Introduction

Nokia welcomes the opportunity to respond to Ofcom's consultation providing views and comments regarding the proposed concepts of hybrid sharing between licenced and unlicenced services in the upper 6GHz band.

Mobile data is increasingly growing and is expected to continue to grow over the next several years. Ofcom's expectations for a medium growth scenario highlight an increase of mobile traffic by 40% year-to-year until 2035[1]. Recent crowdsourced data from Ofcom indicates that on average, users' connectivity relies to services other than Wi-Fi services for 38% of time[2]. At the same time, cellular data traffic is expected to triple globally by 2027 (Figure 1) while the corresponding revenue is increasing by a mere 14% over the same period of time, 2022 to 2027.

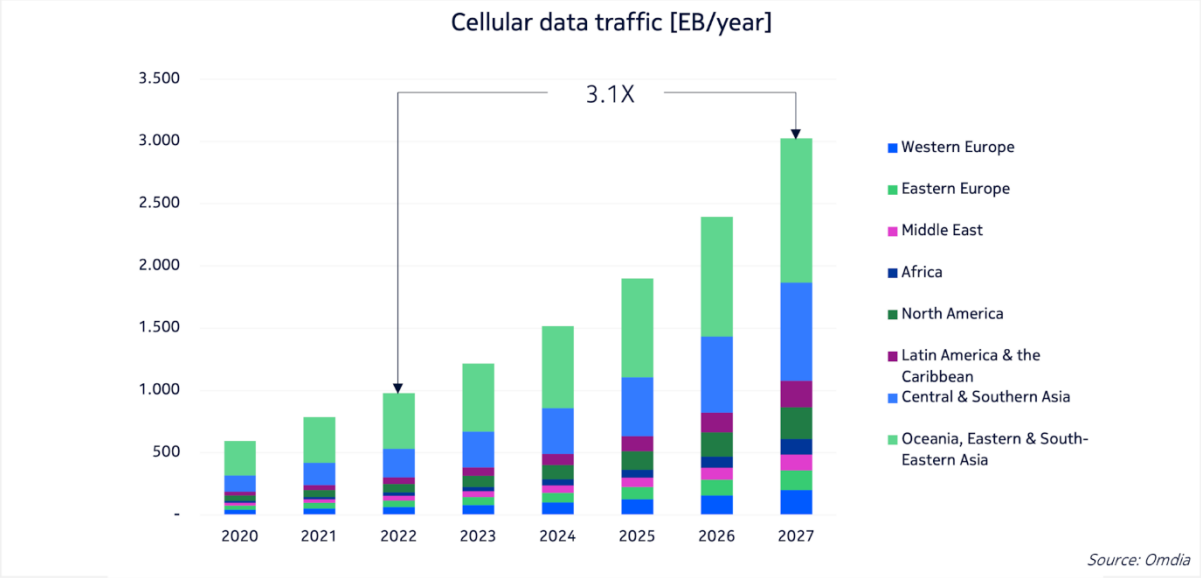

Figure 1: Cellular data traffic growth forecast

It is therefore evident that without additional spectrum for mobile networks the increase in cellular traffic in the coming years cannot be addressed in an efficient and economic manner.

The upper 6GHz band (6425-7125 MHz) is an opportunity for regulators to address the needs for additional mobile capacity, while encouraging innovation and investment, advancing the existing mobile ecosystem and enabling connectivity in an affordable, efficient and sustainable manner.

