RSPG Questionnaire on

Long-term vision for the upper 6 GHz band

Nokia response

19 August 2024

Introduction

Nokia welcomes the opportunity to respond to the RSPG's "Questionnaire on Long-term vision for the upper 6 GHz band" and provide our view on how the upper 6 GHz band would provide the most benefits to the European citizens and industry.

Hereinafter we express Nokia's views as a B2B technology innovation leader in networking, bringing together the world's people, machines and devices to realize the potential of digital in every industry.

Nokia is of view that the European Union and its Member States should place the electronic communications network at the center of its digitalization and broader economic strategy, striving to become the leader in building, running, and successfully monetizing networks that sense, think and act. The EU should be determined to implement its digital connectivity strategy in a consistent way, avoiding policy initiatives that disturb or weaken the competitiveness and investment capacity of its European telecom operators and equipment suppliers. EU policies should support a broad and dynamic European telecom market that retain its competitive position with the rest of the world.

Decisions on the long-term use of the upper 6 GHz band should consider the overall benefits that the use of this band can deliver optimal public benefit in terms of socio-economic impact as well as efficiency in the spectrum utilization of the band. Nokia is of view that the best outcomes can be achieved only when the full upper 6 GHz band is exclusively licensed to deliver mobile connectivity to the European society – governments, citizens and industries.

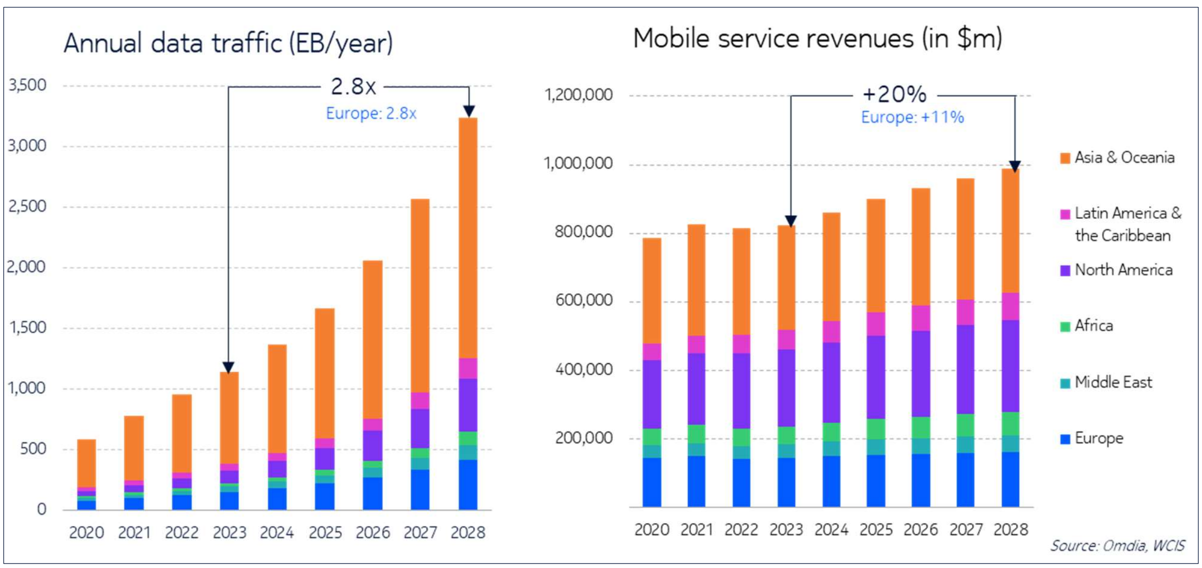
This response is complementary to the contributions provided via the industry association of which Nokia is associated member or observer, GSMA and ETNO, respectively.

A. Questions directed to the MFCN and WAS/RLAN stakeholders:

I. Explain the demand for MFCN or WAS/RLAN in the upper 6GHz band before and beyond 2030

Data volumes transported over mobile networks have grown tremendously over the past decades, fueled by the ever-evolving mobile technology availability and the new use cases for it. At the same time, pervasive mobile data has become ever more affordable to consumers and businesses at constant or declining monthly spends, translating into massive reduction in the price per GB delivered.

