GSMA

19 August 2024

Radio Spectrum Policy Group (RSPG)
European Commission
RSPG Secretariat
CNECT-RSPG@ec.europa.eu

Reference: Questionnaire on long-term vision for the upper 6 GHz band

Respondent: GSMA

Dear RSPG,

The GSMA thanks the RSPG for the opportunity to respond to its "Questionnaire on long-term vision for the upper 6 GHz band". MFCN can deliver optimal public benefit in terms of socio-economic impact and efficiency of spectrum utilisation in the upper 6 GHz band.

- 6 GHz capacity is required to meet increasing customer demand at speeds outlined in the International Telecommunication Union's vision for 5G, as well as future evolution.
- Mobile networks are already densified, but 6 GHz can enable the growth of sustainable mobile capacity on existing macro-cell sites.
- Timely availability of 6 GHz, at reasonable conditions and price, will drive cost-efficient network deployment, help lower the broadband usage gap and support digital inclusion.
- Mobile networks will need, on average, 2 GHz of mid-band spectrum per country by 2030. This is challenging to achieve without 6 GHz.
- The 6 GHz band at 6.425-7.125 GHz should be made available for licensed, stardard power, macro-cell mobile.

Below you will find specific responses to the proposed questions in this consultation that directly impact our members and the future of mobile services. In them, we indicate the benefits of the availability of the upper 6 GHz range to fulfil the capacity needs of public mobile networks, in this decade and beyond, to deliver economic productivity and support the race to net zero..

A summary of around 5 pages is provided, as requested, as well as an Annex containing details that support the GSMA response.

We remain available in case any questions arise, including for meetings and to provide additional information.

Best regards,

Laszlo Toth
Head of Europe, GSMA

GSMA

Summary

The GSMA supports the intention to develop a long-term vision and spectrum roadmap to enable mobile communications to continue to develop over the next decade. Mobile data traffic has experienced strong growth globally over the past ten years, driven by the increasing adoption of smartphones, rising data usage and growing consumption of high-bandwidth applications such as video streaming and gaming. Between 2019 and 2023, global mobile data traffic grew 3.5 times from 39 Exabytes to 137 EB per month, and mobile traffic per connection grew from 6.6 GB/month to 17.3 GB/month.

Demand in Europe for broadband traffic in publicly available fixed and mobile networks is expected to continue. While it is impossible for data to increase as rapidly in percentage terms in the future, the exabyte volume of data will continue to grow rapidly - in 2023, the increase in global mobile data traffic was more than the absolute traffic level in 2018[1]. Despite this, data growth is expected to continue at double digit rates across the EU into the foreseeable future[2]. Mainstream uses such as films and live sports streaming, social networks, gaming, e-commerce and web browsing will all lead to an increase in the amount of GB per hour used, driven by higher definition screens and content that is more intensive in video. Further details and references regarding demand for MFCN can be found in the Annex to this response.

Indoor and outdoor usage

Most traffic over cellular networks is delivered to users indoors, with estimates ranging around 70-80%[3] . This is true even in countries which have fewer households using mobile as the sole means of connectivity (e.g. Germany) but is higher in countries where people rely more on cellular networks to get broadband access at home (e.g. Finland and Austria).

As well as providing services using mobile networks, GSMA members also provide services via Wi-Fi. For example in France, mobile operators have 73.85% marketshare of fixed-line subscribers, in Germany that figure is 69.7%[4]. The experience of GSMA members indicates that offloading indoor traffic to RLAN Wi-Fi networks using unlicensed spectrum is limited by end-user decisions driven by security concerns, the complexity inherent to connect to private Wi-Fi access points (registration and initial login / re-login) or lack of access to the corporate Wi-Fi (from personal smartphones or when visiting others' sites).

While 5G can be deployed across a variety of spectrum resources from sub-1 GHz to mmWave bands, mid-band frequencies in the 1-7 GHz range are especially crucial as these offer the capacity and city-wide coverage to enable mobile networks to offer reliable performance to meet the ITU requirements across densely populated urban areas.

Analysis of indoor signal strength shows mid-bands delivering higher capacity indoors than low bands and a higher percentage of connections. This can be the result of technological advances applied to upper mid-bands like massive MIMO and beamforming that significantly improves the bands performance. This is expected to be valid not just for 5G but also for future technologies such as 6G.

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[1] GSMA Intellience
[2] GSMA Intelligence, Ericsson
[3] E.g. Ericsson, Ookla
[4] GSMA Intelligence, see description in Harnessing Spectrum Diversity, GSMA

The upper 6 GHz band also performed comparably to 3.5 GHz on tests done in real environments confirming the above results. As an example, in Germany, indoor coverage was tested at 200 meters distance from the site obtaining download speeds of 1.7 Gbps, with a measured building entry loss of 25 dB even for thermally active windows. Peak download speeds of 3 Gbps were achieved using just a 100 MHz bandwidth.

Even at the outdoor cell edge, 500 meters away from the roof-top site, 0.5 Gbps were obtained with a stable uplink signal in the same band. Throughout the cell coverage the averaged download speed outdoor was almost 2 Gbps.

3.5 GHz is used heavily for provision of mobile connectivity indoors as well as outdoors, and 6 GHz is expected to be as well. Overall, the trial showed the viability of upper 6 GHz for macro rollout, indoor service provision and coverage equivalence to 3.5 GHz. Information about other trials of IMT in upper 6 GHz can be found in Appendix A of the Annex.

6 GHz timeline

At WRC-23, the upper 6 GHz band was identified for IMT throughout the EMEA / CIS region, and in some countries from APAC and the Americas, with harmonised conditions for its use. This was a significant milestone for mobile evolution. Countries representing around 60% of the global population supported the band at WRC-23.

The timeline for the mobile ecosystem in the upper 6 GHz is an important issue for operators, regulators, and solution providers. This is affected by several factors, namely:

- Regulatory approval – the 6 GHz band already has a mobile allocation in the ITU Radio Regulations and WRC-23 has laid out the conditions for its use by IMT technologies globally. National regulators are now placing the band in their national frequency allocation tables and incorporating it into their spectrum planning processes.

- Device and infrastructure availability – successful trials have been conducted for the upper 6 GHz band by operators, while radio component and network infrastructure providers have been trialling equipment for the past two years.

- Operator demand – mobile networks are already densified, but 6 GHz can enable the growth of sustainable mobile capacity on existing macro-cell sites. Timely availability of 6 GHz, at reasonable conditions and price, will drive cost-efficient network deployment, help lower the broadband usage gap and support digital inclusion. There is thus keen demand for the band from mobile network operators which may occur a little before or after 2030 depending on the market.

Environmental impact assessment

Spectrum policy has an impact on the ability of mobile technologies to a) reduce emissions in their own networks and b) enhance sustainable productivity in other industries to enable carbon emission reduction elsewhere[5], known as the enablement effect.

[5] See Spectrum the Climate Connection, GSMA or Impact of Additional Mid-Band Spectrum on the Carbon Footprint of 5G Mobile Networks, Analysys Mason.

With limited spectrum, operators require more base stations to serve the same amount of traffic. This results in more energy use per unit of traffic and increased footprint in terms of equipment, construction and transport, therefore a higher carbon footprint from MNOs.

Restricted spectrum assignments result in higher retail prices and lower quality of service. Reducing the amount of spectrum for mobile by 100 MHz could result in 5% lower 5G penetration. This would limit the enablement effect of mobile on other industries. GSMA analysis[6] shows that in a high-income country, 100 MHz of spectrum constraint would have result in a 15MtCO2e increase in carbon emissions. The loss of the enablement effect on other sectors increases the carbon footprint by over ten times more than the direct impact on the footprint of the mobile sector itself.

Socio-economic impact

Mid-bands are expected to account for 65% of the total economic benefit of 5G by 2030[7]. Mid-band mobile can deliver 0.38% of European GDP by that time if spectrum is not constrained, meaning a US$121bn boost to regional GDP. If spectrum is constrained, 40% of that value can be lost and delivering sufficient mid-band spectrum to MNOs without the upper 6 GHz band will be challenging.

A detailed economic impact assessment by GSMA Intelligence[8] of the different assignment scenarios of the 6 GHz band across 24 countries, including Germany, France and Italy, found that optimal socio-economic benefits are achieved from at least 700 MHz for licensed 5G use, namely the upper 6 GHz band. Even in countries with extensive fibre broadband penetration, the availability of 500 MHz of spectrum for unlicensed use in the lower 6 GHz band (5.925-6.425 GHz) will be sufficient to address expected Wi-Fi demand. In Europe, the lower 6 GHz is already available for unlicensed use, and it roughly doubled the supply of license-exempt spectrum for WAS/RLAN.

GSMA will release an updated analysis in September 2024 showing the impact of licensed, licence-exempt and shared spectrum in the 6 GHz band, where again the greatest economic benefit in all countries is where the upper 6 GHz is assigned for licensed, macro-cell mobile with standard power levels. This scenario drives the greatest benefit because mobile is much more likely than Wi-Fi to be capacity-constrained in each country over the period to 2035. This means additional spectrum in the upper 6 GHz band will drive greater improvements in network quality and user experience, which will in turn drive greater benefits for the wider economy.

By assuming efficient utilisation of spectrum, which follows best-practice decision making and indeed the practice of the mobile sector, the analysis shows that unlicensed assignments in the 2.4, 5 and lower 6 GHz bands are more than sufficient to meet expected demand for Wi-Fi traffic and thus upper 6 GHz RLAN has limited or no economic impact.

With regard to shared use, the results show that restricting the power levels mobile base stations can emit in the upper 6 GHz band will significantly reduce the additional capacity they can provide. As a result, the economic benefits are lower than having a fully licensed full power macro-cell band.

Furthermore, given that the majority of mobile traffic originates indoors, there is no clear rationale for attempting to enforce an outdoor mobile use of the band and an indoor Wi-Fi use of the band (“indoor/outdoor split)”.

[6] Spectrum the Climate Connection, GSMA
[7] The Socio-Economic Benefits of Mid-Band 5G Services, GSMA
[8] The Socio-Economic Benefits of the 6 GHz Band, GSMA Intelligence

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

MFCN

Communication providers typically utilise both licensed and unlicensed spectrum with different deployment architectures to serve different use cases[9]. Mobile network operators (MNOs) use licensed spectrum in core frequency bands to provide services to industry, governments, and consumers. Spectrum with guaranteed rights of use helps provide secure, reliable, and good quality service for end-users. Licensed spectrum also provides certainty, incentivises investment, and gives predictability for MNOs to develop long-term plans, knowing that they will have access to a certain band for the length of time guaranteed in their spectrum licence.

Mobile networks will need, on average, 2 GHz of mid-band spectrum per country by 2030 to meet speeds outlined in the IMT-2020 vision of the ITU. This is challenging to achieve without 6 GHz. Making the upper 6 GHz band available for mobile use will be key to ensure the future mobile performance and quality of service provided to European citizens and will also secure the last mid-band in Europe for the first implementations of future mobile technologies.

The timing of when the upper 6 GHz spectrum could be made available for mobile is likely to influence the technology that the operators choose to deploy. 6 GHz (6425-7125 MHz) has the potential to enable wider channel bandwidths than currently available, for example 200 MHz per operator if there are three operators, which may support initial deployments of new mobile technologies such as 5G Advanced or 6G. In addition to the reuse of existing spectrum, additional spectrum to support this evolution should also be included as part of a mobile long-term roadmap. The upper 6 GHz, depending on when it is made available, as well as potential spectrum identified at WRC-27, should be part of this longer-term spectrum roadmap to enable mobile evolution towards 6G/IMT-2030 and provide the option for wider bandwidth carriers.

