Questionnaire on
Long-term vision for the upper 6 GHz band

Vodafone Group response

Under the Work Programme2024 and beyond, the Radio Spectrum Policy Group is engaged in building a long-term vision for the upper 6 GHz band (6425-7125 MHz) and in providing policy recommendations on how to best organise its future use to maximise its contribution to the achievement of digital connectivity targets for Europe, as laid down in the Digital Decade Policy Programme 2030 (DDPP)[1].

The following questionnaire will help RSPG to get the additional information needed for this task.

Please note that information provided in response to this questionnaire will be used by the RSPG subgroup on upper 6 GHz band to develop the draft Opinion.

Please note that for transparency reasons, the names of organisations replying to the questionnaire will be published; however, a stakeholder's reply will be published only if the stakeholder has not explicitly claimed confidentiality. All stakeholders are invited to produce non confidential versions.

Deadline for responses: 20 August 2024 at 12:00 (noon) CEST

Please respond to: cnect-RPSG@ec.europa.eu

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

Please limit your answers to maximum 4-5 pages and favour responding through associations as far as possible.

The RSPG intends to build a long-term vision for the upper 6 GHz band by providing policy recommendations on how to best organise the future use of this band in Europe with the goal to maximise the contribution of this part of spectrum to the achievement of digital connectivity targets for Europe, as laid down in the Digital Decade Policy Programme 2030 (DDPP)5. The DDPP highlights the importance of connectivity infrastructure and accordingly sets political targets for 2030, including for the deployment of networks with gigabit speeds. All end users at a fixed location should be covered by a gigabit network up to the network termination point and all populated areas should be covered by a next-generation wireless high-speed network with performance at least equivalent to that of 5G. In this context, please answer the following questions:

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

MFCN Demand

Vodafone's mobile data traffic in Europe has quadrupled over the past 5 years (Figure 1). In the last year alone, traffic increased by 24% across Vodafone markets in Europe and by 28% across all markets globally.

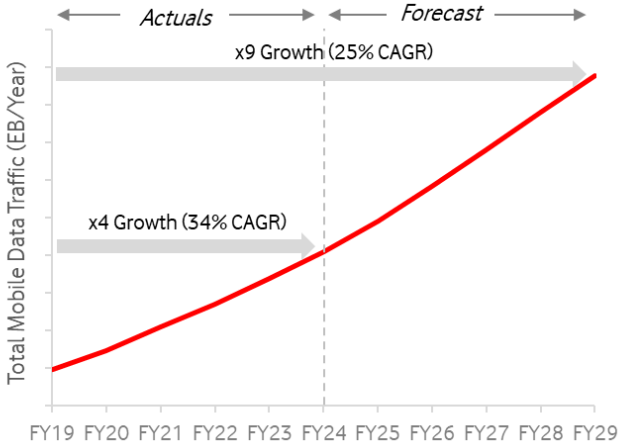

Figure 1: Mobile Network Traffic in Europe

[1] Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030

While the *percentage* year-on-year growth is naturally expected to slowly decrease over time, it is very important to note that traffic continues to grow strongly in *absolute incremental* terms (Figure 2).