The upper 6GHz band is currently being discussed under Agenda Item 1.2 in WRC-23. During this entire WRC cycle, as Nokia, we have been consistent in our view that allocating the band to IMT services is the most appropriate regulatory decision. The available bandwidth of 700 MHz in the upper 6GHz band will enable the evolution of future communication networks, while addressing the growing demand for capacity in urban and suburban areas[3]. At the same time, the similarities of the upper 6GHz band with the 5G pioneer 3.5 GHz band, will allow mobile operators to utilise their existing network grid for deploying advanced 5G and next generation networks in a sustainable and cost-efficient manner[4]. Recent industry research shows that future 5G mobile networks are expected

[1] Conclusions paper: Ofcom's future approach to mobile markets and spectrum
[2] Mobile Matters 2023 report (ofcom.org.uk)
[3] Society cannot cope with the growing demands on 5G without 6GHz | Nokia
[4] Spectrum for 6G explained | Nokia

to lower their carbon footprint if spectrum in the upper 6GHz is made available for licenced use to meet their capacity targets[5]. In the same study, it is highlighted that the availability of the upper 6GHz band to Wi-Fi will not translate to any reduction in carbon emissions, since the fixed broadband targets can be already achieved using the existing spectrum available in the 2.4 GHz, 5GHz and lower 6GHz band. Furthermore, from an economic perspective, allocating the upper 6GHz band for licenced services with sharing limitations may reduce the ability for operators to deploy their networks and consequently reduce the attractiveness of the band for macrocellular deployments. Thus, considering the existing UK spectrum map, authorising the upper 6GHz band for licenced services would deliver balance in the use of the entire 6GHz band in the UK, with the lower 500 MHz given to unlicenced and the upper 700 MHz given to licenced services.

We ought therefore to highlight that our view, and consequently our preference, is that the upper 6GHz band should be authorised entirely for licenced IMT use, and that sharing of the band with unlicensed services does not represent the most viable and effective solution, not only for licenced but also for unlicenced services. It is reminded that the responses to a previous Ofcom consultation regarding the addition of the upper 6GHz band to the UK's Shared Access Framework, indicated lack of evidence of a clear preference from the industry and thus, Ofcom did not decide to proceed with their proposals[6].

Nevertheless, if Ofcom sees that there is no other possible option for licenced services to utilise the upper 6GHz band, other than sharing it with unlicenced services, then we have to emphasise that in any possible sharing approach, licenced macrocellular IMT services should be prioritised over unlicenced services in the band. Mobile network operators who would need to invest significant amounts to acquire licences in the upper 6GHz band, would probably see no benefit and would have no intention of sharing their expensive and scarce spectrum resources with unlicenced services, if they are not guaranteed a de-facto priority to deploy their macro base stations, making the most efficient use of the spectrum they have paid for.

We would also like to draw attention on the fact that while we agree that both IMT and Wi-Fi can deliver wireless broadband services, the IMT networks have a nationwide footprint by nature, while the Wi-Fi services are used more locally and in most cases they are realised as an extension of the fixed network infrastructure (e.g., FTTH) for a few meters. Finally, while the consultation focuses on the possibility of sharing between IMT and Wi-Fi, following the concept of spectrum being assigned in a technology agnostic manner, a level playing field approach should be considered, i.e., licence-exempt use by any technology[7] and not exclusively by Wi-Fi.

With that in mind, in the sections below we provide Nokia's responses to the Ofcom's consultation regarding the possible hybrid sharing of the upper 6GHz band between licenced and unlicenced services. Our answers cover selected sections in the consultation.

[5] Spectrum assignment is a key factor influencing carbon impact of 5G infrastructure rollout (analysysmason.com)
[6] Statement: An update on our sharing proposals for the upper 6 GHz band (ofcom.org.uk)
[7] Technologies using licence-exempt spectrum, like e.g., the 3GPP NR-U