It is imperative that the regulations, from the outset, support macro deployments using standard power to enable the future option for initial 6G as well as 5G Advanced in order to provide the greatest socio and economic benefits and deliver spectrum in line with operators business and technology considerations.

WAS/RLAN

Unlicensed spectrum provides access connectivity to user equipment in localised fixed locations and can be an important component of communications infrastructure. MNOs are broad, and often the largest, providers of fixed connectivity using Wi-Fi in EU countries[10].

However, with Europe having made available 480 MHz in the lower 6 GHz band for RLAN/Wi-Fi, further expansion of licence-exempt spectrum is unwarranted and would be sub-optimal in terms of securing maximum public benefit from the upper 6 GHz band.

The simple facts are (i) that the likelihood of a bottleneck is much lower in RLAN than in mobile networks, and (ii) that if higher RLAN throughputs are required by some users, it can be easily sorted

[9] See Harnessing Spectrum Divsersity, GSMA
[10] See Harnessing Spectrum Divsersity, GSMA

out with the deployment of additional access points in existing unlicensed frequencies in the individual homes, factories and offices that make intensive use of broadband.

It is also important for policymakers and regulators to understand the efficiency of spectrum utilisation by licensed and unlicensed users and whether incentives exist for them to optimise use of scarce spectrum resources. Licensed users have full control over the spectrum management of the bands they are assigned, and a strong incentive to utilise them efficiently exists because they face a payment on their spectrum use – whether they purchase spectrum in an auction, in the secondary market and/or pay renewal or annual fees (or have a license obligation).

Wi-Fi has no such incentive as there is no pricing that accounts for the opportunity costs of accessing new frequencies. Wi-Fi spectrum usage can thus be inefficient, using frequency plans with a very low reuse ratio, similar to the ones used in the first implementation of GSM. Since 3G, all mobile technologies have applied a reuse factor of 1, i.e. using the same channel throughout the country.

Decisions such as when to upgrade routers to next generation technologies to make a more efficient spectrum use are also not coordinated and tend to be consumer-driven at times to suit individual connectivity needs. In the case of the upper 6 GHz band where spectrum decisions are to be made by regulators, outside of a market-based assignment mechanism, policymakers can incentivise efficient spectrum use by mobile and avoid assigning additional spectrum to Wi-Fi to compensate for inefficient use.

Wi-Fi 6 using 2.4 GHz and 5 GHz bands is a standard commercial offering today, supporting throughputs up to 2.4 Gbps for a single device or up to 9.6 Gbps in total, i.e. it supports access to gigabit speed network already. However, recent data by Ookla, detailed within the Annex to this response[11], shows that Wi-Fi 4 continues to represent a significant percentage of the connections . Technology upgrades for Wi-Fi, not additional spectrum, are required.

Shared use

The GSMA recognises the need to use spectrum efficiently, including the valuable mid-band spectrum in the upper 6 GHz band. There are however several challenges associated with sharing the upper 6 GHz band between licensed mobile and Wi-Fi.

Mobile has been designed by 3GPP/ITU from the outset to operate in clean, licensed contiguous spectrum with standard power with user terminals moving throughout any coverage area in different locations. Wi-Fi has been designed by IEEE to operate in licence-exempt shared contiguous spectrum with low power with user terminals moving throughout a limited local area. Co-channel operation at the same place and same time would result in harmful interference and degradation in the performance of systems.

Sharing via frequency segmentation retains mutually exclusive spectrum for Wi-Fi and licensed mobile meaning any increment to Wi-Fi would reduce the bandwidth available for mobile. As highlighted in the economic impact study by GSMA Intelligence, the greatest public benefit is achieved by using the whole upper 6 GHz spectrum for licensed mobile. As the the lower 6 GHz band is available for unlicensed Wi-Fi new spectrum assignments for both technologies can be made either side of 6.425 GHz. Any frequency segmentation option that results in constrained mobile spectrum and reduced economic/GDP impact should be avoided.

[11] To be published by GSMA in September, available in the annex

CEPT has identified three other potential sharing mechanisms, namely indoor/outdoor separation, reduced MFCN base station power, database-assisted coordination and spectrum sensing. The practicalities involved in implementing any of the above options are complex, especially as 6 GHz will be suitable for indoor usage, as seen in 3.5 GHz and detailed above.

There are doubts as to how indoor/outdoor separation would work in real-world situations. There will be many locations without isolation between indoors and outdoors, e.g., where there are openings such as doors and windows and/or where the building penetration loss is lower, and in such cases interference between mobile and Wi-Fi will occur. The signal/penetration loss between indoors and outdoors will vary greatly between different buildings and locations within them.

Trying to improve the sharing case for indoor Wi-Fi and outdoor mobile usage, there are proposals to reduce mobile base station power, so the interference into Wi-Fi is also reduced. As the majority of mobile use is indoors and supported by mid-band standard power base stations, reducing the 6 GHz power would limit its coverage and capacity.

Such an approach can degrade the capacity and performance of the band to an extent that its benefit to European industry and consumers is reduced or it may be unusable by MNOs and thus unused. The other impact of reduced power levels would be lower quality service and lower speeds, and the loss of productivity and the economic benefits of mobile as well as its potential enabling effect on carbon emissions reductions in other sectors. Any approach that reduces power levels of mobile base stations should be avoided.

The decision on the use of the upper 6 GHz band in EU, and its defined conditions will have implications for the standardisation, implementation, technology availability, and cost. The conditions will impact the possibilities to use the band efficiently and the harmonisation of the European market with the global eco-system. Europe should not define conditions and requirements which prevent efficient use of the band for meeting the European society demands. The solution should be both technically and commercially viable.

It is imperative that the regulations, from the outset, support macro deployments using standard power to enable the option for the upper 6 GHz.

The Annex below provides details in response to the questions in this consultation that directly impact our members and the future of mobile services, indicating the high benefits of the availability of the upper 6 GHz range for mobile networks to fulfil the capacity and sustainability needs in this decade and beyond.

Annex

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

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

Expected fixed and mobile traffic

Mobile data traffic has experienced massive growth globally over the past decade, driven by the increasing adoption of smartphones, rising data usage and growing consumption of high-bandwidth applications such as video streaming and gaming. Between 2019 and 2023, global mobile data traffic grew 3.5 times from 39 Exabytes to a 137 EB per month, and mobile traffic per connection grew from 6.6 GB/month to 17.3 GB/month[12].

Demand in Europe for broadband traffic in publicly available fixed and mobile networks are expected to continue to increase at double digit rates across the EU into the foreseeable future. Mainstream uses such as films and live sports streaming, social networks, gaming, e-commerce and web browsing will all require an increase in the amount of GB per hour used, driven by higher definition screens and content that is more intensive in video.

Without accounting for additional growth drivers and emerging use cases, and assuming that usage times are stable, Arthur D. Little (ADL) estimates that mobile traffic per user in the EU will increase, on average, from 13 GB/month in 2022 to 76 GB/month in 2030, a compound annual growth rate of 25%[13]. There are significant differences in data consumption and growth rates across European countries. Leading countries in data consumption like Finland, Austria, Latvia, Lithuania, Estonia and Denmark usually had earlier 5G rollouts, high-volume data-packages, and, in some cases, mobile-fixed substitution. With higher starting points in data traffic the data growth rates would also be lower in these countries. That's the same trend of slowing growth rates observed globally as the absolute traffic increases.

Over the same period, fixed data consumption per home should also increase, albeit at a lower annual growth rate of 19%, from 224 GB/home/month to 912 GB/home/month.

Analysis Mason foresees lower growth figures of 17% CAGR between 2022 and 2029 for mobile in Western Europe[14]. Critically, however, the growth rate expected for fixed data consumption is also lower, a CAGR of 13%. Analysis Mason also estimated the ratio of mobile data traffic over all fixed and mobile traffic as 14.9% at the end of 2022, up from 13.6% in 2020. While Wi-Fi connections accounted for 5 times more traffic than cellular connections in 2022, as expected considering the wide range of devices using Wi-Fi (e.g., smart TVs, laptops etc), on handsets Wi-Fi accounted for approximately half the traffic clearly demonstrating the importance of cellular services for mobile devices.

GSMAi forecasts[15] are aligned with those of Arthur D. Little and indicate that mobile traffic in Europe will be 71 GB per user and month in 2030, up from 17 in 2023, a CAGR of 22%. Ericsson[16], in turn, predicts growth rates of 17% for Western Europe, similar to those of Analysis

[12] Ericsson Mobility Report June 2024
[13] ADL, THE EVOLUTION OF DATA GROWTH IN EUROPE (adlittle.com)
[14] Analysis Mason Datahub, retrieved 20 July, 2024
[15] The Mobile Economy 2024 (gsma.com)
[16] Mobile data traffic forecast – Ericsson Mobility Report

Mason, and 5G penetration going up to 86% by 2029 from 26% in 2023.

The traffic growth rates are lower than those experienced in the 4G cycle, but still amount to a substantial incremental traffic: according to the ADL forecasts, only the incremental traffic in 2030, compared to 2029, will be 13 GB per user and month, exactly the total amount that was consumed, on average, in 2023.

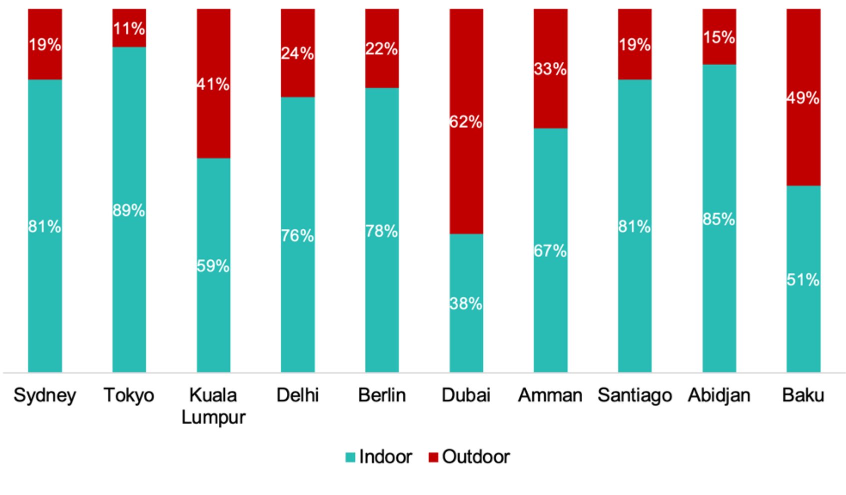
The figures above do not account for the possible impact of emerging use cases which, leveraging ongoing innovation in end user devices and artificial intelligence, could drive mobile traffic demand much further, especially beyond 2030. They also do not account for the possible use of 5G public networks to serve critical industry applications in a cost-efficient way. As 5G technology matures, its full range of capabilities enabled by the rollout of standalone cloud-native core networks and mobile edge computing, will provide enterprises and organisations with the ultra-reliable connectivity required to automate critical operations and the reduced latency to support real-time image recognition and other AI-based applications.

The GSMA analysis of the spectrum needs by 2030 shows that an average of 2 GHz of mid-band spectrum will be required to fulfil the ITU requirements for 5G of 100 Mbps downlink and 50 Mbps uplink.[17] Taking into account that approximately 1 GHz of spectrum is available for IMT in Europe, there is a need for an additional 1 GHz of mid-band spectrum.

