019-PDF-E.pdf, and https://www.3gpp.org/images/articleimages/Releases/rel_17_overviewonly.jpg, and https://cordis.europa.eu/project/id/761413/results/fr

ESOA also understands that a national regulator such as Ofcom has connectivity priorities defined for the country to deal with and is defining its own spectrum management policies to support these. Probably one of the most serious challenges in spectrum management is to accommodate the spectrum needs of both established players and new entrants, and it's quite remarkable that innovation is also steering fundamental changes amongst the incumbents (see our response to Q1).

Regulatory certainty is especially important for the satellite sector, and while ESOA acknowledges that Ofcom wishes to develop its own spectrum management policies, this should be done in a manner that complies with ITU Regulations, Resolutions and international standards and ensures stability.

Whilst UK policy often has to balance a range of priorities and competing interests, it needs to be flexible and responsive to the positions of other countries, and it sometimes needs to take tactical positions as negotiations develop. It also needs to take into account UK interests in spectrum outside the UK, for example with the BBC World Service.

The satellite industry has always been concerned about the risks associated with ad hoc harmonisation amongst selected countries when this goes against the decisions carefully reached in international bodies. Indeed, "harmonisation does not only arise from the formal decisions of bodies like CEPT and ITU, but can also happen in practice if a number of countries adopt similar stances to particular bands." Such flexibility exists e.g. for the definition and adoption of equipment standards because these can often coexist, if not interoperate. However, in the case of radio spectrum, national regulators ought to very carefully adjust their national approach to an environment increasingly exposed to coexistence challenges.

Changing application demands

Ofcom identifies a trend of growing capacity demands of people and businesses. ESOA would like to raise another equally important trend, which is the demand of people to stay connected regardless of their whereabouts. Satellite networks are able to reach users in places that are unreachable through terrestrial networks, including airplanes and vessels. Even if COVID-19 pandemic has temporarily reduced travel, the trend of people relying on technology and connectivity has only increased during this pandemic and is expected to translate to an even steeper curve in demand for communications on the move once travel become normal again.

According to NSR's Aeronautical Satcom Markets, 8th Edition report it projects a viable long-term In-flight Connectivity (IFC) market, despite significant near-term challenges due to COVID-19. Coming off a challenging 2018 and 2019, 2020 has already seriously disrupted the IFC market, with air traffic down by at least 80% in most regions. However, longer-term opportunities remain – once air travel resumes, planes will still require ever more connectivity, yielding a market opportunity more than 2x larger than 2019, with $5B in annual retail revenues by 2029. The next 24 months will be a challenge, no doubt – but IFC plans are largely delayed, not cancelled.

	Therefore, there is a pressing and growing need for Ku-band and Ka-band spectrum to be available in the UK to meet the increasing demand for connectivity by UK consumers of broadband services on Aircraft-mounted Earth stations (AES) and other in-motion satellite terminals (ESIMS and ESOMPS), something that Ofcom identifies in the Space Spectrum Strategy. This growing demand has placed tremendous strain on the available spectrum for satellite services utilising the entire 14.0-14.50 GHz frequency band ("Ku-band"), including the upper half of this band i.e., the frequency range 14.25-14.50 GHz. Similarly, additional spectrum in Ka-band including 27.5-29.5 GHz (Earth-to-Space) may be necessary to meet satellite mobility requirements, for which the recent ITU regulations (Resolution 169) provide the international framework. Regarding the 14.25-14.50 GHz band, we understand that Ofcom was considering opening up this band for further consultation via a Call for Input (CFI), envisaged back in 2019, which we very much welcomed. However, ESOA would also appreciate if Ofcom could confirm whether they have indeed adopted a strategy to allow the deployment of ubiquitously deployed AES and other in-motion satellite terminals within the candidate bands in order to allow satellite operators to meet the pressing demand for spectrum to support relevant services, ensure the efficient use of spectrum and promote new opportunities for growth in the UK at the earliest possible opportunity.
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?	There is little doubt that new technologies such as AI and Machine Learning have the potential to facilitate the role of spectrum managers. This could help facilitating the supervision of spectrum users. These new techniques may also improve the performance and efficiency of radiocommunications systems themselves, and progressively support better coexistence conditions in a world where the expansion of wireless equipment and systems is exponential. ESOA recognises that the performance of both wireless transmitters and receivers can notably help improve coexistence amongst radio systems, and the innovation which the satellite industry is introducing in the ground segment (antennas) indeed moves us towards better resilience. Nonetheless, when Ofcom refers to more robust systems that are "for example, ensuring that receiving equipment effectively filters out signals in neighbouring bands," we need to be mindful that there cannot be magic solutions that makes receivers perfectly immune to interference – especially in an environment of high-deployment of high-power systems such as 5G IMT. We certainly concur with Ofcom that "improvements include the ability of transmitters to minimise out-of-band emissions and the ability of receivers to screen out radio signals transmitted in adjacent bands." Yet, even though new equipment technologies or advanced techniques to manage spectrum can alleviate interference risks to a certain extent, sharing between FSS and IMT will remain dependent on power limits (not *only* for out-of-block emissions) or/and geographical separation. See also our responses to Q8 below.