Data growth is deemed to continue with more intense use of existing services, e.g. video, as well as with new use cases like AR/VR, and ubiquitous access to metaverse expected to be delivered by 5G-Advanced and 6G. E.g., Omdia WCIS predicts ~3x higher data volumes in 2028 as compared to 2023 at only 20% CSP revenue growth globally, and as little as 11% revenue growth in Europe[1].



Policy and regulatory support from the European administrations is required to address the massive growth in demand for mobile data, that is challenging CSPs and their suppliers to deliver additional capacity at almost constant consumer spend. Enabling mobile network capacity to accommodate triple volume of data by 2028 – economically and environmentally sustainable – cannot be achieved without timely and affordable access to the upper 6 GHz band (6425-7125 MHz) in the short to medium-term to address the service-impacting high traffic loads. We note that depending on the national market conditions, including the affordability of the service and the existing and new use cases that emerge with the evolution of technology and network capabilities, mobile data traffic growth can surpass the averaged figures, requiring CSPs to provide additional network capacity in the 2027-2028 timeframe.

[1] Further analysis of the forecasted data indicates that the ~2.8x increase in traffic correspond to a 11% increase in the mobile broadband subscriptions, suggesting that the 11% revenue growth corresponds to the addition of subscriptions at constant monthly revenues per subscription.
Traffic forecast by Omdia WCIS is consistent with Nokia Bell Labs 2024 traffic projections that indicate a positive trend, with ~25-30% annual growth, leading to a x3 higher data volumes over 5-year period.

Authorising the licensed use of the upper 6 GHz band for wide area macrocellular deployments will enable efficient and economic rollouts on existing infrastructure grids, providing the high-performance and quality development of 5G/5G-Adv, which, in turn, will lay the ground for 6G. A successful launch – where appropriate – of a competitive 6G in Europe[2] using the upper 6 GHz band can only start with at least 200 MHz assignments per CSP in this band.

We note that the lower 6 GHz band (5925-6425 MHz) has been assigned in the European Union as of June 2021 under a licence-exempt regime for WAS/RLAN applications, doubling the mid-band spectrum resources available for such use. However, reports on Wi-Fi technologies and markets, e.g., ABI Research, forecast a modest European market share of equipment supporting this band (triband Wi-Fi 6E and Wi-Fi 7) for both residential and enterprises: 7.6% of total 2023 shipments, forecasting 11.2% for 2024, and cumulated shipments of 34.8% over the 2020-2030 period. With these numbers in mind, a saturation of the lower 6 GHz seems unlikely in the medium-term. As such, we do not see the need to consider additional spectrum from the upper 6 GHz band for Wi-Fi, considering that Wi-Fi 8 equipment (using mmWave frequencies) will also account for 14% of the market by 2030.

The existing allocations at 2.4 GHz, 5 GHz and lower 6 GHz bands to licence-exempt use are deemed sufficient for the evolution of Wi-Fi, considering that it provides the last meters of wireless access to fixed broadband connections. Should additional Wi-Fi access requirements materialize in the longer term, these can be met with the equipment upgrade to newer Wi-Fi standards and/or the densification of Wi-Fi access points within premises.

II. Provide information about the sustainability of the above explained demand, especially the:

1) Environmental impact assessment

As underlined by the RSPG report on the role of radio spectrum policy to help combat climate change no information is available yet regarding the relationship between frequency band and energy consumption. Hower, the spectrum policy design will benefit from an approach that is environmentally oriented and principles like technology neutrality, timely spectrum availability, larger contiguous spectrum bands, longer licence durations and transparent licensing and licence renewal conditions have their role in reducing the environmental impact of mobile networks.

Achieving the European Digital Decade connectivity goals in an economic and sustainable manner cannot be done without timely access to suitable and affordable spectrum in the short to medium-term. Combined with the technology and semiconductor evolution, the spectrum can provide for the expected data growth efficiently and affordably, as explained below.