Indoor and outdoor usage

It is well established that most of mobile traffic is delivered to users indoors with estimates ranging around 70-80%[18]. That is true even in countries like Germany where the number of mobile-only homes is relatively low and should be much higher in countries like Finland or Austria where people rely much more on cellular networks to get broadband at home.

Figure 1: Majority of mobile traffic is indoors



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

This reflects the fact that when outside their home, end users consume mobile broadband mostly in indoor public spaces, offices or in other people's homes. Looking forward, GSMA

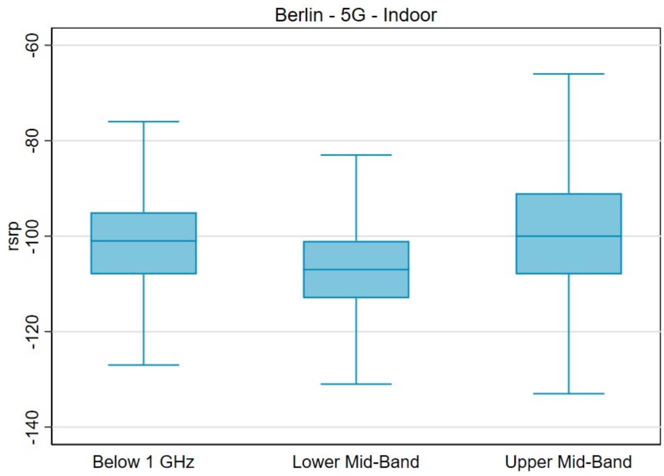
[17] GSMA and Coleago Consulting. Estimating the mid-band spectrum needs in the 2025-2030 time frame, July 2021. https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf
[18] For example, see Ericsson, Planning indoor 5G coverage; Cisco, 5G Thriving indoors; Huawei, Better Indoor coverage, Better 5G networks

members expect that pattern to continue for mainstream services. In other words, a majority of the incremental traffic that is expected in the foreseeable future, up to 2030, will also be consumed indoors. Beyond that date and those traffic volumes, traffic increases should be driven by emerging use cases whose traffic consumption pattern is harder to predict. It would not be surprising, however, if most of that traffic would also be consumed indoors.
The experience of GSMA members indicates that offloading indoor traffic to RLAN Wi-Fi networks using unlicensed spectrum is limited due to end user decisions driven by security concerns, the complexity inherent to connect to private Wi-Fi access points (registration and login) or lack of access to the corporate Wi-Fi (from personal smartphones, or when visiting others' sites).

While 5G can be deployed across a variety of spectrum resources from sub-1 GHz to mmWave bands, mid-band frequencies in the 1-7 GHz range[19] are especially crucial because these offer the balance of capacity and coverage that enable mobile networks to offer reliable performance that meet the ITU IMT-2020 requirements[20] across densely populated urban areas.

In fact, the analysis of indoor signal strengths with current deployments in Berlin shows upper mid-bands delivering better coverage than lower mid-bands and similar coverage to low bands across city areas. This can be the result of technological advances applied to upper mid-bands, like 5G massive MIMO beamforming, that greatly improves the band performance, along with larger channel bandwidths. This is expected to be valid for 5G and also for 6G.

Figure 2: Mid-bands indoor signal strength

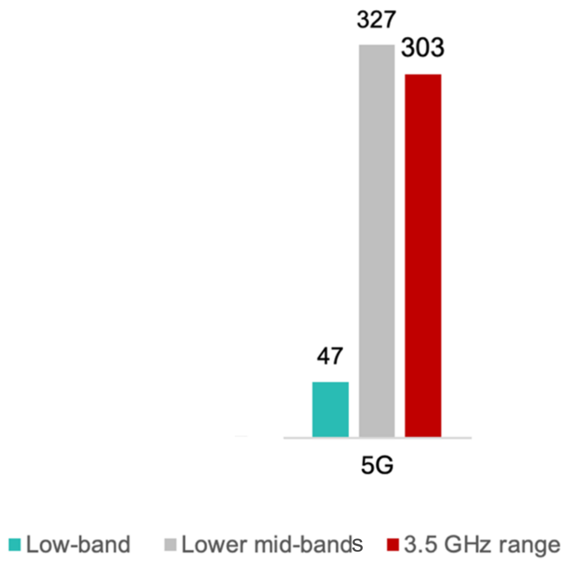


Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

When considering download speeds, mid-bands provide significant advantages over low bands – for example, in Berlin as illustrated in the figure below, Ookla measurements show upper mid-band indoor performance on 5G six times faster compared to low-bands. This is unsurprising given the wider channels that are available in mid-bands, but it highlights their importance in providing the quality of service that consumers expect. While low bands are critical to provide coverage in rural and remote areas, as well as deep indoor coverage in urban areas, the majority of traffic in urban areas (both indoor and outdoor) is supported by mid-band spectrum, which also provides much faster speeds.

[19] Mid-band spectrum includes, but is not limited to, lower mid-bands (i.e. 1500 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2600 MHz) and upper mid-bands (i.e. 3.3–4.2 GHz, 4.5–5.0 GHz and 5.925–7.125 GHz).
[20] ITU. Minimum requirements related to technical performance for IMT-2020 radio interface(s). Report ITU-R M.2410-0 , November 2017. https://www.itu.int/pub/R-REP-M.2410-2017

Figure 3: Median indoor download speeds by spectrum bands (Mbps), Berlin[21]



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Upper 6 GHz band also performed extremely well on tests done in real environments confirming the above results[22]. Indoor coverage was tested at 200 meters distance from the site obtaining very high download speeds of 1.7 Gbps, with a measured building entry loss of 25 dB even for thermally active windows, comparable to 3.5 GHz. Peak download speeds of 3 Gbps were achieved using just a 100 MHz bandwidth.

Even at the outdoor cell edge, 500 meters away from the roof-top site, 0.5 Gbps were obtained with a stable uplink signal in the same band. This implies that if the uplink and signalling is handled in another lower frequency band, the cell range could even be further extended, as the uplink is the range limiting factor while capacity demand is usually heavily downlink focussed. Throughout the cell coverage the averaged download speed outdoor was almost 2 Gbps. Overall, the trial showed the viability of upper 6 GHz for macro rollout, indoor service provision and coverage equivalence to 3.5 GHz.

Considering an evolution in mobile traffic like that predicted by ADL for the mainstream uses, and assuming that inter-site distances in cities are kept at current levels (i.e. more densification is either not financially viable or operationally not possible), cellular networks will reach congestion in dense areas before the end of the decade.

6 GHz timeline

WRC-23 marked a significant milestone in the evolution of mobile communications. The upper 6 GHz band was identified for IMT throughout the EMEA / CIS region, and in some countries from APAC and the Americas, with harmonised conditions for its use. Around 60% of the global population supported the band at WRC-23 and more countries are expected to join the 6 GHz harmonised footprint at the next WRC in 2027.

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[21] Germany has a lower bandwidth availability per operator of 3.5 GHz than other EU countries. Lower mid-bands refer to aggregated and non-aggregated use of all lower mid-bands (below 3 GHz).

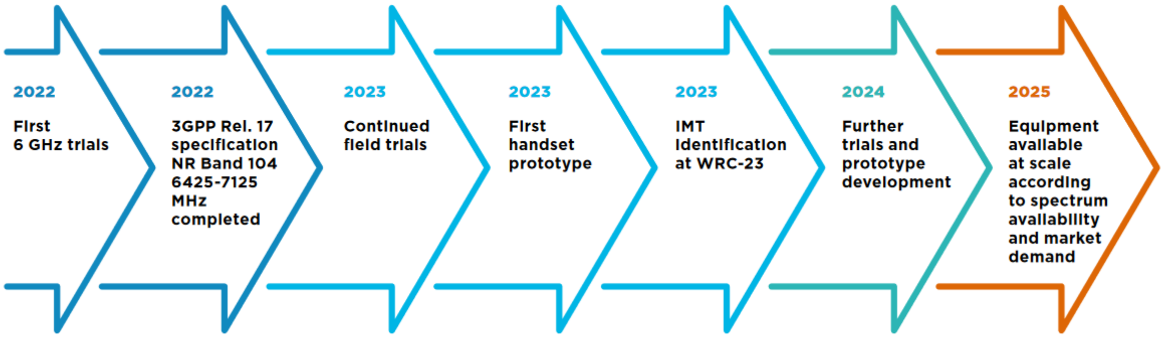
[22] https://cept.org/ecc/groups/ecc/ecc-pt1/client/meeting-documents/file-history?fid=81128

The timeline for the mobile ecosystem in the upper 6 GHz is a key consideration for operators, regulators, and solution providers. This depends on several factors, namely:

- Regulatory approval – the 6 GHz band already has a mobile allocation in the ITU Radio Regulations and WRC-23 has laid out the conditions for its use by IMT technologies globally. National regulators are now placing the band in their national frequency allocation tables and incorporating it into their spectrum planning processes.
- Device and infrastructure availability – successful trials have been conducted for the upper 6 GHz band by operators, while radio component and network infrastructure providers have been trialling equipment for the past two years.
- Operator demand – mobile networks are already densified, but 6 GHz can enable the growth of sustainable mobile capacity on existing macro-cell sites. Timely availability of 6 GHz, at reasonable conditions and price, will drive cost-efficient network deployment, help lower the broadband usage gap and support digital inclusion. There is thus keen demand for the band from mobile network operators which may occur a little before or after 2030 depending on the market.

Taking the above into account, the potential timeline for the commercialisation of the 6 GHz IMT ecosystem is as follows.

Figure 4: The 6 GHz mobile ecosystem timeline



Source: GSMA

In a recent industry statement[23], the GSMA along with stakeholders across the mobile value chain called for collaboration between governments and industry to support the full development of 6 GHz for mobile, to ensure a spectrum roadmap is delivered for mobile operators, and to put in place clear timelines for equipment and handsets to be ready at scale. The statement co-signed by 36 companies including all the main European operators.

Wi-Fi can be upgraded selectively and at reasonable cost without the U6 GHz band

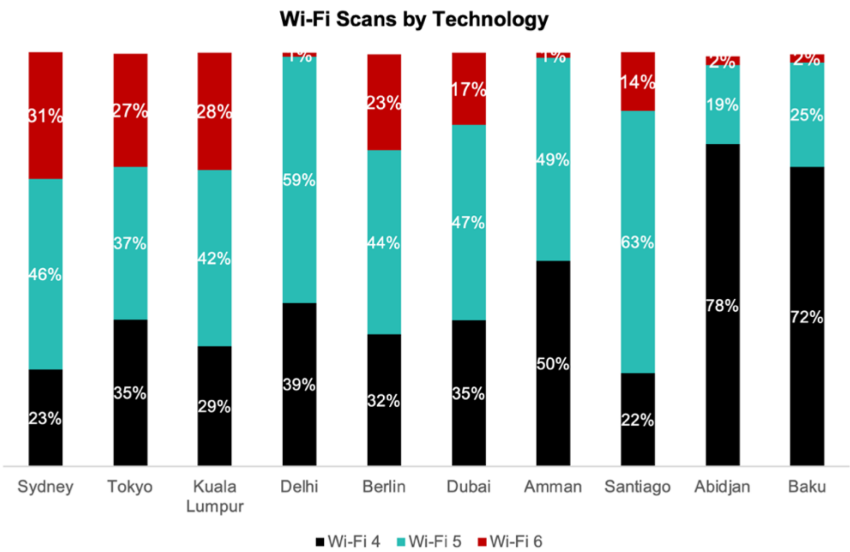
Broadband capacity will not be limited in the foreseeable future by scarcity of WAS/RLAN spectrum. There are some reasons for this:

First, users demand for connectivity through Wi-Fi are not in the highest throughput range as clearly demonstrates the large share of Wi-Fi 4 equipment in the market   providing a theoretical maximum speed up to 450 Mbps. Thus, Wi-Fi capacity can be improved by updating Wi-Fi access points to a newer (not even the newest) generation increasing the spectral efficiency.