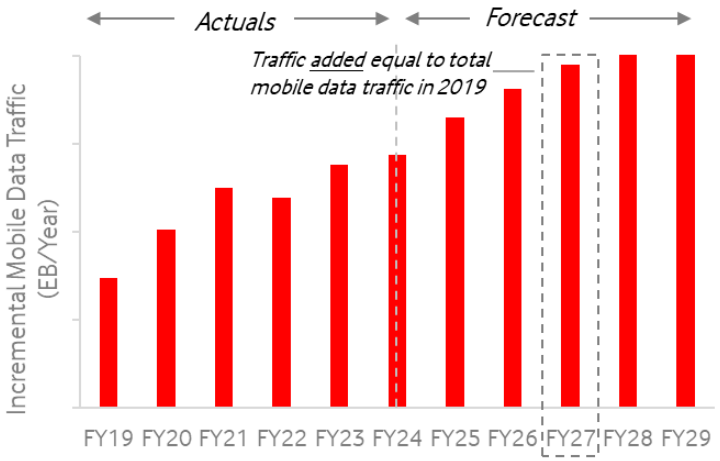

Figure 2: Mobile Network Traffic Growth in Europe

So, for example, we forecast that the *incremental* data traffic added to networks in 2027 will be equivalent to the *total* mobile data traffic carried in networks in Europe in 2019. By 2029, we estimate Mobile traffic levels in Europe will be approximately 9 times the levels in 2019. This is a relatively conservative traffic forecast based on a gradual evolution of services and their use today - however, there are clearly emerging technologies and capabilities such as Gen AI, AR/VR, edge cloud computing, network slicing etc which could result in considerably higher mobile traffic levels in the next 5 years.

Vodafone has modelled the impact of this forecast traffic growth on its mobile networks in Europe, based on real traffic distributions across sites (Figure 3).

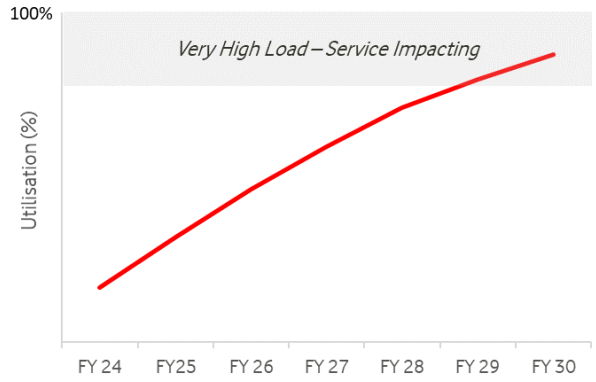

Figure 3: Urban Cell Utilisation for Top 10% Cells
(3.5GHz Layer, Large European network)

This analysis shows that some urban 5G cells in larger markets will begin to experience service-impacting capacity limitations on their primary 5G capacity layer (3.5GHz) in around 2028-29. This progressively worsens over time, impacting an increasing number of urban cells and the areas they cover. The availability and deployment of the U6GHz spectrum band for MFCN will therefore be critical to maintain and evolve 5G network services towards the end of this decade and beyond.

In a scenario where the upper 6GHz cannot be deployed for MFCN, Vodafone has conducted a total cost of ownership (TCO) analysis, assessing the network cost impact of meeting the forecasted growth in traffic by alternatively densifying its networks in urban areas, by building new small cell sites using already-deployed 3.5GHz spectrum or new mmWave bands. The estimated number of small cells required for a large market is not too dissimilar to UK Ofcom's reported figure

of around 30,000 to 50,000 small cells for the UK[1]. Figure 4 shows the very high prohibitive costs this extensive small cell build would require; between 7 to 15 times the annual TCO of deploying 6GHz spectrum on existing macrocell sites.

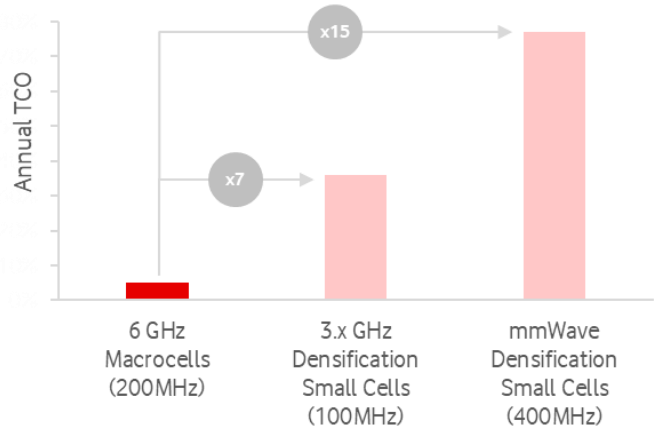

Figure 4: Network Cost Analysis with/without U6GHz macrocell deployments

Small cell deployments also come with significant practical and technical challenges, in terms of: finding, building and operating new sites in urbans areas; ensuring coverage and performance where required - across outdoor and, in particular, indoor areas (where the majority of traffic is consumed today) especially if using mmWave spectrum; and managing mobility and interference between different network layers and sites.

