techUK
FOR WHAT COMES NEXT

Industry views on the potential use of 6 GHz (5925-7125 MHz) for licensed and licence-exempt systems

This is an industry views document by techUK with differing levels of input from members as well as inputs from non-members and includes those who spoke at the UK SPF Cluster 4 event on WRC-23 agenda items related to the upper 6 GHz band. This document is not intended to fully represent any one single company's view but is a compendium of all views that have been expressed and relevant factual information.

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Industry views on the potential use of 6 GHz (5925-7125 MHz) for licensed and licence-exempt systems

This document captures industry views on "Pros and Cons of Licence-exemption for WAS/RLAN" and "Pros and Cons of Individual Licensing for Mobile Systems" in the 6 GHz (5925-7125 MHz) frequency range.

1. Executive Summary

Due to the significant differences in views, it was not possible to reach consensus on a single preference but that was never the intention.

Two views were expressed: some advocating for licence-exempt access for Wireless Access Systems/ Radio Local Area Network (WAS/RLAN) in both the lower 6 GHz (5925-6425 MHz) and upper 6 GHz (6425-7125 MHz), and some others generally accepting a licence-exempt approach for WAS/RLAN in the lower 6 GHz (5925-6425 MHz) in Europe but advocating for a licensed approach for use of mobile systems in the upper 6 GHz (6425-7125 MHz). A tabular representation of this, which capturers the implication on technology choices is shown in table 1.

Frequency Band	View 1: Licence-exempt WAS/ RLAN	View 2: Licensed Mobile Systems
5925-6425 MHz Lower 6 GHz	Wi-Fi and 5G NR-U (precludes 5G NR)	N/A
6425-7125 MHz Upper 6 GHz	Wi-Fi and 5G NR-U (precludes 5G NR)	5G NR (precludes Wi-Fi and 5G NR-U)

Table 1: Options for the 6 GHz band

Noting that 5G (Fifth Generation) New Radio (NR) (which is an International Mobile Telecommunications (IMT) technology) and 5G New Radio-Unlicenced (NR-U) (which is not an IMT technology) are specified at 3rd Generation Partnership Project (3GPP) and Wi-Fi is specified at the Institute of Electrical and Electronics Engineers (IEEE).

It is hoped that this document might be of some use for stakeholders including UK Ofcom in their deliberations in relation to the World Radiocommunications Conference 2023 (WRC-23) Agenda Item 1.2 which is considering a possible IMT identification within International Telecommunication Union (ITU) Region 1[1] for the upper 6 GHz band (6425-7125 MHz).

It is to be noted that the choice between Wi-Fi and 5G NR-U on one hand, and IMT 5G NR on the other hand, are partly influenced by sharing issues with respect to other users of these bands, for example the Fixed Service (FS) and Fixed Satellite Service (FSS). Such sharing issues in the upper 6 GHz (6425-7125 MHz) have not been examined in this Report and sharing between 5G NR and the incumbents is expected to be studied as part of the work on WRC-23 Agenda Item 1.2.

2. Discussion Document Scope and Objective

This discussion document is intended to capture "Industry views on the potential use of 6 GHz (5925-7125 MHz) for licensed and licence-exempt systems" in line with the scope of the techUK Licence-exempt Shared Spectrum Working Group. This discussion document captures, and consolidates where possible, a range of industry views on the "Pros and Cons of Licence-exemption for WAS/RLAN" and "Pros and Cons of Individual Licensing for Mobile Systems" in the 6 GHz band[2].

Within this discussion document 6 GHz means 5925-6425 MHz (lower 6 GHz) and also 6425-7125 MHz (upper 6 GHz).

3. Structure of the Report

This discussion document provides background on 6 GHz technology options; data traffic volume and growth; mid-band spectrum requirements; economic value of spectrum; spectrum authorisation regimes; role of WRC's; 6 GHz frequency allocation tables; European Commission (EC) 6 GHz Mandate; 6 GHz coexistence studies; 6 GHz technical regulatory requirements; 6 GHz standardisation status; product availability; finally summarising the –

- Pros and Cons of Licence-exemption for Wireless Access Systems/Radio Local Area Network (WAS/RLAN)
- Pros and Cons of Individual Licensing for Mobile Systems

4. 6 GHz Technology Options

There are a number of technologies that could be deployed in the 6 GHz band (5925-7125 MHz), in particular those standardised by the IEEE[3] and 3GPP[4]. There is also the possibility for further technologies since there is an expectation that the regulatory conditions in the UK, and indeed Europe, for accessing the 6 GHz band will be technology neutral. It is however noted that some regions might not adopt the principle of technology neutrality. The current technology options are detailed in the following sub-sections.