Your response

Question	Your response
Question 1: Hybrid sharing could mean that the upper 6 GHz band will be used for mobile outdoors and Wi-Fi indoors. What are your views on the priorities for each of these two services, assuming that suitable coexistence mechanisms are developed?	*Is this response confidential? –N* At first it is important to highlight that Ofcom, in their seek for a potentially workable hybrid sharing approach between licenced and unlicenced services in the upper 6GHz band, should establish a precise definition for the classification of indoor and outdoor environments (e.g., an overground train station is indoor or outdoor, building perimeters – especially around windows and doors, large stadiums, etc.). IMT services should not mean to be prioritised for indoor or outdoor environments. In contrast, their purpose is to be able to provide and maintain service continuity from outdoor to indoor environments and vice versa. Any potential prioritisation of one environment or the other, would inevitably risk the creation of coverage holes, reducing the opportunities for operators to monetise over their network deployments impacting inevitably the user-experience of the consumers. One of the primary objectives of public mobile networks is to enable seamless mobility, realised through wide-area coverage and hotspots, maintaining sufficient QoS for the users. Thus, we are of the view that for the realisation of the purpose and the benefits of IMT, even if suitable sharing mechanism that would allow coexistence between licenced and unlicenced services could be developed, IMT services should not be authorised with the mindset to prioritise their use in indoor or outdoor environments only and should be licenced with the intention to provide mobility, wide and local area coverage as well as sufficient QoS. The assumption that suitable mechanisms for coexistence between IMT and Wi-Fi will be developed is an optimistic statement. Given the

	operational characteristics of both systems, we expect that any coexistence mechanism will lead to some degradation in the performance for both systems.
Question 2(a): Hybrid sharing could mean that the upper 6 GHz ban will be used for mobile in some locations, and Wi-Fi in others. We would like feedback on the priorities for each of these two services, assuming that suitable coexistence mechanisms are developed. From the point of view of mobile, is the upper 6 GHz band most useful to provide outdoor coverage, or indoor coverage? Is it most useful in urban areas, or in those base stations that are currently carrying more traffic, or some other split?	*Is this response confidential? –N* As also indicated in the previous question, the usefulness of mobile (IMT) services cannot and should not be distinguished between indoor and outdoor environments, since this would deviate from the primary objective of their nature, which is mobility. With today's technology, even in buildings where indoor IMT penetration is lower, femtocells can significantly enhance indoor coverage. The upper 6GHz band can enable the advancements of 5G. Advancements in IMT antenna technologies allow for similar performance between 6 GHz and 3.5 GHz frequency bands. This will allow mobile operators to utilise their existing 3.5 GHz network grids to deploy mobile networks in the upper 6GHz band. As such, the initial IMT deployments in the upper 6GHz band are expected to be primarily in urban and suburban environments. This will enable operators in the initial phase to utilise the band addressing the growing demand for data, and in the next phase for the advancements of 5G. However, when it comes to rural areas, it is important to highlight that certain rural areas might also have a certain level of density (e.g., a village). Thus, the demarcation of urban/rural areas is a challenging concept and a single definition for the distinction between urban/rural areas would probably not fit all cases. It is, perhaps, more desirable to make geographic split based on mobile traffic demand and growth potential (e.g., population density) than land morphology. However, such split should consider the potential evolution of demand and the aim of reducing the digital gap between the densely and scarcely populated areas and assure the same quality of experience across UK territory. Beyond urban areas – where additional mid-band spectrum is necessary to address the mobile traffic growth and the increasing

	demand for quality (e.g., lower latency and higher reliability) – also in rural areas, the spectrum in the upper 6GHz band can address the digital gap, providing affordable high-speed fixed wireless access (FWA) connectivity to small towns and villages, increase the available capacity along major transport routes, and help addressing the connectivity needs of industrial use cases. Moreover, past experience has shown that even for the provision of coverage in rural areas, the use of licensed spectrum prevails with respect to reliability of both connection and services, therefore the use of the upper 6GHz to provide macrocellular connectivity also in rural area should be considered as an option for the future.
Question 2(b): Similarly, what are the priorities from the point of view of Wi-Fi deployments?	*Is this response confidential? – N* We would like to highlight that the use of unlicenced spectrum under a technology neutral framework should allow for level playing field between all technologies that can make use of such unlicenced spectrum, with Wi-Fi being one them. NR-U should be considered as well as an equally potential technology for such use. The use of unlicenced spectrum is mainly targeted towards consumer use and non-critical systems, primarily for indoor and local scale applications that do not require guaranteed quality of service. We agree with the view expressed in the RSPG Draft Opinion on 6G that states that "License exempt spectrum could be used as the last few meters link for the FTTH network at homes or even from mobile smartphones devices to other devices but will always be relying on the fixed or mobile networks to provide end to end connectivity to the users. Due to the license exempt spectrum usage, limited coverage, limited power to provide the last few meters link, the spectrum needs for license exempt are covered already with the identified spectrum in Europe." As such, we see the role of unlicenced spectrum as complementary to fixed lines and to mobile networks in licensed spectrum. We