Therefore, the **deployment of 6GHz spectrum for MFCN is the *only* economical and practical way to provide the additional capacity requirements critically required for mobile networks towards the end of this decade.**

WAS/RLAN Demand

Vodafone is a converged service operator, offering customers in Europe both mobile and fixed broadband solutions. Through its combined investments in fibre and cable TV networks, Vodafone has the largest footprint of next generation fixed access technology of any provider in Europe. We therefore take seriously the need to ensure we can meet the future traffic needs of our customers, across both fixed and mobile environments.

While we expect traffic to continue increasing across both our Mobile and Fixed networks (albeit at a slightly lower growth rate for Fixed networks), **we do not see the existing spectrum available for WiFi in Europe (2.4GHz / 5GHz / Lower 6GHz bands) as a limiting factor in achieving the Europe's digital connectivity targets**, and in fact we see considerably more opportunities to improve the performance and capacity of WiFi solutions using existing bands available for this technology.

As an operator heavily utilising WiFi technologies for customers services, we would provide the following observations supporting our position:

- Coverage – rather than capacity - is the key constraint for WiFi performance in the home today. Routers deployed with boosters and extenders provide better coverage and performance. Without coverage enhancement features or methods, coverage will continue to be the key constraint for WiFi performance in the home.
- This is supported by information presented at the recent European Spectrum Management Conference[2] on a comprehensive trial conducted to assess WiFi performance in residential environments. This trial confirms:
    - Coverage (not spectrum) is the key factor constraining WiFi performance in the home and, when coverage is improved, performance improves significantly,
    - Existing WiFi spectrum across 2.4GHz / 5GHz / Lower 6 GHz bands is sufficient to meet the EUs 2030 digital connectivity targets of 1Gbps to the home, even in dense apartment blocks with high utilisation.

[1] Discussion paper: Meeting future demand for mobile data (ofcom.org.uk), Ofcom

[2] WiFi Indoor Connectivity Tests, Comtel, 19th European Spectrum Management Conference, Brussels, June 2024

- Another constraint today is the widespread use of legacy WiFi Access Points, operating to pre-WiFi 6 standards and delivering inferior performance. Wider adoption of the latest generation access points, as Vodafone is driving today, with more spectrally efficient features, has already shown to considerably improve performance.

- Going forward, WiFi will evolve further, with new WiFi-7 features[1] such as Multi-link Operation (MLO), 4K QAM, 16 Spatial Streams, Multiple RUs, Compressed Block Acks and, in future, WiFi-8 is expected to include additional features including further enhanced spectral efficiency and lower latencies for services on existing bands. All of these developments will lead to considerable improvement in WiFi performance, in existing bands.

- Alternative higher-frequency spectrum bands - better suited for short-range WiFi communications - such as mmWave bands being considered for WiFi-8, mean there are other spectrum options to expand WiFi capacity in future if necessary.

While the high cost of mobile spectrum licences provides a very real economic incentive for mobile operators to invest in the latest cellular technologies (such as 5G and massive-MIMO) to maximise the efficient use of this spectrum, the same is not true for WiFi. As one of Europe's largest broadband and WiFi service providers, we do not recognise claims made by major US tech providers that both the upper AND Lower 6GHz bands are needed to accommodate WiFi traffic.

Analysis of these claims indicates channel re-use factors of up to seven (meaning, at most, only one-seventh of total WiFi allocated spectrum is actually being used in any zone) – combining this with the assumption that 160 MHz channels are needed to support future demands in the home leads to the conclusion that more WiFi spectrum is needed. However, we have found no evidence to support this claim, while the recent detailed WiFi field trial in Italy mentioned above contradicts the US tech sector claims. Naturally, any system or technology requiring high (inefficient) channel re-use and with large channel bandwidths is going to be inherently spectrum inefficient and result in unrealistic and unnecessary spectrum demands.

Contrast this with mobile cellular technology, where frequency reuse patterns (last used in GSM) were abandoned 25 years ago with the introduction of 3G CDMA technology, which supported full frequency reuse between cells, and which has been further enhanced with 4G and 5G, including beam forming and steering, maximising efficient spectrum use.