The 5G rollouts using the C-Band typically add 100 MHz carriers to existing macro sites, effectively doubling the amount of DL RF resources available from multiple FDD bands, with a single radio unit per sector. The evolution of semiconductor allows to process increasingly larger RF bandwidths and more antenna elements at constant cost and energy efforts. Thus, such 5G upgrades with massive MIMO antennas also add spectrum efficiency, leading to a DL capacity and performance increase per macro sector of a factor of 3x and more.

[2] In line with EU's goals of fostering Europe's technology sovereignty in 6G as set through the EU R&D funded programmes under SNS JU, HEXA-X I and II.

The next logical upgrade step to growth in capacity and performance is to add an upper mid-band 200 MHz carrier per sector to existing sites, again doubling DL RF resources and further increasing the spectrum efficiency in the additional spectrum with more antenna elements. To permit for plannable Quality of Service and optimum spectrum efficiency, such spectrum must allow for macro-cellular transmit power levels and exclusive spectrum access when and where used.

Consequently, securing additional spectrum in upper 6 GHz – ideally 200 MHz per CSP – with the right conditions for wide area macro-cellular mobile deployments is the only way forward for the projected growth environmentally sustainable and affordable to consumers and business. Any less, and the spectrum will become unattractive, disincentivizing operators from acquiring spectrum as it will be unable to support growing needs.

The early stage of technology testing demonstrates the potential of the upper 6 GHz spectrum to provide additional capacity at similar coverage as for the 3.5 GHz, using its' existing macro grid and thus, reduced network footprint. Nokia-Telia trial in Finland in June 2024 confirmed the macro-grid readiness of upper 6 GHz with M-MIMO, showing that massive capacity can be added in urban areas where higher demand for broadband is experienced, and high throughput can be achieved in suburban or rural areas. This offers CSPs an evolution path to 5G-Advanced and 6G in the future.

2) Social economic impact

For reasons of economic, sustainability, future connectivity requirements, competitiveness and security, assigning the upper 6 GHz band for mobile licensed wide-area mobile deployments is in Europe's best social and economic interest.

The direct link between the economic development and the increased deployment of broadband infrastructure (fixed and mobile) is well documented. Advanced digital network infrastructures and services form the basis of the future competitiveness of all sectors of the European (and global) economy, for GDP growth as well as the digital and green transition of society and economy. Businesses across Europe will require additional connectivity for the digitalization of their operations and in direct link to their goals of energy efficiency and carbon footprint reduction.

As explained above, adding 200 MHz per CSP from the upper 6 GHz band can enable the efficient delivery of the 3x data traffic increase at constant consumer spend in the short-term.

Digitization of industries can also benefit from availability of upper 6 GHz to provide both indoor and outdoor connectivity, as e.g., in manufacturing: Nokia's connected and digitalized factories (Oulu, ASN in Calais) have seen productivity increases of 50% and energy-efficiency improvements of up to 30% and annual cost savings of millions of euros.

A recent GSMA Intelligence report[3] concluded that 5G is expected to generate $960 billion in gross domestic product (GDP) in 2030 on a global basis, with $610 billion of this being attributable to deployments in the mid-bands, which represents almost 65% of the overall socio-economic value generated by 5G. According to the report, up to 40% of the expected benefits of mid-band 5G could be lost if no additional mid-band spectrum is assigned to mobile services.

Last but not least, from both environmental and economic perspectives, the existing 5G network grid should be reused as much as possible as we move towards 5G-Advanced and 6G. Mobile

[3] GSMAi report "The Socio-Economic Benefits of Mid-Band 5G Services"

network densification using mmWave spectrum (e.g., 26 GHz) can significantly boost capacity, but its' limited coverage would require acquisition of many new sites and much more infrastructure, increasing both network rollout schedules and project costs. Additionally, the limited device ecosystem further restricts the viability of such densification. The trade-off between extreme densification and deployment of additional capacity with new mid-band is in favour of mid-bands.