	therefore consider that the best opportunities for the upper 6GHz band will arrive from using this spectrum for IMT for macro cellular deployments.
Question 3: What are your views on a modified AFC or SAS-type approach to enable hybrid sharing? What additional work do you think would be required?	*Is this response confidential? – N* In a potential approach towards hybrid sharing between licenced and unlicenced services in the upper 6GHz band, we ought to emphasise once more that priority should be given to IMT services. We believe that a database approach, implemented in the unlicenced side, as opposed to an approach relying only on sensing, could be a possibly workable solution, but significant modifications should be made to ensure smooth operation. Some examples of the questions that need to be answered are, how quickly the database is being updated, how quickly the spectrum can be allocated, how the aggregate interference is taken into account or how a mobile handset that uses the 6GHz band for tethering can be registered in the database. In any case, in a sharing approach based on databases, as mentioned, priority should be given to IMT services as it is really difficult to conceptualise and justify any approach on the opposite direction. It is also worth mentioning that the way the SAS database is described in Ofcom's consultation does not fully entail the way it is actually used in CBRS. In CBRS, even licenced-by-rule users need to be added in the database, not only to be protected, but in order to have the right to access spectrum and operate. We believe that the development of a potential sharing system does not need the complexity of SAS/ESC, but it probably needs to be more like an advancement of AFC, dealing with the changes in the sharing environment to cater for the needs of the users.
Question 4: How could existing access protocols and sensing mechanisms be leveraged (i.e., those in Wi-Fi or 5G NR-U) to enable hybrid sharing?	*Is this response confidential? –N* Sensing has been proven not to be a very robust mechanism for sharing. As mentioned in

	Ofcom's consultation, tests on the Wi-Fi ACS mechanism indicated that it is operational only when the Access Point is powered-up or rebooted. If unlicenced services were to utilise sensing mechanisms to detect IMT signals, significant changes should be made to Wi-Fi sensing protocols. First and foremost, such mechanisms should be guaranteed that they are constantly in operation. Suitable triggering thresholds would need to be identified, agreed and implemented to ensure accurate and timely detection of IMT signals. It is also necessary that the sensing mechanisms implemented in unlicenced devices eliminate the potential of false positives when sensing the wireless environment. Furthermore, possible consideration should be made towards sensing the power emitted from the IMT user equipment. It is worth emphasising that sensing cannot be a suitable solution for IMT services. Hidden node phenomena would not allow the detection of other macro-cells and they would end up transmitting simultaneously creating packet collisions. Furthermore, contention among IMT users would significantly increase, resulting in large congestion in mobile networks. In addition, IMT MAC protocols are designed to allow managed QoS. Thus, any introduction of sensing in IMT such as e.g., LBT as a mechanism for sharing would dismantle the IMT QoS management.
Question 5: What mechanisms could potentially enable device-to-device connectivity?	*Is this response confidential? – Y / N (delete as appropriate)* If device-to-device indoor use is considered to be the use case requiring additional licence exempt spectrum, the additional frequencies for RLAN that are already available should be considered and progressively exploited (e.g., the gradual take-up of lower 6GHz, as well as the 60 GHz band, 61-71 GHz, in the longer term).
Question 6: If hybrid sharing is eventually adopted, and requires licensed mobile to	*Is this response confidential? –N*