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?	The attention to "local access" seems to be focussed on demand for private or specialised use of mobile technology for a private system, for example within a factory or campus. Given that mobile network licences are normally constructed on the basis of a common block of spectrum with full national use, it is for terrestrial mobile where this new approach has most relevance. Regarding satellite broadband connectivity, it is not apparent that such an approach could be applied or would be useful. Satellite broadband connectivity using fixed terminals is in any case provided to a single location or premises, and so is automatically applied to a local area, but such premises could be anywhere in the UK. Satellite broadband connectivity is also provided using mobile terminals which can operate on terminals anywhere in the UK. In both cases, systems are typically using bands which are available nationally and are typically not shared with terrestrial users. This is necessary since mobile terminals, whether used on land, on ships or on aircraft can be deployed at any location, making geographically shared use impractical. It therefore does not seem useful to apply the concept of local licences to satellite broadband connectivity solutions. One useful case to consider is the use of Ka-band ESOMPs, where some of the available spectrum is shared with terrestrial use in the UK (parts of the 28 GHz band, which are licensed nationally for terrestrial use). While the same bands are potentially also available for ESOMPs on ships and aircraft, the need to keep adequate physical separation means that in practice they can only be used by ESOMPs on aircraft above a certain altitude, or on ships a certain distance offshore. While this "shared" spectrum use is welcome, the fact that its use by ESOMPs is so constrained illustrates the importance of maintaining some bands for satellite use free from sharing with terrestrial services. Similarly, regarding satellite TV broadcast services, there does not seem to be a market for service limited to small local areas and there does not seem to be a means to allow shared use of spectrum on a localised basis. Where terrestrial local licencing may have an impact is in bands which are normally shared between FSS earth stations and terrestrial use. We have seen that Ofcom plans to introduce this concept in the 3.8-4.2 GHz band, which is heavily used by receiving earth stations in the UK. In this case, it will be important that local terrestrial licences are limited geographically and perhaps limited to indoor use so that a practical sharing framework with earth stations is established. Any new local terrestrial licences are likely to prevent the deployment of new FSS earth stations in the same areas and probably some distance away. For 5G mobile systems, the necessary separation distances from earth stations are at least 10s of km and sometimes 100s of km, depending on the local terrain. There is a risk that local mobile licences become a significant constraint to the deployment of new earth stations and therefore the technical conditions and the extent of use will need to be tightly controlled so as to avoid this band becoming a de facto terrestrial service band. It is important also to note that local licensing could constrain FSS earth station deployment even if those terrestrial licences are not actually used, since earth stations will likely have to avoid interference to the entire area subject to local licensing. Assessing the value to the UK of satellite use from 3.8 – 4.2 GHz requires an appreciation of how these links form part of international communications networks.

	These bands are used as downlinks for associated uplinks in spectrum between 5.8 – 6.4 GHz, and services carried are downlinked outside the UK as well as within the UK. Where a policy is developed for these bands from a domestic perspective, it is important to also understand any impact on UK interest in this spectrum outside the UK, as well as how a policy developed for a national context might be received if promoted as an option outside the UK. Similarly to the 3.8-4.2 GHz band, there are parts of Ku-band, Ka-band and Q/V bands that are used or will be used for gateway satellite earth stations where sharing with terrestrial systems on a geographically limited basis is feasible. More usually in these bands, the terrestrial service needs to be the fixed service, which lends itself to realistic sharing with FSS earth stations given the fact that highly directional antennas are used, and authorisation is normally made on a link-by-link basis. These characteristics facilitate coordination with existing earth stations and give scope to allow new earth stations to be established. This type of shared use is therefore workable, but it may be possible to extend this approach to local area licences, subject to careful examination and definition so as not to damage the framework for satellite use of the bands. In particular, it needs to be ensured that there is always the potential for deployment of new earth stations in a range of locations - urban and rural – and this requires that local licensing needs to be limited geographically and that information on their use is provided so that suitable new earth station locations can be identified. Furthermore, and as for the 3.8-4.2 GHz band, it needs to be ensured that local area licences are actually used and are revoked if they are not. Otherwise, there is a risk that local licences become an unnecessary blocking of alternative users of the same spectrum such as FSS earth stations.
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?	N/A
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**	ESOA notes that Ofcom is committed to take account of the interests of the space and satellite industries: "We engage closely with the Government and UK industry to ensure that we understand and are able to take account of all UK interests in the development of UK positions. For example, we take account of wider UK interests in the space sector, such as space launch, satellite broadband, and navigation and positioning where appropriate." ESOA expects this to include international players with active contribution to the UK connectivity goals.