[23] GSMA. 6 GHz statement, June 2024. https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2024/06/6-GHz-Statement-Shanghai-FINAL.pdf

Wi-Fi 6 using 2.4 GHz and 5 GHz bands is a standard commercial offering today, supporting throughputs up to 2.4 Gbps for a single device or up to 9.6 Gbps in total, i.e. it supports access to gigabit speed network already. The newest Wi-Fi generations have features supporting higher capacity, e.g. Wi-Fi 7 supports Multi-Link Operation allowing simultaneous reception and transmission across different frequency bands and channels (2.4 GHz, 5 GHz, 6 GHz).

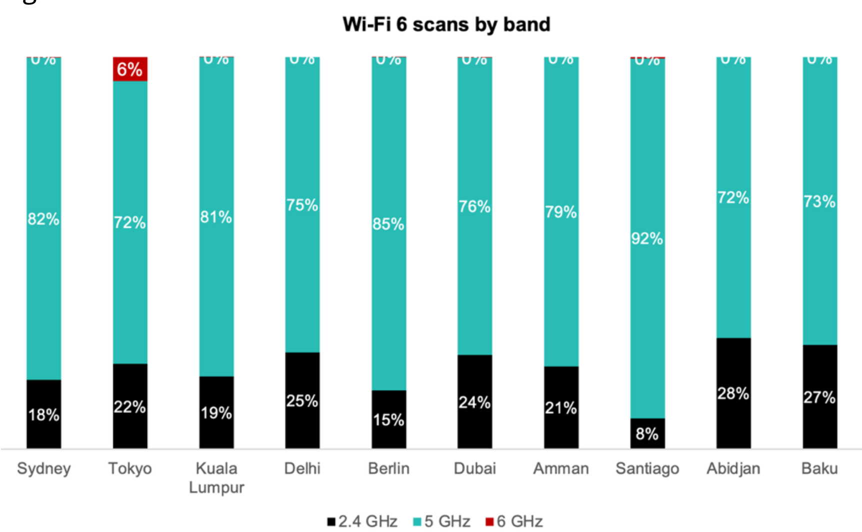
Figure 5: Distribution of Wi-Fi scans based on technology



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Secondly, the 480 MHz recently allocated for RLAN in the lower 6 GHz band provides additional 3 channels of 160 MHz each that are not yet being used. They almost double the amount of spectrum available and provide enough capacity for meeting expected demand even in homes with a large number of intensive users.[24]

Figure 6: Distribution of Wi-Fi scans based on bands



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Finally, as recent tests conducted by Comtel[25] show, the limiting factor is, in many homes, Wi-

[24] GSMAi (2023). The socioeconomic benefits of the 6 GHz band

[25] Indoor Connectivity - English - Comtelitalia

Fi coverage rather than capacity. The solution to that problem is installing more access points, rather than increasing the amount of spectrum per access point.

Beyond 2030, if extreme traffic scenarios materialise, selective densification of Wi-Fi access points is the most efficient way to address Wi-Fi quality of service in apartments, houses and offices with very high-throughput demand. We expect that Wi-Fi APs densification with Fiber To The Room (FTTR) solutions will become more widespread in such locations. The 60 GHz spectrum band of spectrum would complement FTTR deployments for providing extremely high throughputs.

II. Provide information about the sustainability of the above explained demand, especially the: 1) Environmental impact assessment

GSMAi conducted a study in 2023 analysing the impact of spectrum policy on the fight against climate change[26]. It concluded that artificial scarcity of spectrum for 5G has a significant negative environmental impact:

- With limited spectrum, operators require more base stations to serve the same amount of traffic. This results in more energy use per unit of traffic and increased footprint in terms of equipment, construction and transport.
- From the end user perspective, restricted spectrum assignments result in higher retail prices, lower quality of service or both. GSMAi estimates that reducing the amount of spectrum for 5G by 100 MHz could result in 5 percentage points lower 5G penetration, with a negative impact on the enablement effect of mobile that, in terms of tonnes of CO_2 emissions, would be more than ten times larger than the direct impact on the footprint of the mobile sector itself.

Analysis Mason[27] reached similar findings in a report focused specifically on the impact of assigning the upper 6 GHz to either Wi-Fi or IMT:

- When the upper 6 GHz is assigned for mobile networks, carbon emission savings from having less network densification are at least 2.9 times greater than the carbon emission cost of deploying and operating new mid-band radios.
- The availability of the upper 6 GHz band for Wi-Fi would not translate into any reduction in carbon emissions when targeting an aggregated throughput of at least 1Gbit/s per premise.

2) Socio-economic impact

A detailed economic impact assessment by GSMA Intelligence[28] of the different allocation scenarios of the 6 GHz band across 24 countries, including Germany, France and Italy, found that optimal socio-economic benefits are achieved from the allocation of at least 700 MHz, namely the whole of upper 6 GHz band, for licensed 5G use. Even in countries with extensive fibre broadband penetration, the availability of 500 MHz of spectrum for unlicensed use in the lower 6

[26] Spectrum: the Climate Connection (gsma.com)

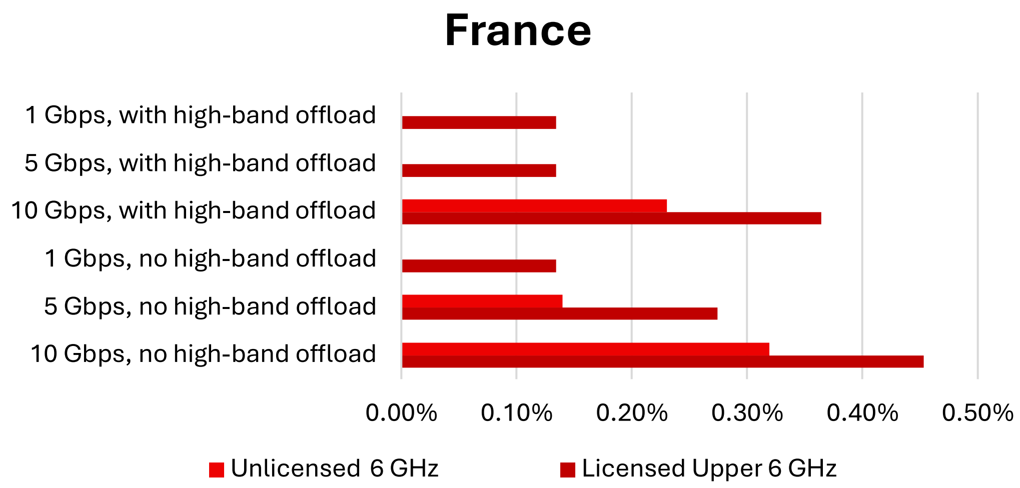
[27] Analysis Mason (2023), Impact of additional mid-band spectrum on the carbon footprint of 5G mobile networks: the case of the upper 6 GHz band

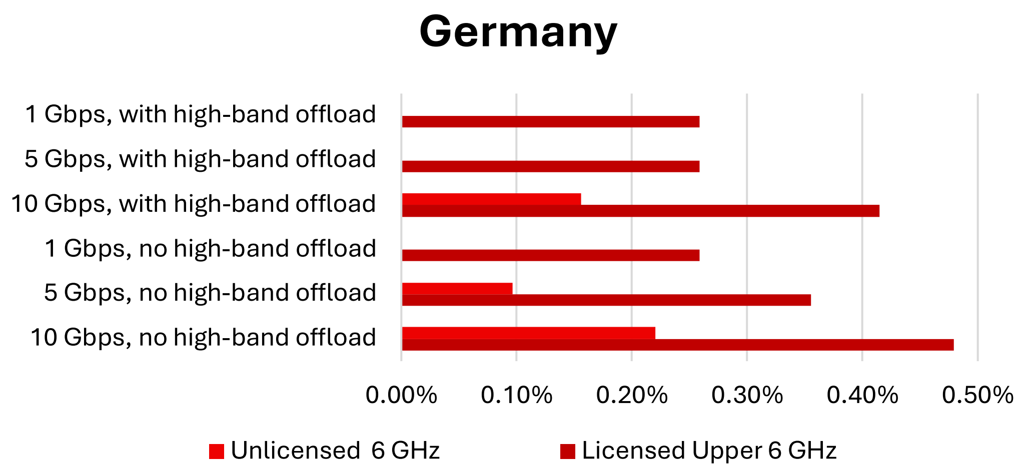
[28] GSMA Intelligence. The socioeconomic benefits of the 6 GHz band: considering licensed and unlicensed options, June 2022.

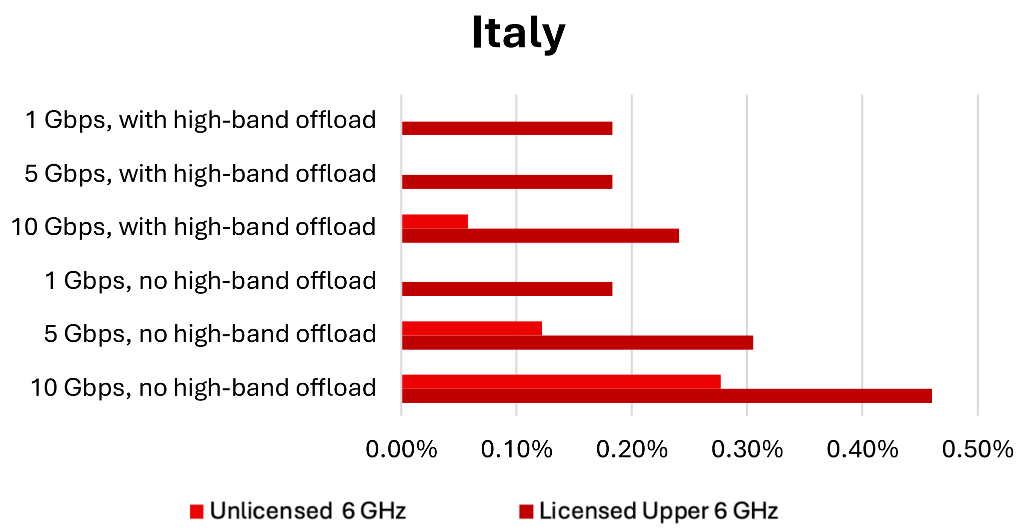
GHz band (5.925-6.425 GHz) will be sufficient to address expected Wi-Fi demand. In Europe, the lower 6 GHz is already available for unlicensed use, and it roughly doubled the supply of license-exempt spectrum for WAS/RLAN.