As detailed above, we therefore believe future WiFi traffic can be accommodated effectively on existing licence-exempt bands, primarily through coverage improvements in the home, but also through ongoing modernisation of WiFi routers installed in the market and use of evolved WiFi standards enabling enhanced spectral efficiency and lowering latencies for services on existing bands.

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

1) **Environmental impact assessment**

As detailed in Section 1, to meet future growth in mobile traffic demand, Vodafone has modelled the relative cost of massively densifying its networks across Europe with small cells, as an alternative to deploying 6GHz spectrum on its existing macrocell network grid. This model considers the impact of energy consumption in the radio network and estimates **small cell densification would result in a 3 to 6 times increase in energy consumption** (Figure 5).

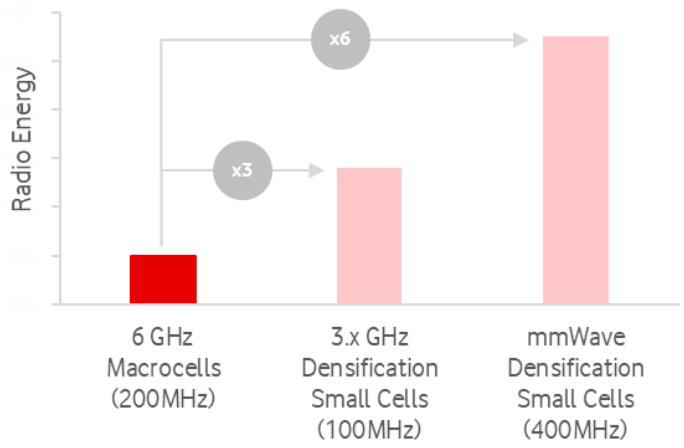

Figure 5: Radio Energy Analysis with/without U6GHz macrocell deployments

[1] Wi-Fi CERTIFIED 7 | Wi-Fi Alliance

This substantial increase would have a significant impact on carbon emissions from mobile networks and Vodafone's Net Zero emissions targets for 2030[1]. It is important to highlight this considers radio network energy alone and excludes any energy increases in other parts of the network (e.g. supporting transmission network) or the energy associated with civil works required to build the new sites. There are also significant environmental impacts which need to be considered in building these new sites across urban areas.

This view is reinforced in a report published by Analysys Mason[2] - the key findings of which conclude that the alternative to deploying the upper 6GHz band in mobile networks is a massive build programme of new radio transmission sites in cities, which would significantly impact the cost of services to customers, and, have a huge impact on carbon emissions predicting an increase in carbon emissions equivalent to up to 800 million km of car travel for just one city (Figure 6).

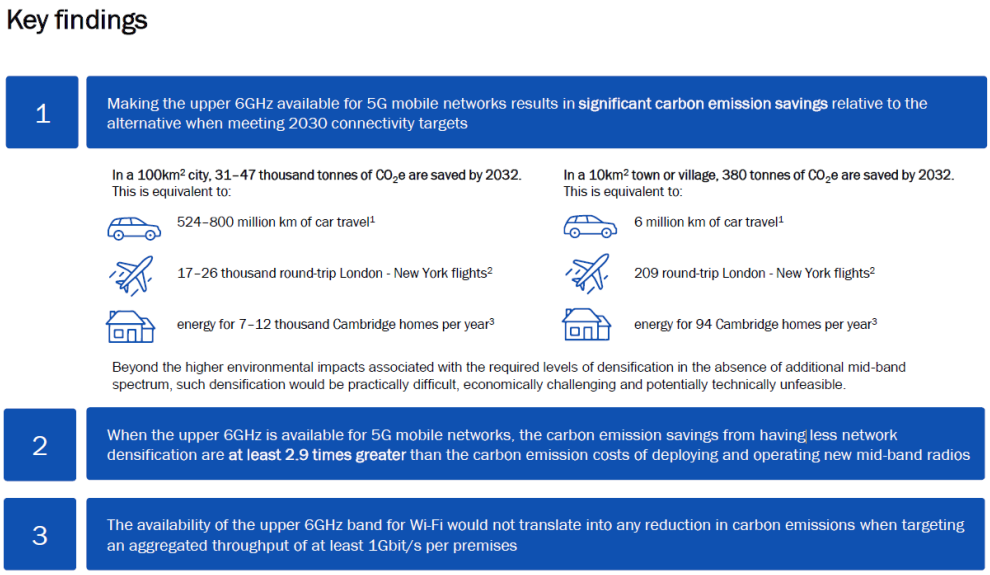

Figure 6: Key findings from Analysys Mason study.