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?	Innovation in the satellite sector generally takes place in the frequency bands allocated for satellite services (FSS, MSS and BSS). Innovation takes place in both the space segment and ground segment, including opening up new frequency bands as technology allows. In the space segment, advances in technology make more efficient use of the available spectrum, for example by using smaller spot beams to allow reuse of the frequencies and through the use of new LEO and MEO orbits, which allow the use of smaller user terminals. Innovation also takes place in the ground segment, for example using new antenna technology to allow low profile antennas for use on aircraft. In most cases, innovation fits within the existing national and international frequency regulations and no particular action is necessary by regulators. In other cases however, innovation requires a change to the regulatory framework (for example with ESIMs in the Ka-band) but for satellite services such changes normally require action at the regional level (i.e. within CEPT) or the global level (i.e. with the ITU). Since any changes to the regional and international regulatory framework can take many years to accomplish, it is important that regulations are crafted in the most flexible way possible, to allow satellite operators to innovate without the need for a change wherever possible. It is also important that Ofcom supports changes to the international framework where this is necessary to support a vibrant and innovative UK space sector. There has been considerable innovation in recent years with the evolution of "New Space" operators, which are typically focussed on developing low-cost LEO systems, typically using very small satellites and taking benefit from new low cost launch providers. For that type of use, the introduction of provisions for "short duration missions" for certain frequency bands in the Radio Regulations provides a valuable step to support innovation. With these considerations, making spectrum available for innovation on a purely national basis is probably little value for satellite use. However it should be ensured that test and development licences are available for use in bands allocated for satellite use to allow for the development of new technology for satellites and earth stations, with conditions to ensure that such use is compatible with conventional satellite users. Where Ofcom seeks to consider new options to support innovation in terrestrial services, we would of course be concerned if such use was to be in bands shared with satellite services. At least it should be ensured that any new terrestrial use does not cause interference to or restrict satellite operations, and in such a circumstance it seems likely that a specific public consultation would be required before any new decision.
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**	ESOA agrees that it is important to encourage spectrum users to be good neighbours and satellite operators have considerable incentives to do so. The spectrum available for satellite use is limited by the available allocated bands and most bands are heavily shared among different satellite operators and users, which naturally leads to a high incentive for efficient use of spectrum. Regarding the three specific proposals in the question, ESOA provides the following comments:

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?**	*a) increase realism in coexistence analysis at a national and international level* On the face of it, it is obvious that coexistence analysis should be as realistic as possible. Among the ways in which Ofcom can help to improve realism, one option is to make information available on the extent of deployment of existing systems. For example, information on deployment of existing terrestrial mobile networks can help to determine realistic assumptions for planned future deployment scenarios in potential new mobile bands. We notice that such information on mobile networks is often not available, presumably since operators are authorised nationally and are no longer required to provide individual base station information. In such a case, Ofcom could consider changing the licence terms to require such information to be provided and ideally to be made available publicly. As Ofcom identifies in the consultation document, assumptions regarding radio propagation models are often a key consideration. We are pleased to see that Ofcom has often supported such activities with its own measurement campaigns and working in the international fora to develop and improve standard propagation models. We encourage Ofcom to continue to invest in this area. *b) Encourage users to be more resilient to interference.* Ofcom notes that improvement in receiving equipment is sometimes key to introducing new spectrum users. The examples cited by Ofcom are where it has been suggested that equipment receivers are sensitive to signals on the adjacent frequencies, i.e. as a consequence of insufficient selectivity. Where Ofcom does identify a need for receivers with improved selectivity (discussed in para 7.91), it is important that sufficient time is provided to implement the transition. Where users have purchased and are using equipment that fully complies with the applicable regulations at the time, they should be entitled to use that equipment for a reasonable period. Ofcom raises the prospect of using financial incentives to encourage replacement of equipment (paras 7.92 and 7.93). In this regard, it would be important to use a “carrot” rather than a “stick”, i.e. to reward users of improved equipment with reduced licence fees where possible, rather than to penalise users of old equipment with increased licence fees. Ofcom should also consider direct subsidy of the cost of replacement equipment, which could be used in cases where a tiered licence fee is not possible or not effective. Such a direct subsidy could easily make economic sense overall if the benefits provided by the new spectrum user outweiingh the costs of upgrading receivers. Separate to the discussion about improvements in receiver selectivity, Ofcom discusses requiring users to accept higher levels of interference. ESOA has noticed that Ofcom has sought to challenge the interference criteria used for studies related to FSS protection in the ITU. Ofcom’s policy in this regard, seems to be rather piecemeal – it is not clear why it seeks to challenge the protection criteria used by the FSS, but is apparently not concerned by the criteria for receivers used by other services, e.g. IMT mobile systems. The policy in this regard would benefit from some general conditions to ensure that it is applied fairly and consistently.