operate at medium power, in what way would mobile networks use the upper 6 GHz band?	A potential restriction of macro base stations to medium power only, would be very limiting for IMT. Limiting the in-band power of mobile network Base Stations, would not enable cost efficient adoption of the band for wide area coverage. Based on traffic forecast (Figure 1 in this response), additional spectrum is needed to address the cellular data growth in the medium term. Nevertheless, IMT is identified on a technology neutral basis, thus any de-facto restriction imposed in the power of IMT base stations in the upper 6GHz would put additional unnecessary challenges in utilising the band for the advancements of 5G and for future generations of mobile networks.
Question 7: How would you suggest that the mechanisms presented here can be used, enhanced, or combined to enable hybrid sharing or are there any other mechanisms that would be suitable that we have not addressed?	*Is this response confidential? –N* Looking at possible alternative mechanisms for sharing, it is worth acknowledging that any split of the band is very likely to be irreversible. It would fragment the ecosystem and it is also likely to pose challenges in cross-border coordination. In any approach that considers sharing of the upper 6GHz band, priority should be given to licenced services over unlicenced services. Regarding sensing, any combination that considers enhancement of sensing mechanisms would likely result to additional complexity for products in the 6GHz band, eventually leading to increased cost. As we also highlighted in Q4, sensing has not been a robust mechanism for sharing and it would require significant and additional enhancements to ensure its appropriateness. With respect to a possible combination of sensing with databases, the experience we have from sensing using a separate network of external sensors, such as the ones used along the US coast to detect ships and inform SAS on how to use spectrum, has shown that such an approach is problematic. In any case, sensing (on its own or as a combination) in the context of sharing between licenced and unlicenced services from our perspective, should only be considered as a candidate mechanism for unlicenced services. In Q4, we have indicated thoroughly the

	reasons why we believe it is not suitable to be implemented on the IMT side. Regarding databases, the implementation of databases alongside a geographical separation for unlicenced services to protect IMT could be an option to be further investigated, however we have doubts on how realistic from a policy perspective such approach can be. Unlicenced services in the 6GHz band could be allowed to operate in areas where IMT services are not deployed (e.g., rural), subject to the consideration that sufficient separation from the areas where IMT services are in use is ensured. The question however of how this approach can be implemented from a regulatory perspective still remains to be answered.
Question 8(a): Assuming the future of the band includes indoor use for Wi-Fi and outdoors use for mobile: How could this be achieved without creating or suffering interference?	*Is this response confidential? – N* At the moment, CEPT ECC PT1 through a dedicated work item, has started looking at the potential sharing of the band between licenced and unlicenced services and we expect this topic to be further studied, in more detail, after WRC-23. The sharing discussions at CEPT ECC PT1 so far, haven't narrowed down the focus of the sharing potential to a possible indoor/outdoor split. As also highlighted in Q1, there needs to be an accurate and clear definition for indoor and outdoor environments. Although Wi-Fi use is expected to be predominantly, if not only, in indoor environments, we believe that an outdoor/indoor split of licenced/unlicenced services is very challenging from a technical perspective, and it hides significant coexistence risks. The challenges of interference in the "indoor-outdoor boundary regions" will be high and user experience will degrade for both WiFi and IMT users, unless one network has a higher priority over the other while accessing the spectrum. This, in turn, may cause the terms of operation unattractive for the users with lower priority. The indoor/outdoor sharing concept of unlicenced/licenced services, in our view, can most likely be conceived through spectrum

