Your response

Question	Your response
Question 1: Do you have comments on the overall approach to the review?	Confidential? – N Nokia agrees with the overall approach of Ofcom and the views expressed. Spectrum is scarce resource and its use will continue to grow towards the end of this decade for both regular usages and for research and innovation. It is therefore essential for Ofcom to take into account all these aspects and update its strategy to reflect the needs and support raising demands from various stakeholders, including particular sectors with specific needs. As spectrum use will become even more intensive over the coming years, improvements in spectrum management will become mandatory to provide greater flexibility in support to such usage. To this end, new approaches and automation of some of the spectrum management processes/tools are to be considered to ensure that full efficiency is achieved in using the spectrum resources.
Question 2: Have we captured the major trends that are likely to impact spectrum management over the next ten years?	Confidential? – Y / N We are of view that main trends are well captured in the consultation document. The licensed spectrum will continue to play a major role in providing national wireless capacity and coverage to the UK population, while specific requests will continue to emerge with the evolution of use cases and applications for industries and business in parallel. These will impact the spectrum demand, its use and its management. One obvious trend is the growing demand for wireless connectivity and digital applications and usages by both people and business. The continuing technological innovation in 5G and beyond will support applications like augmented and virtual reality, automated industrial processes, massive industrial IoT usages, etc. that will require extra-capacity and improved connectivity and coverage, and even

	extreme capacity and connectivity reliability in specific locations. While existing spectrum can support some of these applications, their multiplication and adoption will require additional spectrum that can be accessed whenever and wherever needed. As such, traditional management of spectrum may prove to be inadequate to support such evolutions and an automated spectrum management can be necessary for some specific cases.
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?	Confidential? – Y / N Nokia acknowledge that the technologies cited in the Annex 6 are in line with Nokia's Bell Labs vision towards 6G. New trends are emerging in shaping the 6G system requirements and technologies to transform the communication experience and the interaction with the physical world. The rapid advances in artificial intelligence make it likely to become an important component for the 6G air interface and network. Other technology transformations in the 6G context include access to new (high) spectrum bands, self-adaptive spectrum sharing methods, extreme performance requirements on latency and reliability, to name a few. Moreover, going up in the spectrum frequency ranges towards the sub-terahertz bands (114-300 GHz) for cellular use, sharing and reuse of resources is to be considered and therefore adequate frameworks should be taken into account. These developments will have an impact in the resource management framework, including flexibility in spectrum licensing schemes, and the automation of the spectrum management tools will need to take into consideration the more dynamic aspect of spectrum access in space, frequency and time that 6G will require.
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?	Confidential? – Y / N Ofcom is already pioneering in authorisation access to spectrum on local basis with different authorisation schemes (local licenses, shared use, for indoor/outdoor and low/medium power, etc.). If the demand for local access to spectrum exceeds the supply, new options

	should be investigated in order to satisfy such requests. Nokia already expressed its position in favour of local access to spectrum in the previous Ofcom consultations and is working towards enabling such solution in markets at global level. Access to locally licensed spectrum shall not preclude any implementation scenario from standalone private networks implemented as 5G network slices, individually deployed or via mobile operators that can leverage their know-how to deploy private networks that respond to specific needs and characteristics. When local access to spectrum is considered, adapted tools such as spectrum controllers should also be considered for effective spectrum management. With a look towards the future and the developments that are considered for 6G and the use of high and even-higher frequency bands (up to terahertz), access to spectrum on very specific geography/time period/frequency will increase and therefore the use of spectrum on local basis will become gradually increase. Such use, as stated previously, will require considering new tools of spectrum management to allow a more dynamic access to spectrum resources to accommodate different usage patterns and facilitate efficient and higher spectrum reuse.
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?	Confidential? – N We see the benefits of a common European approach in establishing technical coexistence conditions and equipment standards as playing a major role in achieving economies of scale and opening the market to harmonised technologies and equipment. E.g., Nokia is supporting a technology and service neutral approach in defining the technical spectrum usage conditions for license-exempt use for SRD and any other usage of the license-exempt spectrum.
Question 6: Do you agree with Ofcom's proposals to improve our outreach and reporting activities, and spectrum information tools?	Confidential? – N Nokia welcome the proposed actions and tools that Ofcom considers improving its outreach towards the stakeholders. From a technology