The key takeaway is that the probability of congestion in mobile networks is much higher than the probability of congestion in fixed networks. To illustrate this point, the figure below shows the potential economic benefits of upper 6 GHz spectrum in Germany, France and Italy as a percentage of GDP in 2035 for a range of theoretical FTTP download speeds (1, 5 and 10 Gbps). The distinction is relevant because the benefits of additional licence-exempt spectrum for Wi-Fi are tied to the capability of fixed line connectivity speeds. Noting that the EU has already made available the lower 6 GHz for RLANs, results are shown for two scenarios – Scenario A in which the whole of upper 6 GHz is also made available for licence-exempt use, and Scenario B in which the upper 6 GHz is assigned to licensed mobile use.

Figure 7: Impact of licensed 5G vs licence-exempt use of 6 GHz in France, Germany and Italy (% expected GDP 2035)







Source: GSMA Intelligence

The results clearly demonstrate that licensed 5G mobile is the optimal use of the upper 6 GHz band. Even in cases with fixed broadband speeds of 10 Gbps, assigning the upper 6 GHz for licensed 5G, instead of licence-exempt use (RLANs/Wi-Fi), delivers at least a 50% higher benefit in terms of GDP impact by 2035. Allowing licence-exempt technologies in the entire 6 GHz band will never be the most beneficial option.

III. Provide information about:
1) The possible role of the upper 6 GHz for MFCN or WAS/RLAN

MFCN

For the reasons and evidence set out in this submission, the GSMA firmly believes that MFCN can deliver optimal public benefit in terms of socio-economic impact and efficiency of spectrum utilisation in the upper 6 GHz band. This can ensure that affordable mobile capacity is available to drive industrial and economic competitiveness in the sustainable, digitalised markets of the future. The GSMA and the mobile industry[29] firmly believe that:

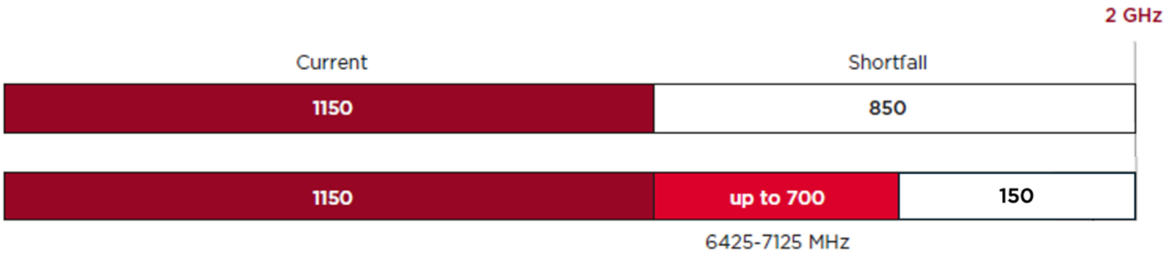
- 6 GHz capacity is required to meet increasing customer demand at speeds outlined in the International Telecommunication Union's vision for 5G, as well as future evolution.
- Mobile networks are already densified, but 6 GHz can enable the growth of sustainable mobile capacity on existing macro-cell sites.
- Timely availability of 6 GHz, at reasonable conditions and price, will drive cost-efficient network deployment, help lower the broadband usage gap and support digital inclusion.
- Mobile networks will need, on average, 2 GHz of mid-band spectrum per country by 2030. This is challenging to achieve without 6 GHz.
- The 6 GHz band at 6.425-7.125 GHz should be made available for licensed, stardard power, macro-cell mobile.

Mobile networks will need, on average, 2 GHz of mid-band spectrum per country by 2030 to

[29] GSMA Statement. Commercialising the 6 GHz IMT Ecosystem, June 2024. https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2024/06/6-GHz-Statement-Shanghai-FINAL.pdf

meet the ITU vision for 5G[30]. This is challenging to achieve without 6 GHz[31].

Making the upper 6 GHz band available for mobile use will be key to ensure the future 5G performance and quality of service provided to European citizens and will also secure what will probably be the last substantial block of contiguous mid-band spectrum in Europe for the first implementation of 6G.



WAS/RLAN

With Europe having made available 480 MHz in the lower 6 GHz band for RLAN/Wi-Fi, further expansion of licence-exempt spectrum is unwarranted and would be sub-optimal in terms of securing maximum public benefit from the upper 6 GHz band. The simple facts are (i) that the likelihood of a bottleneck is much lower in RLAN than in mobile networks, and (ii) that if higher throughputs are required by some users, it can be easily sorted out with the deployment of additional access points in existing unlicensed frequencies in the individual homes, factories and offices that make intensive use of broadband.

It is also important for policymakers and regulators to understand the efficiency of spectrum utilisation by licensed and unlicensed users and whether incentives exist for them to optimise use of scarce spectrum resources. Licensed users have full control over the spectrum rights they are assigned, and a strong incentive to utilise them efficiently exists because they face a payment on their spectrum use – whether they purchase spectrum in an auction, in the secondary market and/or pay renewal or annual fees (or have a license obligation).

On the contrary, since unlicensed spectrum is free. Wi-Fi have no incentive for an efficient spectrum usage as there is no pricing that accounts for the opportunity costs of accessing new frequencies. Wi-Fi spectrum usage is very inefficient, using frequency plans with a very low reuse ratio, similar to the ones used in the first implementation of GSM. Since 3G, all mobile technologies have applied a reuse factor of 1, i.e. using the same channel throughout the country. Decisions like when to upgrade routers to next generation technologies to make a more efficient spectrum use are taken in an uncoordinated way, by many different users driven by the fulfilment of their connectivity needs.

In the case of the upper 6 GHz band where spectrum decisions are to be made by regulators, outside of a market-based assignment mechanism, it is crucial that policymakers incentivise the efficient use of spectrum by mobile and avoid assigning additional spectrum to Wi-Fi to compensate for inefficient use.

See Appendix B for further discussion on spectrum utilisation by mobile and Wi-Fi.

[30] Coleago report for GSMA (2021) https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf
[31] GSMA | New Spectrum for 5G: Adding Up the Mid-Band Maths - Spectrum

GSMA

Shared use

The GSMA recognises the need to use spectrum efficiently, including in particular the valuable mid-band spectrum in the upper 6 GHz band. We therefore appreciate the desire to explore various forms of traditional and non-traditional sharing which might potentially help to enable more efficient use of spectrum. We believe, however, that there are several difficult challenges associated with sharing of the upper 6 GHz band between licensed mobile and Wi-Fi.

Co-channel operation of mobile networks and Wi-Fi at the same place and time would result in extensive harmful interference and severe degradation in the performance of both types of radio systems. Licensed mobile operates in clean, contiguous spectrum with user terminals moving throughout any coverage area in unknown locations while unlicensed terminal locations are, by their nature, also not fixed.

Firstly, regarding frequency segmentation, we note that this approach retains mutually exclusive allocations for Wi-Fi and licensed mobile meaning any increment to Wi-Fi would reduce the bandwidth available for mobile. As highlighted in the economic impact study by GSMA Intelligence, the optimal allocation and greatest public benefit is achieved by using the whole upper 6 GHz spectrum for licensed mobile with the lower 6 GHz band for unlicensed Wi-Fi, thus allowing for sufficient new spectrum assignments for both technologies to develop. Any frequency segmentation option that results in constrained mobile spectrum and reduced economic/GDP impact should be avoided.

With regard to geographic segmentation, the main challenge is that mobile and Wi-Fi demand are likely to peak in similar areas (i.e. in dense urban clusters) and segmentation by geographic area or location is unlikely to meet the needs of both uses. We are of the view that this is not a viable planning option for the upper 6 GHz band.

As for non-traditional sharing, CEPT has identified different potential mechanisms, namely including indoor/outdoor separation, reduced MFCN base station power, database-assisted coordination and spectrum sensing. The practicalities involved in implementing any of the above options are highly complex.[32]

In the case of an indoor/outdoor separation, there are serious doubts whether it would work more generally in practice. There will be many locations where there will be much less isolation between indoors and outdoors, e.g. where there are openings such as doors and windows and/or where the building penetration loss is lower, and in such cases interference between mobile and Wi-Fi will occur. The signal/penetration loss between indoors and outdoors will vary greatly between different buildings and locations within them. More importantly, as discussed in Section 3, the majority of mobile use is indoors and dependent on mid-bands. As recent trials have shown, 6 GHz outdoor cells can provide indoor coverage at high data rates.

Trying to improve the sharing case for indoor Wi-Fi and outdoor mobile usage, there are proposals to reduce mobile base station power, so the interference into Wi-Fi is also reduced. Such an approach will significantly degrade the capacity and performance of the band to an extent that its value for mobile drops and remains unused for mobile. As the majority of mobile use is indoors and supported by mid-bands standard power base stations, reducing the 6 GHz power would limit its coverage and capacity.

[32] See for example ongoing CEPT work in ECC PT1 and Ofcom (2023), Hybrid sharing: enabling both licensed mobile and Wi-Fi users to access the upper 6 GHz band – Summary of responses and next steps

The other impact of reduced power levels would be lower quality service and lower speeds. This would result in loss of productivity and the economic benefits of mobile as well as its potential enabling effect on carbon emissions reductions in other sectors.[33] Moreover, the indoor signal strength from mobile networks may not be reduced enough to avoid interference into Wi-Fi and will therefore not enable the sharing between mobile and Wi-Fi that is envisaged under this scenario.

Any approach that reduces power levels of mobile base stations should be avoided.
Power limits drastically reduce the capacity of a new 6 GHz layer in existing sites. The chart below, derived from input submitted by Ericsson to CEPT[34], shows the impact of different power limits. In practice, those power limits imply that adding an U6 GHz layer would be, from a capacity point of view, not very different from adding the same layer in the 26 GHz band, destroying the inherent differential value of mid-band spectrum discussed above.

Initial EIRP (dBm/100 MHz)	Final EIRP (dBm/100 MHz)	Initial Cell Capacity (Mbps)	Final Cell Capacity (Mbps)	Cell capacity loss (%)	Coverage loss (% pop)	Total Capacity loss[35]
83	71	1419	888	37.4%	3.8%	**41.2%**
83	65	1419	609	57.1%	8.4%	**65.5%**
83	59	1419	345	75.7%	14.6%	**90.3%**

Limiting the power of the macro base stations would produce a capacity loss of 40% up to 90% of the 6 GHz band and so, result in a very inefficient usage of the band for mobile that is unacceptable for justifying the capex to deploy another frequency layer.

While spectrum sensing mechanisms and database sharing solutions have been discussed for many years, successful implementations have been limited. There are a number of challenges that would need to be overcome, such as how to accurately predict interference (both between BS and APs and between UEs) so as to avoid interference from one service to another without leaving a substantial ‘buffer zone’ between areas that are used by the two services, or how to ensure that all Wi-Fi routers deployed comply with a potential obligation to not use the band in the presence of mobile deployments.

It would also imply changes in the standards for both systems impacting the time to market of these solutions as well as the costs of routers and IMT equipment and mobile and Wi-Fi deployments in the upper 6 GHz band. The standard change for Europe will also have an impact on economies of scale, even risking the production of equipment (routers, base stations and devices) compliant with the European specific standard.
Finally, bespoke national solutions or national requirements on products should always be avoided to ensure that consumers can benefit from global ecosystems and economies of scale.

[33] GSMA. Spectrum: the climate connection, May 2023. h https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2023/05/Spectrum_Climate_Connection.pdf
[34] https://api.cept.org/documents/ecc-pt1/83527/ecc-pt1-24-110_ericsson-6 GHz-mfcn-downlink-spectral-efficiency-considerations
[35] The cell median throughput is equivalent to the available cell capacity for the mix of users served by the cell both outdoor and indoor. The reduced median throughput consequence of limitations in power would mean a reduction of the cell capacity shown on the Cell capacity loss column. Coverage loss reflects the percentage of population that are left outside of coverage when compared with the full power cell.