A GSMA report[3] also assesses the significant impact of spectrum policy and availability for mobile networks on carbon emission and highlights that more efficient networks with fewer base stations not only increases the energy efficiency of mobile networks but creates an enabling effect for reducing carbon emission from other industries and sectors.

2) Social economic impact

As a large established converged service operator across Europe heavily relying on both technologies to provide services to consumers and enterprises, Vodafone believes it is well positioned to understand the socio-economic impact of using the U6GHz band for MFCN or RLAN. Our views are unanimously agreed by other major converged service operators in Europe.

GSMAi have conducted a comprehensive socioeconomic analysis of the U6GHz band considering its use for MFCN or RLAN. The study finds **the use of the upper 6GHz band for licensed mobile use complements the existing assignment of the lower 6GHz band for unlicensed use and provides the best socio-economic benefits for markets in Europe** and other regions assuming widespread adoption of high-speed fibre or cable (up to 10 Gbps), even without future use of 60GHz band available for WiFi.

This study is well aligned with Vodafone's view - however Vodafone strongly welcomes, and is willing to contribute to, any further socio-economic assessment on best use of the upper 6GHz band considering all aspects such as demand, cost-benefits, alternative options etc.

[1] Tackling carbon emissions (vodafone.com)
[2] Impact of additional mid-band spectrum on the carbon footprint of 5G mobile networks: the case for the Upper 6GHz band", Analysys Mason, 2nd June 2023.
[3] GSMA | Spectrum: the Climate Connection - Spectrum

III) **Provide information about:**

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

Vodafone has conducted an extensive field trial[1] using advanced prototype network equipment demonstrating the significant performance benefits achieved across both outdoor and in particular indoor areas (where the majority of mobile network traffic is consumed) when deploying the U6GHz for MFCN on existing macrocell sites.

It is important to note **these performance benefits can only be achieved by macrocell base stations operating at standard power levels** and any regulatory restrictions applied to limit power levels below these standard levels would have a significant impact on coverage and performance. In fact, it is unlikely that Vodafone would deploy the band for mobile networks in these circumstances given the substantial performance limitations and impact on the investment business case.

The trials in particular validate the incremental capacity benefits achieved by using larger 200 MHz channels relative to the typical 100 MHz deployments in the 3.5GHz band today. Larger channel bandwidths translate into better cost efficiency to support new or evolved higher bit-rate customer services and general network traffic growth. Our current estimates indicate the use of larger 200MHz channel bandwidths in the upper 6GHz band can provide between 40%-50% better capacity cost efficiency (cost/GB) than 3.5GHz radio equipment today. Channel bandwidths greater than 200MHz would naturally improve capacity cost efficiency further.

Larger channel bandwidths also form a key component of any technology evolution. As the largest remaining single block of mid-band spectrum in this decade and likely beyond able to accommodate larger channel bandwidths (200MHz / 300MHz) in multi-operator markets this makes the U6GHz for MFCN essential for Europe - enabling it to be at the forefront of mobile network evolution through the introduction of new technologies such as 5G Advanced or initial 6G deployments.

Together, these two considerations mean that mobile deployment in the Upper 6GHz band will improve the traffic economics of future mobile-enabled services and enable new higher performance services to be supported.

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

Assuming the U6GHz is made available to mobile operators for MFCN on the same basis as 3.5GHz, and can be generally operated at standard power levels without restrictions (unless restrictions in particular location related to sharing with incumbents), Vodafone expects it to be primarily deployed as an overlay on existing 3.5GHz macrocell sites, providing an effective performance and capacity layer for mobile customers. As detailed in Section 1, Vodafone estimates the U6GHz band is critically required for capacity expansion on 5G networks in Urban areas towards the end of this decade (2028-29).