Extreme network densification to compensate the deficit of mid-bands spectrum for delivery of the targeted performance levels would translate into 3-5x higher total cost of network ownership over a ten-year period and 1.8-2.9x greater carbon footprint. This, without addressing the practical restrictions in acquiring the additional sites required within an already dense network grid, the technical challenges including harmful interference management and mobility management, or the economic feasibility in terms of both CAPEX and OPEX resulting from such extreme densification.

Even through the refarming of spectrum, the modernization of existing networks, or by the introduction of new features, is it likely that the capacity gap left by the absence of the clean spectrum afforded by the upper mid-band cannot be overcome.

III. Provide information about:

1) The possible role of the upper 6GHz for MFCN or WAS/RLAN

For **MFCN**, the upper 6 GHz band is crucial to provide additional wide-area mobile network capacity to address the service-impacting high traffic loads the macro base stations in urban areas will experience by 2027-2028, driven by the affordability of mobile data traffic and the existing and new cases emerging with the evolution of technology and network capabilities. With spectrum allocated under technology-neutral conditions, European CSPs will equally be able to efficiently use the upper 6 GHz band for initial 6G deployments as soon as 2030. To this point we underline again that the successful launch of a competitive 6G in Europe can only start with at least 200 MHz assignments per CSP in the upper 6 GHz band, in a harmonized, coordinated and timely manner across Europe, to exploit economies of scale and facilitate cross-border interoperability.

It is therefore important that upper 6 GHz to be assigned with the right regulatory conditions allowing the macrocellular deployments that leverage existing infrastructure and earlier 5G investments, allowing for the provision of a 5G /5G-Advanced/6G services in a more efficient, secure, resilient, economic and sustainable way. Assigning this spectrum with restrictive regulatory conditions would negatively impact its potential and the investments associated with the deployment of the band for wide-area footprint.

In our view, no additional spectrum from upper 6 GHz is necessary for **WAS/RLAN**, as spectrum is not the bottleneck of the Wi-Fi services. Higher throughputs required for such services can be easily provided through optimization of access points configurations (densification) and upgrading to newer standards such as Wi-Fi 6/6E. Upgrades to Wi-Fi 6E will take advantage of the underutilized lower 6 GHz band. However, considering the license-exempt regime of the WAS/RLAN services, we acknowledge that upgrading Wi-Fi routers to newer generations of the IEEE 802.11 standards – to make a more efficient spectrum use – is uncoordinated, driven by the fulfilment of individual connectivity needs of many different users. The use of the upper 6 GHz by Wi-Fi requires compatible equipment. However, forecasted shipments of Wi-Fi 6E and 7 tri-band equipment makes difficult to foresee a rapid adoption rate of such access point equipment that would lead to a congestion of the already existing spectrum in the lower 6 GHz band.

Lastly, while acknowledging the **shared use** of upper 6 GHz discussions taking place in the CEPT, Nokia is of view that several challenges associated with shared use need to be attentively considered to preserve the possibility for MFCN to be deployed with standard power macro base stations by reusing existing infrastructure. Any reduction in MFCN power would negatively impact the successful deployment of mobile networks, rending this spectrum inefficiently used. Equally, non-traditional options such as indoor/outdoor separation or spectrum sensing mechanisms and database sharing solutions, while possibly theoretical appealing may lead in practice to challenges in deployments and therefore limited successful implementations. Concerns with such solutions range from complexity of solutions considered, implementation and running costs, breakdown of roles between governments and stakeholders, to the net benefit of such deployments to the two technologies.