With regard to the possibility for satellite systems to tolerate higher interference levels, it is important to take account of the practical and real-world considerations. For terrestrial systems, an increase in the receiver noise by 1 dB might be easily compensated by a 1 dB increase in the corresponding transmitter power. In a satellite system, the scope to increase the downlink power to compensate for higher interference at the receiver is limited by at least two factors:

First, the available power on the satellite is limited since satellites are solar powered and have a strictly limited power budget which cannot be increased once the satellite is launched. As an example, an increase of 1 dB in the downlink power to compensate for increased interference would require a 26% reduction to the usable satellite bandwidth to maintain the overall EIRP budget. That would be a significant loss in capacity of the satellite, which could significantly change the economic viability.

Second, an increase in the downlink EIRP will have a knock-on effect to other satellite systems which share the same spectrum. The ability of two GSO satellites to operate with small orbital separation is often governed by the downlink interference from one network, received by the earth stations of the adjacent network. A 1 dB increase in the downlink EIRP on one network results in a 1 dB increase in interference to the neighbouring network. Hence the desire to increase the interference tolerated by an earth station impacts not only the network in question but also adjacent networks.

A requirement to accept greater interference at the receiver will always come at some cost, which does not seem to be recognised or acknowledged in Ofcom's discussion. It is always possible to look at any situation and say that a small adjustment to one parameter would improve the situation. However unless there is consideration of the costs and the practical limitations, it would be possible to justify one small adjustment after another indefinitely.

c) ensure an efficient balance between the level of interference protection given to one service and the flexibility for others to transmit?

While this objective sounds worthwhile in principle, it is very difficult to implement in practice in a fair manner given the wide range of factors which influence interference protection on one hand, and transmitter characteristics on the other hand. This is made more difficult still when the transmitter and receiver are in different services. If an improvement can be achieved by either a reduction of the OOB emissions of the transmitter or by the receiving accepting a higher level of interference, it is difficult to see how these two options can be fairly judged against one another. This objective of finding an efficient balance would benefit from greater clarity on this aspect.

While it is clear that both transmitter and receiver have a role in any compatibility issue, from the discussion in the consultation document and from actions we have seen taken by Ofcom in CEPT and the ITU, it seems that Ofcom's focus is much more on receiving equipment than transmitting equipment.

	In fact it seems that Ofcom's focus has shifted so far towards receiver performance that it is overlooking the important role of transmitter performance and out-of-band emissions. This is particularly noticeable in the case of 5G terrestrial equipment using the mmWave bands, where we see that equipment is being developed and deployed with highly inefficient transmitter characteristics. This seems to be a consequence of a number of technology factors: (1) The trend towards very wide bandwidth channels (100 MHz and more), meaning sharp band edge filters are difficult or costly to implement and "out-of-band" emissions extend well beyond the band edge. (2) Mobile manufacturers are shifting to TDD technology. Compared to other duplex techniques like FDD, the use of TDD technology tends to lead to high power out-of-band emissions, due to the high frequency signal transients. (3) The trend towards the use of *synchronised* TDD networks means that mobile operators have little requirement to avoid out-of-band emissions between operators' spectrum blocks and hence have no direct incentive to have adequate out-of-band emission levels towards the users of adjacent frequency bands. (4) The use of AAS antenna technology makes significant filtering costly or impractical, further limiting the quality of out-of-band emission suppression. (5) The performance of AAS antennas in the quality of the sidelobes has been questioned, with some information suggesting that high side-lobes will occur due to undesired "grating lobes", increasing the risk and level of interference to other spectrum users. All these factors lead to new 5G system characteristics which are less able to coexist with other services in the same bands and in adjacent bands than more traditional technology (3G, 4G). ESOA is surprised to see that in CEPT and ITU discussions on these aspects, Ofcom seems to have turned a blind eye to poor performing 5G mobile equipment, apparently allowing the manufacturers to dictate the equipment performance requirements with no regard to efficient spectrum sharing. ESOA wishes to stress the importance of examining the transmitter requirements as well as the receiver requirements and suggests that Ofcom should re-balance its focus back toward the transmitter and be prepared to critically examine terrestrial mobile equipment performance.
Question 9: Are there any other issues or potential future challenges that should be considered as part of this strategy?	N/A
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?	N/A

Question 11: Is there anything else we should be considering doing, or doing differently, to promote our objectives?	N/A