	sensing mechanisms. Since sensing is not yet a robust and reliable mechanism and since material changes need to be made in Wi-Fi protocols to ensure coexistence is feasible, we believe that an indoor/outdoor sharing does not represent a feasible sharing approach.
Question 8(b): Could there be a combination of technical adjustments such as power limits and other mechanisms (including databases or sensing mechanisms)?	*Is this response confidential? – N* As we mentioned in our response to Q6, we believe that adjustments of power limits for IMT Base Stations would not be a suitable consideration, neither on its own nor as part of a combination of mechanisms. Thus, we encourage Ofcom to not include it in their considerations towards a potential sharing approach as the disadvantages would outweigh any benefits that Ofcom sees in sharing this band. Even though CEPT ECC PT1 is currently investigating the potential for sharing between licenced and unlicenced services in the upper 6GHz band, we feel necessary to reiterate that in a potential sharing approach priority should be given to licenced IMT services. We already know that sensing has proven to not be a reliable sharing mechanism and we definitely do not see it as a suitable mechanism to be implemented on the IMT side in this band. In a possible seek of combining different mechanisms to achieve sharing in the band, databases together with geographical separation and prioritisation of IMT services, can be jointly implemented in the unlicenced side to additionally enhance the coexistence potential. For such an approach to be efficient, enhancements in the database solutions as well as suitable regulatory considerations should be made.
Question 9(a): We are interested in input about the importance of the upper 6 GHz band for its incumbent users, and on the potential impact of hybrid sharing of the band. What evidence do you have on whether incumbents are likely to coexist with hybrid sharing of the band with mobile and Wi-Fi? Are	*Is this response confidential? – N* No answer

there unique advantages of the upper 6 GHz band for these uses?	
Question 9(b): What are your views on the initial analysis we have conducted around hybrid sharing and coexistence with incumbents?	*Is this response confidential? – N* No answer
Question 9(c): For any incumbent uses that you view as unlikely to be able to coexist, what alternatives are there? What are the barriers that might prevent those alternatives?	*Is this response confidential? – Y / N (delete as appropriate)*
Question 10: Do you have any other thoughts that you would like to share about hybrid sharing in the upper 6 GHz band, or about hybrid sharing more generally and its potential for applications in other bands?	*Is this response confidential? – N* The concept of spectrum sharing has multiple dimensions. Depending on the services involved, sharing can be conceptualised as coexistence, which has a more static approach, or as opportunistic, which has a more dynamic approach. In all cases, there is a clear set of rules defining which service is prioritised and under what conditions the services involved may use spectrum. Since the nature and the requirements of the different services that may be involved in spectrum sharing approaches can vary, it is likely that a single approach may not be suitable for all spectrum bands. To identify and develop a suitable spectrum sharing approach, the characteristics of the frequency band, the deployment locations, the nature of usage, the protection criteria and the cost of acquiring spectrum are some of the parameters that have to be considered when trying to determine a suitable spectrum sharing mechanism. Alongside the consideration of the implementation complexity for specific mechanisms, a clear prioritisation of spectrum usage needs to be defined that ensures smooth coexistence among the services involved. The hybrid sharing approach can intuitively work in higher frequencies (e.g., mmWave) due to the propagation characteristics of those frequency bands, where signal attenuation occurs rather rapidly, especially in non-LoS conditions and building penetration loss is also high.

Question 11: Do you have any other comments to make on these proposals or on the future use of the upper 6 GHz band?	*Is this response confidential? – N* The proposed hybrid spectrum sharing concept of the upper 6GHz band between the two most dominant and widely deployed mobile services, will result in high number of emissions. Inevitably, this will increase the noise floor, creating additional challenges in sharing. Our primary view is that the upper 6GHz band should be allocated for licenced IMT use as this will enable the industry and the ecosystem to evolve towards the advancements of 5G and the networks of the future in a sustainable and cost-efficient manner. In addition, authorising the upper 6GHz band for licenced use will provide balance in the way the entire band is authorised in the UK. In the case where Ofcom sees no other possible use of the upper 6GHz band for licenced IMT services except of sharing it with unlicenced services, our view is that this is only feasible if the use of licenced IMT services are prioritised over unlicenced. In terms of the potential mechanisms for unlicenced services to protect licenced use under a spectrum sharing approach, spectrum sensing has been proven not very reliable or efficient mechanism. A database framework could be considered as a possible candidate to create the necessary geographical separation that ensures no interference into the coverage area of licenced services. For that, appropriate protection thresholds and further modifications to the Wi-Fi protocols need to be made to ensure smooth coexistence.

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