For reference, Vodafone has currently deployed 3.5GHz spectrum for 5G networks on over 18,500 sites with 52,000 antennas across its markets in Europe (inc. UK) – nearly 3 times the number of base stations deployed 2 years earlier – providing high speed 5G network coverage in over 250 cities.

IV) **Provide information about standardization and technology impact**

The World Radiocommunication Conference in 2023 (WRC-23) identified the U6GHz band for IMT across Europe, Africa and the Middle East (Region 1) and for selected countries in Regions 2 & 3. The global support for the U6GHz band at WRC-23, estimated to represent around 60% of the global population[2], will drive significant economies of scale for product ecosystems. More countries are expected to support harmonised use of the band for IMT at WRC-27

3GPP has already specified band n104 for the U6GHz band in its Release 17 specifications, with first band combinations between n104 and n78 in Release 18. Further ongoing improvements are being made in Release 19.

While discussions continue in Europe on harmonised use of the U6GHz band for IMT and potential sharing scenarios with RLAN/WAS, **it is vitally important Europe does not define conditions or mechanisms which prevent or restrict all the benefits highlighted in this paper**, and which increase development costs, introduce ecosystem fragmentation and create uncertainty around timescales - all of which will have a significant negative impact on Europe achieving its

[1] 6GHz Field Trials – Reference IMT Indoor Performance levels for standard power base stations operating in the 6GHz band, Contribution to ECC PT1 Meeting, ECC PT1 24 (033), Gronigen, 23-25th January 2024.

[2] GSMA | The Importance of 6 GHz to Mobile Evolution - Spectrum

digital connectivity targets outlined in the Digital Decade Policy Programme 2030 (DDPP)[1] as well as Europe's competitiveness and leadership position in the global market.

Vodafone is already planning its next phase of trials with suppliers using more advanced pre-commercial network equipment to drive further performance enhancements for U6GHz deployments on macrocells.

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

- Fixed service
- Fixed satellite service
- Radio astronomy service
- SST (Sea Surface Temperature) sensors
- UWB

Please limit your answers to maximum 2-3 pages and favour responding through associations as far as possible.

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?

As with many other MNOs, Vodafone operates Fixed Service (FS) links using the upper 6GHz band for radio site backhauling in a number of its markets in Europe. Current FS usage for mobile backhaul across Vodafone markets in Europe is in the range of 20 – 200 links per country. Typically these longer haul links are deployed in more sparsely populated areas outside urban areas, though may require a single central aggregation point within or near an Urban area. Upper 6 GHz backhaul links are typically covering distances of 20 to 50km, although the majority of backhaul links are much shorter distances (e.g. 50% of Vodafone links are below 4km). Vodafone also uses a number of other spectrum bands for these longer-haul links: lower 6GHz, lower and upper 7GHz, and, lower and upper 8GHz. Generally, within a country, two or three of these 6 bands are used. Around 13% of all our links across these bands use the upper 6GHz band.

Regarding future spectrum needs up to 2030 and beyond, we expect general stability in terms of our number of longer-haul links. The specific use of upper 6GHz spectrum for these links will depend on a number of factors, such as existing utilisation of bands, potential use of alternative bands or technologies and in particular deployed radio capabilities. There is demand for wider channel bandwidths for mobile network backhauling to enable 5G data rates, however such demand will not be addressed by FS links in the 6 GHz band. The deployment of high-capacity radio capabilities for 5G today using the 3.5GHz band is expected to continue to focus on Urban areas and large towns with similar deployment areas for 6GHz. Therefore, Vodafone believes any future U6GHz spectrum needs for backhauling and for MFCN can be managed as described in the following sections.

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

As a total telecoms service provider, Vodafone fully respects all incumbent services operating in any frequency band and, as explained above, in the case of the U6GHz band Vodafone itself, as well as other MNOs, have services operating in the band. However, as a precious resource, it is also important that spectrum is efficiently utilised to maximise its benefits to economies and societies. As mid band spectrum with unique coverage and capacity capabilities, this is particularly the case for the upper 6GHz band.