2) Use cases, expected deployments (e.g. number of BS for MFCN) and timeframe

The 700 MHz of spectrum in the upper 6 GHz is needed to accommodate – in both an economic and sustainable manner – the three-times growth of data traffic by 2028 compared to 2023 (providing additional capacity), while also helping to fulfil the increasing demand for superior quality of service (lower latency and higher reliability). Enhanced mobile broadband (eMBB), massive machine-type communications (mMTC), and ultra-reliable low-latency communications (URLLC) are expected to remain the main drivers for additional capacity prior to the introduction of 6G starting 2030. While noting that demand vary per country, even per operator, we expect deployments in the upper 6 GHz to follow the path of 3.5 GHz initial deployments[4], using the same infrastructure grid pending on capacity demands in the network. Likely, additional capacity demands will appear in sites serving many users in dense urban and suburban areas, but new type of use scenarios, e.g. fixed wireless access (FWA) may impact on demands as well. Noting that deployments of 5G using the 3.5 GHz band cover already, on average 50% of the EU population (DESI index 2024), there is a high potential for deployment of upper 6 GHz band to use its grid.

IV. Provide information about standardization and technology impact

The WRC-23 achieved the IMT identification of the 3GPP band n104 (6425-7125 MHz) and defined its technical regulatory conditions. 3GPP specification on the conformance to the limits set at WRC-23 for the use of the upper 6 GHz band n104 are under development and due to be finalized at the end of this year (2024).

Equally, several trials and tests have taken place in the last couple of years, latest one being done by Nokia and Telia in June 2024.

[4] E.g., France, ANFR: L'Observatoire des réseaux mobiles shows that on August 1st, 2024, the 3.5 GHz band was authorized to be used in 45K sites, out of which 33.7K sites were operational (30.9K sites in total, considering the shared ones). Note that operations in the 3.5 GHz band started in December 2020 (more statistics in ANFR's report. According to EC's 2024 DESI Report, this corresponds to ~65% households 5G coverage using the 3.5 GHz band.

From technology perspective, Nokia sees good opportunities of deploying both 5G-Advanced and 6G services using this band, depending on the market demands, with large carriers of multiples of 100 MHz, as explained in this response. We are of view that the optimal use of this band for wide-area mobile services require a minimum of 200 MHz per operator for efficient and effective rollouts.

B. Questions directed to the stakeholders providing incumbent services in the upper 6 GHz band, such as Fixed service

I. Explain impact of possible future usage of the upper 6GHz for MFCN and/or WAS/RLAN on existing services:

1) What are your current and future spectrum needs (before and beyond 2030) in the upper 6GHz band?

The 6 GHz usage by fixed links for long-haul applications vary in the national European markets and by CSPs, being of higher relevance in less populated areas where alternative solutions such as fibre are deemed unjustified. Overall, the use of the 6 GHz band for fixed links beyond 2030 highly depends on the national licensing decisions, the alternative demands for this spectrum, and the alternative solutions/bands.

Likely, CSPs could decide preserving some fixed links to continue delivering affordable connectivity to consumers and business in these more rural areas. However, while some links could be maintained in the upper 6 GHz range, others may be replaced with other solutions or moved in other portions of the 6-8 GHz range. In dense urban/suburban areas – where the need for additional licensed spectrum from the upper 6 GHz will arise initially – we expect balanced CSPs decisions to facilitate the mobile macro cellular deployments where/when needed.

2) What impact on your service do you expect from the introduction of MFCN and/or WAS/RLAN in the upper 6GHz band?

The licensing conditions defined by the NRAs to allow MFCN operations in the upper 6 GHz band should consider the existing use and set conditions to protect them, if necessary, e.g., consider ways to assure coordination between fixed service (FS) and future IMT systems in the areas of main interest for IMT – the dense urban environments (coordination/protection zones). Timely decision will allow CSPs to start planning the potential MFCN deployments and the measures required to coordinate and protect their FS links in the band (e.g., consider alternative solutions for the fixed links where/when needed to facilitate MFCN deployments, such as other FS frequencies, fibre).

WAS/RLAN proponents have interest to deploy equipment using this spectrum in densely populated areas. However, the license-exempt nature of these operations cannot guarantee risk-free deployments, including in areas where FS are in use. The ongoing studies in CEPT SE45 on the impact of potential introduction of RLAN in the band indicate possible risk of interference. The latest draft ECC Report also acknowledges that the interference models and protection criteria have restrictions, and the ongoing investigation of time-varying interference (such as RLAN) impact to FS may change the results of RLAN/FS sharing to the worse. It would be premature to open any portion of the upper 6 GHz band to RLAN as it may create additional and uncontrollable interference into fixed links services.