2) Use cases, expected deployments and timeframe

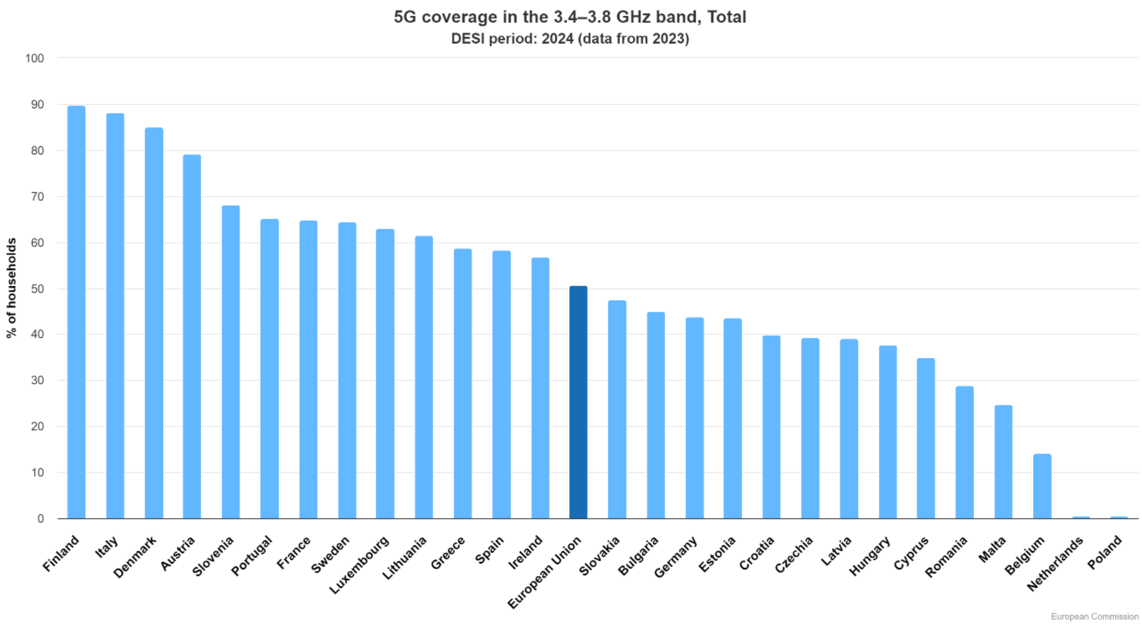
MFCN

As explained above, existing mainstream mobile use cases are expected to demand 5 times more traffic in 2030 compared to 2022, driven by higher definition and more intensive use of audiovisual content. On top of that, augmented reality applications with sensing and multimedia are also expected to be use cases in cellular networks because of the need for mobility.

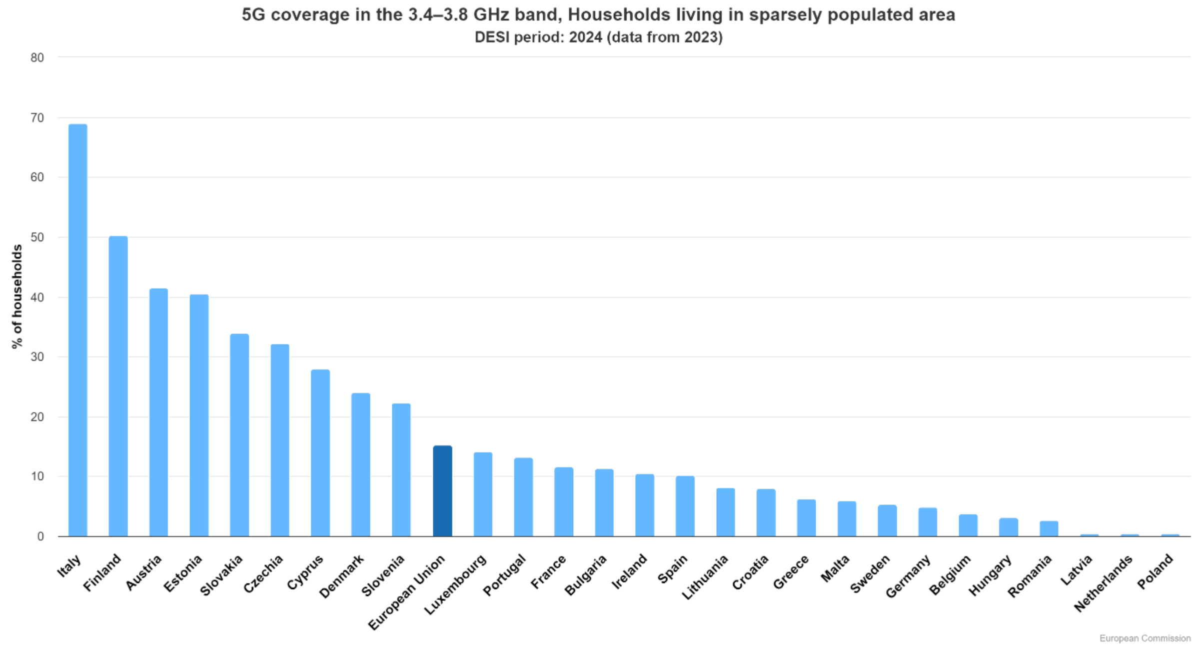
We expect spectrum demand to require deployments to start on average towards the end of the decade noting that the demands vary per country, even per operator. We expect operators to deploy in this band using the 3.5 GHz grid depending on capacity demands in the network. This likely means that first deployments of upper 6 GHz are done where early 3.5 GHz deployments were done. Typically, capacity demands appear in sites serving many users in urban/ suburban areas, but new type of use scenarios, e.g. FWA, may impact on demands.

3500 MHz current deployments are in our view a good proxy for future 6 GHz deployments. The population coverage reached today with the 3500 MHz band is therefore a good measure of the population that will be positively impacted by the allocation to IMT. The figures below are extracted from the latest Digital Decade report.[36]

Figure 8: 5G coverage in 3.5 GHz



[36] DESI indicators - Digital Decade DESI visualisation tool (europa.eu)



Source: European Commission

WAS/RLAN

Use cases for Wi-Fi in the 6 GHz band will in our view be driven by fixed broadband traffic, which is expected to grow at a slower pace than mobile. It is hard to estimate the market adoption rate of access point equipment, but we note that, as described above, operators and end users are not extensively installing routers that make use of the lower 6 GHz, despite being available since 2021, in stark contrast with IMT deployments in the 3.5 GHz band which started around that time in Europe (according to the EU, network coverage that relies specifically on the high-performance 3.5 GHz band has reached 51%[37]).

IV. Provide information about standardisation and technology impact

For cellular networks standardization and development has started and several trials have been conducted by mobile vendors and operators. Wi-Fi equipment supporting full 6 GHz band is available for US market.

The decision on the use of the band in EU and the defined conditions will have implications for the standardisation, implementation, technology availability, and cost. The conditions will also impact on possibilities to use the band efficiently to serve the demands, which impacts on market interest and thus even to development and implementation timelines for equipment that will be suitable for European market.

Europe should not define conditions and requirements which prevent efficient use of the band for meeting the European society demands. The solution should be both technically and commercially viable.

[37] 5G Observatory releases latest report, July 2024

GSMA

Appendix A: Upper 6 GHz trials for IMT

Several recent field trials and tests involving the upper 6 GHz band provide evidence on the ability of the upper 6 GHz band to provide an effective coverage and capacity layer for IMT. Further details on these trials are provided below.

Chulalongkorn University (February 2023) [38]

Chulalongkorn University, Thailand, conducted a field test of upper 6 GHz to study the data transmission quality for 5G Outdoor to Outdoor (O2O) and Outdoor to Indoor (O2I) deployment scenarios using the upper 6 GHz band. Using a channel bandwidth of 80 MHz, the test achieved average throughputs of 1100 Mbps (O2O) and 550 Mbps (O2I). This trial demonstrates that upper 6 GHz is able to offer good macro base station coverage performance, making it a suitable band for nation-wide IMT deployment.

Du, e& (August 2023)[39]

UAE operators du and e& completed a successful 5G-Advanced trial project involving the upper 6 GHz band. Using 400 MHz bandwidth, the trial achieved a throughput of 10 Gbps. The TDRA which confirmed the results, noted that the increase in data speed will support many future projects at the UAE level, especially those that require highly sophisticated technologies (e.g. nanotech) and high internet speeds, such as remote diagnostics in healthcare, or autonomous (self-driving) vehicle projects in transportation, as well as help in the management of some industrial installations.[40]

Deutsche Telekom (August 2023)[41]

German operator Deutsche Telekom completed a trial which achieved a data rate of ~12 Gbps. To achieve this speed, two 5G data streams – from upper 6 GHz and 3.7 GHz spectrum – were combined. The results highlight the capacity expansion benefits of 5G deployment using carrier aggregation of 3.5 GHz and upper 6 GHz mid-band spectrum and the ability of such a deployment to achieve reasonable indoor coverage.

Maxis, Universiti Malaya (September 2023)[42]

This upper 6 GHz trial conducted by Malaysian operator Maxis and Universiti Malaya achieved a peak throughout of 1.28 Gbps with 80 MHz bandwidth using a prototype Active Antenna Unit and a prototype mobile device. The test results showed good indoor penetration and the ability to achieve speeds of over 300 Mbps at locations more than 400m away from the mobile site, as well as potential for improvements in mobile signal propagation with more advanced antenna technology.

Vodafone Spain (October 2023)[43]

Vodafone announced a successful test of the upper 6 GHz band in Spain which achieved download speeds of up to 5 Gbps and on average 2 Gbps across various indoor locations. It

[38] More information at https://www.chula.ac.th/en/news/118185/

[39] More information at https://www.eand.com/en/news/29-aug-etisalat-by-eand-5G-advanced-network-speed-trials.html and https://www.du.ae/about/media-centre/newsdetail/du-breaks-new-ground-in-5g-advanced-trial

[40] More information at https://www.chula.ac.th/en/news/118185/https://tdra.gov.ae/en/media/press-release/2023/tdra-announces-successful-completion-of-phase-ii-of-advanced-5g-trials

[41] More information at https://www.telekom.com/en/media/media-information/archive/world-record-12-gigabits-per-second-in-mobile-communications-1048610 and https://api.cept.org/documents/ecc-pt1/81398/ecc-pt1-24-032_%C2%ADdt_6-ghz-trial

[42] More information at https://www.maxis.com.my/en/about-maxis/newsroom/2023/september/setting-the-right-path-to-meet-growing-data-consumption/

[43] More information at https://www.vodafone.com/news/technology/vodafone-tests-reveal-6 GHz-spectrum-to-avoid-5g-capacity-crunch

was noted that 75% of all mobile traffic originates from users at home, in the office, or in enclosed public places such as cafes, bars, shops, and gyms, and the ability of upper 6 GHz to serve indoor users will ensure consumers and businesses receive even faster access and more reliable 5G services over the next 5-10 years.