Sharing and compatibility of FS and IMT operating in the upper 6GHz band has been extensively studied as part of WRC-23 AI 1.2. FS links are generally deployed as elevated highly directional point-to-point radio beams between a transmitter and a receiver. For an unmanaged, uncoordinated, worst-case scenario - where an IMT base station transmitter, also using narrow beams to direct signals to users on the ground, may have a beam pointing directly to the FS receiver - separation distances of 10's of kms are needed. However, with some level of coordination, where IMT base stations are not pointing directly at FS receiver antennas, separation distances can be reduced to a few kms.

IMT networks are deployed on licensed spectrum and typically licensing decisions are national. Licences specifically allow any conditions to be set, if needed, to protect existing use, such as protection/coordination zones (e.g. protection of FSS earth stations from 5G base stations). Regulators can evaluate and consult on the respective use and demands

[1] Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030

of services before deciding on license conditions and timelines. Licensing allows national regulators to manage and coordinate use of spectrum where necessary, maximising its utilisation and benefit to consumers. As explained above, in the case of the U6GHz band, the spectrum is already extensively used by MNOs and therefore more granular levels of coordination and management are possible. This is not possible for licence-exempt devices which, although they operate at lower power levels, cannot be controlled and guaranteed to not interfere with fixed services, especially if deployed in vertically elevated positions in multi-storey buildings. Nonetheless, we accept that there will be some links where coexistence with mobile deployment may be more challenging, at least in the short term.

CEPT SE45 (Work Item SE45_04) is studying possible technical conditions under which Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) could operate and coexist with existing services in the 6425-7125MHz band. The work has not yet been finalised, with long and extensive discussions on suitable parameters for the studies (e.g. WAS/RLAN activity factor and market adoption factor). Work is also still being carried out in CEPT SE19 (Work Items SE19_49) to provide a generic methodology for deriving protection criteria for any source of time-varying interference to an FS receiver. This work item studies how current FS receivers perform in the presence of pulse/burst type interference (e.g. WiFi Access Point beacon signal), with and without ACM (Adaptive Coding and Modulation). There are indications that pulsed/bursty signals (e.g. WiFi beacon signals with and without traffic on top) may have a more noticeable interference effect than continuous, noise-like signals at the same interference tolerance (i.e. I/N) level. The conclusions of the ongoing work may have an impact on the results of the WAS/RLAN - FS sharing. Considering these discussions, and that in the US, there are several FCC filings on WAS/RLAN interference in the 6 GHz band, uncoordinated interference cases from WAS/RLAN to FS may be expected, which is concerning to us as an operator of FS.

3) **What measures could improve compatibility from your perspective?**

Coexistence studies show that un-coordinated introduction of MFCN and/or WAS/RLAN in the upper 6GHz shall be avoided to protect FS. However, both MFCN and FS are by nature licensed services, allowing for coordination.

We consider conventional licensed use for IMT, with national evaluation of use and demands, and as needed appropriate conditions, e.g. geographical separation, possible phased refarming of links or network topology changes are best approaches to ensure compatibility and maximise efficient utilisation of precious spectrum. With use permitted on a licensed basis, professional personnel are responsible for ensuring deployments, configurations and operation respect licence conditions.

Therefore, we strongly believe **fixed link and Mobile network coexistence can be handled through coordination and/or geographic separation**. Licensing spectrum for Mobile networks enables co-existence as regulators can specify through licence conditions where and when Mobile network operators can deploy base stations, and through knowledge of base station and Fixed link locations can identify potential sources of interference and take any mitigating action. Some of the findings from the ECC Report 303 (“toolbox”) providing mechanisms which allow for continued FS operation in the 26 GHz pioneer band, where appropriate could be also relevant for the 6 GHz band and help achieving coexistence.

In addition, we also expect to replace fixed links in upper 6 GHz band with other solutions/bands or even reconfigure our fixed network topology in specific circumstances where and when needed to facilitate our mobile demands. Growing availability of fibre in urban areas in particular may decrease the need for wireless backhauling in urban areas. The vast majority of sites in our urban areas in Europe where high capacity capabilities are deployed today and where 6GHz will be deployed for MFCN in future are already connected via Fibre or other FS backhaul solutions not using the upper 6GHz band.