3) What measures could improve compatibility from your perspective?

Generally, fixed services are using frequency bands with primary allocation for the service and equipment were designed considering such primary use of the upper 6 GHz band and incumbency of the service, with no specific measurements to protect FS against other services. FS are deemed not so sensitive to other services, but on case-by-case basis, measures to allow coexistence are considered.

Coordination in frequency or geography is a well-known measure permitting compatibility and co-existence of FS and MFCN operations. Licensing the upper 6 GHz band for MFCN would add a limited number of additional players in the band, facilitating its sharing among incumbents and new licensees, and would allow professional planning of MFCN and FS services to ensure the best coordination and coexistence of the two services and minimize the interference.

Uncoordinated license-exempt operations in any portion of the upper 6 GHz band may lead to unpredicted interferences into FS and mitigation measures might not be in place.

Annex: Nokia-Telia trial in the Upper 6 GHz band

In June 2024, Nokia and Telia completed a successful outdoor field pilot in the upper 6 GHz range to test the potential of adding supplementary capacity and coverage to existing macrocell sites in dense urban areas for next generation 5G-Advanced and 6G networks.

The trial performed at the Nokia test site in Espoo, Finland, confirmed Nokia's technology leadership in offering seamless network evolution path to mobile operators when 5G-Advanced and 6G networks become available.

- The trial used a Massive MIMO antenna based on Nokia's AirScale Habrok radio and test terminal from MediaTek with integrated antennas;
- The pilot demonstrated macro-grid-ready uplink performance of the upper 6 GHz spectrum band used with Massive MIMO radio, confirming readiness for large area capacity growth for 5G and 6G networks;
- The test confirmed that upper 6 GHz range will add crucial capacity to existing cell sites to support next-generation 5G-Advanced and 6G networks.

The pilot examined whether the uplink coverage on the new, higher frequency is compatible with the existing inter-site distances. Telia and Nokia tested the upper part of the band (n104) and used a 3.5 GHz massive MIMO cell of the same RF-bandwidth across various distances to replicate different real-world scenarios. The field tests confirmed the macro-grid-readiness of the upper 6 GHz spectrum used with Massive MIMO, showing that:

- Massive capacity can be added in urban areas, where higher demand for TDD broadband emerges;
- High throughput can be achieved in suburban or rural areas.

Results confirmed that upper 6 GHz band offers operators an evolution path to 5G-Advanced and 6G in the short- to medium-term future, enabling enhanced digitization in a sustainable way and using existing site grids for faster deployments with reduced environmental impact and less carbon emissions than the alternative of adding capacity by building additional new sites.

The field pilot demonstrated Nokia's readiness to support the integration of the bandwidth of the new spectrum in the upper 6 GHz seamlessly into the mobile operators existing networks, allowing them to provide coverage from the existing macro cell sites.

Initial findings: Based on outdoor-to-outdoor field measurements, the RSRP[5] values (UL coverage) for 7GHz are equal to 3.5 GHz up to a 650 m distance from the rooftop antenna. Above this distance, the RSRP value attenuates more for 7 GHz as compared to the 3.5 GHz spectrum: 9 dBm attenuation at 790 m away from the antenna, and 12 dBm respectively, when 1000 m away from the radio. Nokia will publish more measurements during Q4 2024.

<u>Note</u>: the RSRP measurements were done using a reduced power of 52 dBm for the 7 GHz radio (23 dBm less) due to test license limitation, while the 3.5 GHz radio used 75 dBm output power.

Initial findings: In good radio conditions (256 QAM), using & 100 MHz bandwidth for the 7 GHz spectrum, we noticed a 170 Mbps UL speed. By using a 200 MHz bandwidth, the UL speed would reach over 300 Mbps UL speed. Nokia will publish more measurements during Q4 2024.

[5] RSRP – Refence Signal Received Power, the power of the main signal received from the cell tower (in dBm)