Ericsson, MediaTek (November 2023)[44]
Ericsson and MediaTek successfully carried out an interoperability test involving 5G NR data calls over upper 6 GHz band. This was performed with a MediaTek prototype test device and an Ericsson base station. The test was the first 5G NR data call on the 3GPP-defined n104 band (6.425-7.125 GHz) and highlights the efforts by telecom vendors, service providers, and device/chipset makers to build a global ecosystem for IMT in the upper 6 GHz band.

Telefonica Germany (September 2023)[45]
Telefónica Germany tested 5G in the upper 6 GHz band using an existing site in Stuttgart, with results that show the good propagation characteristics of the band in real environments, and its large potential value for both indoor and outdoor coverage.

The tests achieved peak download speeds of 3 Gbps using just a 100 MHz bandwidth in the upper 6 GHz base station. Even at the outdoor cell edge, 500 meters away from the roof-top site, 0.5 Gbps were obtained. Throughout the cell coverage the averaged download speed outdoor was almost 2 Gbps. Indoor coverage was also tested at 200 meters distance from the site obtaining very high download speeds of 1.7 Gbps.

The test shows the indoor coverage reach of 6 GHz in mobile networks, providing high download speeds that make indoor use of Wi-Fi very difficult in the same frequency and location as 5G. This suggests any power restrictions intended to reduce indoor penetration and accommodate Wi-Fi would result in impaired services, affecting the capacity and performance of the band and should be carefully analysed.

Nokia, Telia (June 2024)[46]
Nokia and Telia successfully completed a field pilot in the upper 6 GHz spectrum band that will add crucial capacity and coverage to existing macro cell sites in dense urban environments for next-generation 5G-Advanced and 6G networks.

During the trial, Nokia used a 128TRX Massive MIMO radio based on its AirScale Habrok platform and a test terminal from MediaTek with integrated antennas. The pilot examined whether the uplink coverage on the new, higher frequency is compatible with the existing inter-site distances. The companies 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.

Field tests confirmed the macro-grid-readiness of the upper 6 GHz spectrum used with Massive MIMO. It showed that massive capacity can be added in urban areas, where there is higher demand for TDD broadband, and high throughput can be achieved in suburban or rural areas. This offers operators an evolution path to 5G-Advanced and 6G, in the future.

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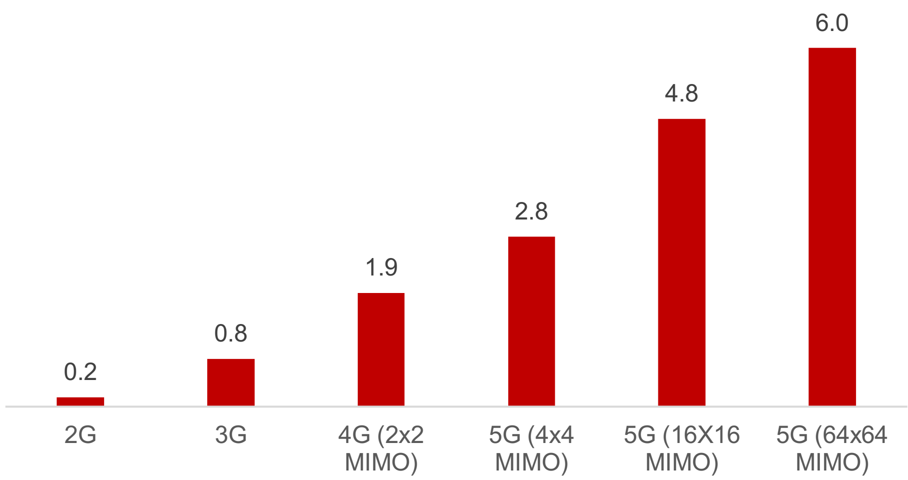
[44] More information at https://www.ericsson.com/en/news/2023/11/ericsson-and-mediatek-demo-on-6-ghz-licensed-5g-band
[45] https://www.telefonica.com/en/communication-room/blog/6 GHz-will-bring-high-benefits-for-society-with-the-right-rules/
[46] https://www.nokia.com/about-us/news/releases/2024/06/04/nokia-and-telia-complete-successful-outdoor-trial-in-6-ghz-range-with-massive-mimo-radio/

Appendix B: Mobile and Wi-Fi spectrum utilisation

Almost all governments and policymakers have an objective of ensuring that spectrum is used efficiently.[47] With each technology cycle, mobile has made more efficient use of spectrum, as shown in Figure B1, with the spectral efficiencies of 5G more than 7 times greater than 3G.

Operators also have an incentive to utilise spectrum efficiently because in almost all countries, they face a pricing signal to do so – whether they purchase spectrum in an auction and/or pay renewal or annual fees (or have a license obligation). This means that in addition to improving spectral efficiencies, they also re-use spectrum where possible by densifying networks.

Figure B1: Mobile spectral efficiencies by generation (bit/s/Hz)



Source: GSMA Intelligence

By contrast, where a spectrum user does not face a pricing signal, there is less incentive to deploy it as efficiently as possible. Figure B2 shows how Wi-Fi spectral efficiencies have evolved by generation, with the spectral efficiencies of Wi-Fi 6 around 2 times greater than that of Wi-Fi 4. However, these headline rates are rarely achieved due to co-channel and non-co-channel interference, especially in dense urban apartment buildings.

Given this challenge, several studies have sought to assess actual Wi-Fi spectrum needs to deliver certain speed requirements, for example 1 Gbit/s, in dense urban apartment blocks. This includes analysis by Qualcomm (2016 and 2023)[48], Analysis Mason and Huawei[49] and Plum Consulting.[50] More recently, Comtel published the results of a series of field tests on Wi-Fi connectivity in a high-density urban residential environment, with the aim of evaluating the ability of Wi-Fi access points to effectively handle high traffic volumes while subjected to significant interference.[51]

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[47] For example, Decision No 676/2002/EC of the European Parliament and of the Council, Article 1 states, "*The aim of this Decision is to establish a policy and legal framework in the Community in order to ensure the coordination of policy approaches and, where appropriate, harmonised conditions with regard to the availability and efficient use of the radio spectrum necessary for the establishment and functioning of the internal market in Community policy areas such as electronic communications, transport and research and development (R & D)*".
[48] Qualcomm (2016), A Quantification of 5 GHz Unlicensed Band Spectrum Needs and Qualcomm (2023), Presentation for the UK Spectrum Policy Forum On Future Demand for Unlicensed Spectrum
[49] Analysis Mason (2023), Impact of additional mid-band spectrum on the carbon footprint of 5G mobile networks: the case of the upper 6 GHz band
[50] Plum Consulting (2024), Wi-Fi Spectrum Requirements
[51] See https://www.comtelitalia.it/indoor_connectivity_test_en/

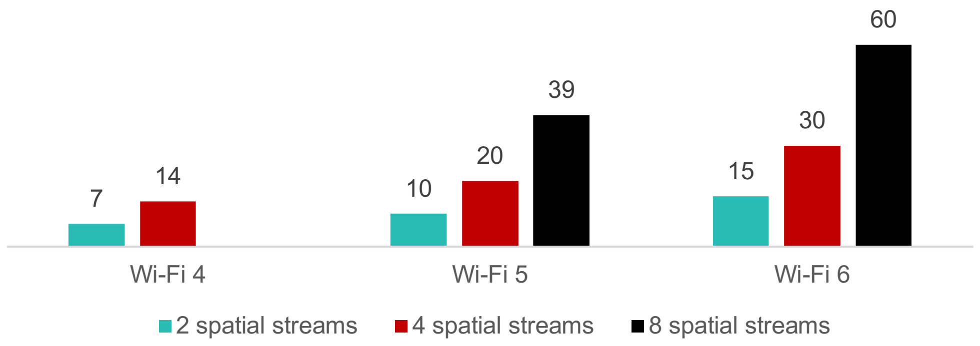
The results of these studies vary considerably based on the assumptions and inputs regarding:

- The frequency bands and channels used
- The number of access points
- Backhaul between access points (Ethernet or WLAN)
- Number of devices (or STAs)
- Number of antennas per access point and per STA
- Coverage
- Frequency re-use
- Access Point channels
- Use of unlicensed mmWave in the 57–71 GHz range

Figure B3 shows the range of spectral efficiencies implied from each study, based on the spectrum required to deliver 1 Gbit/s. The lower range typically assume one access point, 99% coverage, minimal frequency re-use, no utilisation of mmWave and that STAs will have 2 antennas even in the long-term.

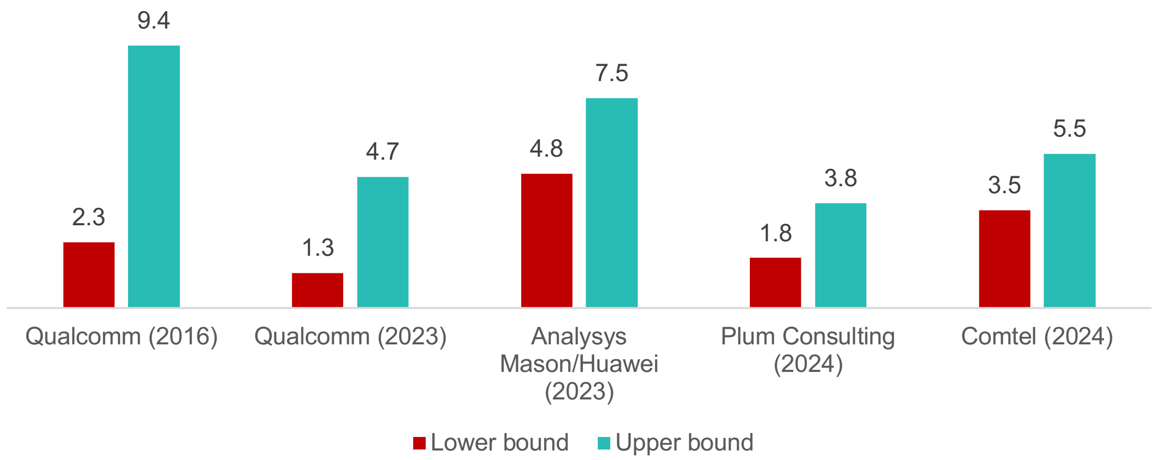
The upper range adjusts one or two of these assumptions, for example 2-4 access points, 90% coverage, greater frequency re-use or assuming STAs will have 4 antennas in the long-term. This is important because when deciding how to assign spectrum outside of a market-based mechanism, policymakers should incentivise the efficient use of spectrum and avoid assigning spectrum to compensate for inefficient use.