• **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**	and equipment vendor perspective we see benefits in continuing regular engagement between Ofcom and the industry for exchanges on technology developments and best practices. An important area of communication towards the great public is related to the EMF to provide accurate scientific information on the effects of wireless technologies, especially 5G. Additional actions under consideration aimed at improving accessibility to information on the Ofcom site and to relevant documents is appreciated.
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?	Confidential? – N Nokia considers important the possibility to access spectrum for innovation for the early stages of new technology deployments. An example is the decision from Ofcom to enable greater access spectrum in the 100-200 GHz frequency range on flexible service neutral basis and the extension of the EHF light licensing in the 57-71 GHz band. In view of 6G developments access to spectrum in high bands is of interest for testing particular technologies and equipment while benefiting of a flexible use without requiring complex sharing arrangements. We expect the sub-terahertz bands to become available and practical for use in cellular systems in specific scenarios of the future; the access to such bands is important for innovation and for testing new technologies subject to significant amount of research and development in order to lead to viable deployable solutions. Having access to spectrum on a light-licensing basis with clear terms and conditions (including clearing notice) allow for better planning of the testing of the new technologies.
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?**	Confidential? – N Wireless communication needs will continue to grow in many sectors of activity that will see the benefits of using digital solutions. 5G technology is already addressing such usages and proposes solutions for connected vehicles, smart cities, health and wellbeing, industries and utilities, along with the mobile broadband

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?**	services for the citizens. Accessing additional resources in new spectrum bands is likely to imply more sharing of new bands with existing incumbents. The deployment of 5G is already taking advantage of specific technologies that improve performance of networks and increase the efficiency of spectrum use. The research towards 6G considers additional techniques and technologies to optimise communications by making use of AI/ML, advanced beamforming techniques, self-configuring spectrum sharing methods, and many others. Encouraging the spectrum use on 'good neighbours' basis requires revising existing sharing conditions to improve the efficiency of sharing spectrum bands with incumbents by relaxing existing sharing conditions. All measures described provide levers to reduce the "risk areas" by revision of hypothesis and analysis based on worst case scenarios and update them using more realistic ones. The combination of technical assessments and strategic decisions like no specific protection of poor receiver/system performance, differential "protection pricing" or pricing to incentivize better interference rejection capabilities, provides a balanced way to improve efficiency of spectrum use. However, we note that some of the described actions should be taken not only at national level, but in coordination at regional and international for a in order to assure that services with an international coverage are benefiting of harmonised technical rules. As a future step, automated authorising tools capable of managing and monitoring the levels of performance of the licensee may be of relevance for further efficiencies.
Question 9: Are there any other issues or potential future challenges that should be considered as part of this strategy?	Confidential? – N The strategy proposed is quite extensive and covers widely spectrum matters for various stakeholders using spectrum resources. With a view for the medium-term, Nokia sees opportunities in opening more spectrum bands for wireless communications in low, mid, high and ultra-high bands, including sub-terahertz frequencies, for both traditional players and newcomers from different sectors. While spectrum sharing continues to gain relevance,

	exclusive license spectrum that provide certainty for investments and adequate coverage and quality of service continues to be a proven licensing scheme not only for public mobile networks but also for some vertical applications. Indeed, we see a need for such exclusive access in certain sharing environments for URLLC services for 5G since ultra-reliability and low latency may not be guaranteed with listen-before-talk and other courtesy protocols typically used in license-exempt spectrum. This will continue to be important for our clients and any additional spectrum will build up on existing infrastructure.
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?	Confidential? – N With respect to mobile communications the existing spectrum management tools will continue to pay an important role in the future, especially for the exclusive licensing. However, access to new higher frequency bands as well as the sharing of spectrum bands with incumbents on national or local basis will have to consider additional tools that manage efficiently the spectrum assignments and usage. Implementing such tools should preserve the confidence of all spectrum users, including on the confidentiality and security of their data and their development should take into account developments and initiatives at global level, including those in the USA.
Question 11: Is there anything else we should be considering doing, or doing differently, to promote our objectives?	Confidential? – Y / N Nokia thanks for the opportunity to provide its comments and reiterates its availability to continue engaging with Ofcom on spectrum management topics and share our technical expertise.