Figure B2: Wi-Fi spectral efficiencies by generation (bit/s/Hz)



Source: GSMA Intelligence calculations based on the MCS Index table

Figure B3: Wi-Fi spectral efficiencies to deliver 1 Gbps (bit/s/Hz)



Source: GSMA Intelligence calculations based on the respective studies

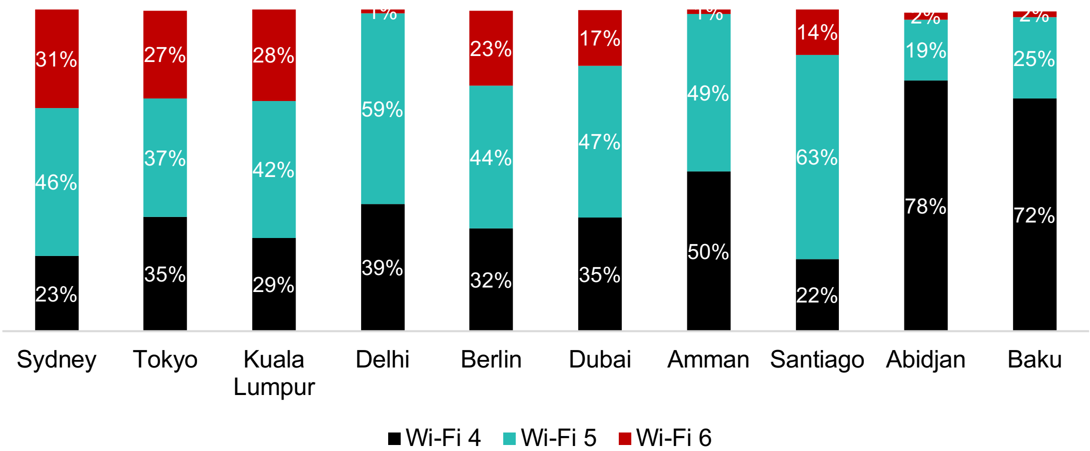
Wi-Fi performance can be significantly improved by upgrading Wi-Fi 4 devices

A related point regarding the efficient deployment of unlicensed networks is whether they are utilising the most efficient technology. In the 10 cities considered in this study, Figure B4 shows a significant proportion of Wi-Fi scans were on Wi-Fi 4, ranging from 22% in Santiago to 78% in Abidjan.[52]

As demonstrated in Figure B5, the type of Wi-Fi technology has a significant impact on user experience – download speeds on Wi-Fi 6 were up to 15 times faster than Wi-Fi 4. This shows that Wi-Fi performance could be significantly enhanced by upgrading users to the latest technology, as well as more efficient deployments indoors. It is also worth emphasizing that the fast speeds observed on Wi-Fi 6 in this analysis have not been dependent on access to the lower 6 GHz band. Figure B6 shows that when looking at Wi-Fi scans, less than 1% have utilised the lower 6 GHz band, with the exception of Tokyo. This includes cities such as Berlin, Sydney and Santiago, where the lower 6 GHz band has been available to use for unlicensed RLAN technologies.

It is also important to note that Wi-Fi speeds will be constrained by the maximum speed of the underlying copper, fibre or cable connection. Around half or more fixed broadband subscriptions cannot deliver speeds greater than 100Mbps in Europe, Latin America and the Caribbean, South Asia, Southeastern Asia, Sub-Saharan Africa and MENA (outside of the GCC).[53] In such cases, Wi-Fi and the amount of unlicensed spectrum will never be a capacity bottleneck.

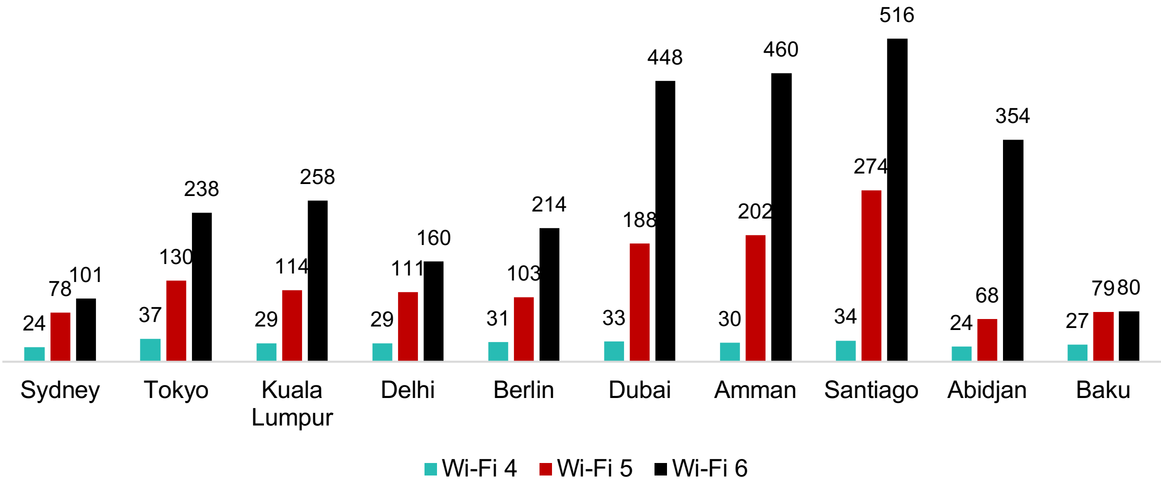
Figure B4: Distribution of Wi-Fi scans based on technology



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

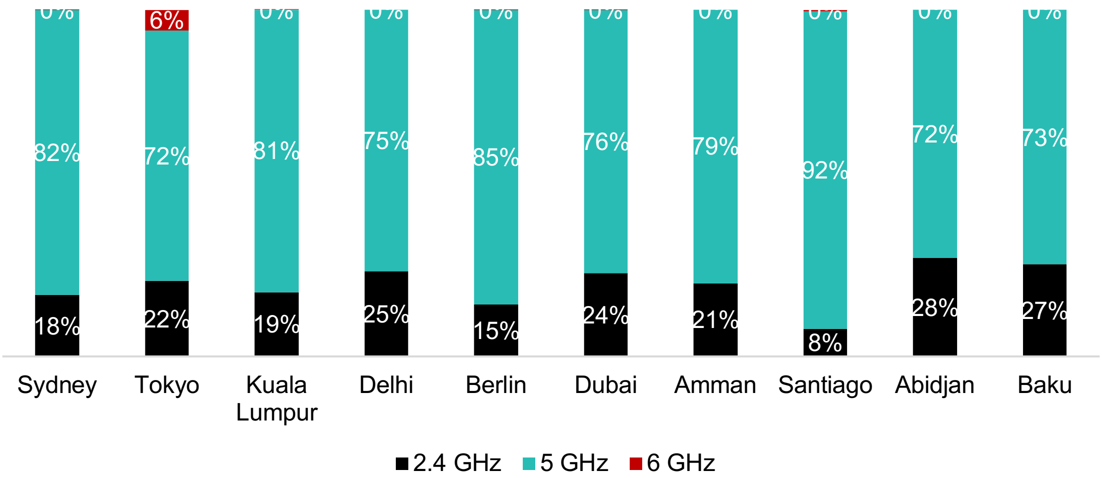
[52] This is further supported by analysis in other cities and countries, see for example https://www.ookla.com/articles/improve-Wi-Fi-in-the-home-q1-2023 and https://www.ookla.com/articles/gulf-fiber-Wi-Fi-standard-q2-2023
[53] GSMA Intelligence analysis of ITU data

Figure B5: Median download speeds by Wi-Fi technology



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Figure B6: Distribution of Wi-Fi scans by frequency



Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

B. Questions to the stakeholders providing incumbent services in the upper 6 GHz: I) Explain impact of possible future usage of the upper 6 GHz for MFCN and/or WAS/RLAN on existing services: II) What are your current and future spectrum needs (before and beyond 2030) in the upper 6 GHz band? III) What impact on your service do you expect from the introduction of MFCN and/or WAS/RLAN in the upper 6 GHz band? IV) What measures could improve compatibility from your perspective?

Many GSMA members have fixed links in 6 GHz band in some of their markets. Demands vary per markets. In general, these are longer haul-links, and have more relevance in less populated areas. Use may continue also beyond 2030 - pending on national licensing decisions, and possibilities for alternative solutions, and alternative demands of this spectrum in our networks. We have elaborated our conflicting interests in an input to CEPT WGSE[54].

MFCN

Cellular networks are deployed on licensed spectrum. Licensing decisions are national. The Regulator evaluates and consults on the demands before deciding on licensing, license conditions, and timelines. Licenses allow setting conditions to protect existing use (e.g. protection/coordination zones) if needed. As fixed links in 6 GHz bands are typically longer haul links in less populated areas, and mobile capacity demand is typically highest in populated urban/suburban areas, geographical sharing may be considered. However, we also expect to replace fixed links in upper 6 GHz band with other solutions/bands where and when needed to facilitate our cellular demands.

WAS/RLAN

WAS/RLAN networks operate typically on license-exempt spectrum. As WAS/RLAN use is low power and demand is mainly in populated areas whereas fixed links are primarily in less populated areas, the impacts might be low. However, as WAS/RLAN use is license-exempt, in reality it is impossible to ensure the use is as allowed (e.g. low power indoors, very low power outdoors). For example, WAS/RLAN interferences to Meteorological radars in 5 GHz band were brought up in ECC meeting in June 2024. Problems were caused by illegal use of WAS/RLAN, either wrongly configured networks, or equipment that are not allowed in European market.

CEPT SE is studying the possible impact of WAS/RLAN impact to FS. The work has not been finalized yet. There have been for example long discussions on parameters for the studies, e.g. WAS/RLAN activity factor and market adoption factor.

Based on the draft, almost all studies seem to conclude that WAS/RLAN are not causing harmful interference to FS (Long Term Protection Criterion and Fractional Degradation Performance is respected). However, work is still being carried out in SE19 to provide a generic methodology for deriving protection criteria for any source of time-varying interference into an FS receiver. This work studies how current FS receivers perform in the presence of pulse/burst type interference, with and without ACM (Adaptive Coding and Modulation). There are

[54] SE(23)059, European Mobile Network Operators' considerations for 6 GHz studies, May 2023

indications that pulsed/bursty signals (e.g. beacon signals with and without traffic on top) may have a more noticeable interference effect than noise-like/continuous signals at the same I/N level. The conclusions of the ongoing work may have impact on the results of the WAS/RLAN - FS sharing. Considering these discussions, and that in US, there are several FCC filings on WAS/RLAN interference in 6 GHz band[55], we may expect interference cases from RLAN to FS.

We consider that licensed use, with national evaluation of demands, and as needed appropriate conditions, e.g. geographical separation, phased refarming of link, are best approaches to ensure compatibility. If use is allowed on licensed basis, professional personnel are responsible of ensuring that deployments, configuration and operation respects the license conditions.

A licensed approach in the upper 6 GHz band would also facilitate coordination between existing fixed link users and new licensees. The number of parties involved would be much lower, and in many cases incumbent fixed link users and mobile operators acquiring licences would have similar interests.

[55] FCC ex-parte filing, AT&T, Unlicensed Use of the 6 GHz Band (9 September 2022) (First claim), FCC ex-parte filing, AT&T, Unlicensed Use of the 6 GHz Band (3 October 2022) (Analysis of the improper Cable Labs study), FCC ex-parte filing, AT&T, Unlicensed Use of the 6 GHz Band (19 December 2022) (Final conclusion), FCC ex-parte filing, Fixed Wireless Communications Coalition, Unlicensed Use of the 6 GHz Band (14 December 2022), FCC ex-parte filing, Fixed Wireless Communications Coalition, Unlicensed Use of the 6 GHz Band (6 June 2023), FCC ex-parte filing, Miami-Dade Security Department, Unlicensed Use of the 6 GHz Band (22 November 2022), FCC ex-parte filing, APCO, Petition for reconsideration (28 May 2020), FCC ex-parte filing, attached report, Southern Company, Test Report on the Effects of 6 GHz Unlicensed RLAN Units on Fortson to Columbus Microwave Link (21/23 June 2021) (filing, report), FCC ex-parte filing, Southern Company, Unlicensed Use of the 6 GHz Band (24 October 2022), FCC ex-parte filing, FirstEnergy, 6 GHz Additive Interference Study (12 October 2022), FCC ex-parte filing, FirstEnergy, 6 GHz Additive Interference Study, Phase 2 – Winter (9 May 2023)