4.1. IEEE 6 GHz Wi-Fi (Wi-Fi 6 and Wi-Fi 6E)

Wi-Fi is one of the success stories of the technology era. The latest generation of the Wi-Fi standard is Wi-Fi 6, also known as IEEE 802.11ax, which was released in 2019. Building on the strengths of IEEE 802.11ac, Wi-Fi 6, adds additional efficiency, flexibility, and scalability that provides existing and future networks with increased speed and capacity to enable next-generation applications and services[5].

Wi-Fi 6 allows enterprises and service providers to support new and emerging applications and services on the same infrastructure while delivering a higher grade of service to legacy applications. This scenario sets the stage for new business models and increased adoption.

Wi-Fi 6 devices already have been widely deployed but consumers, enterprise and public sector users alike arguably will only be able to realise the full benefits of the new standard's innovation if access to the whole 6 GHz band is available. Wi-Fi 6 enables concurrent use of

multiple large bandwidth channels (160 MHz and more) and hence greatly benefits from larger blocks of spectrum to deliver optimal performance in terms of speed, latency, user experience, etc.

The key features and benefits from Wi-Fi 6 are shown in Figure 1.

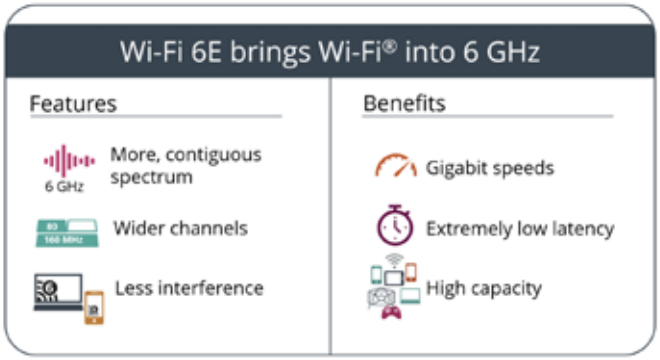

Figure 1: Key features and benefits of Wi-Fi 6 technology include[6]

Wi-Fi 6 (incorporating Wi-Fi 6E for the 5925-7125 MHz band), will accelerate the deployment of next generation Wi-Fi connectivity by delivering increased throughput with lower latency. Wi-Fi is the primary and most cost-effective indoor wireless access technology, providing the urgently needed data offload capacity for mobile networks, thereby potentially helping to reduce the costs of 5G rollout for mobile operators.

If backhaul / infrastructure is not the bottle neck, Wi-Fi 6 can improve the average throughput per user by a factor of at least three in dense user environments. By 2023, approximately 27%[7] of all Wireless Local Area Networking (WLAN) endpoints will be equipped with Wi-Fi 6.

Wi-Fi alongside other small cell technologies has a powerful role to play in delivering key use cases going forward in the 5G era.

4.2. 3GPP 6 GHz 5G NR (5G New Radio)

3GPP is one of the success stories of the technology era. 5G NR[8] is a new radio access technology (RAT) developed by 3GPP for the 5G (fifth generation) mobile network. It was designed to be the global standard for the air interface of 5G networks. Study of 5G NR within 3GPP started in 2015, and the first specification was released late 2017[8]. While the 3GPP standardisation process was ongoing, industry had already begun to implement infrastructure compliant with the draft standard, with the first large-scale commercial launch of 5G NR occurring in 2019.

5G NR is an IMT[9, 10] technology where IMT includes standards encompassing IMT-2000 (3G), IMT-Advanced (4G), and IMT-2020 (5G).

5G NR is the most advanced 3GPP technology to date, enabling not only enhanced mobile broadband (eMBB) and fixed wireless access (FWA), but also use cases for Industry 4.0 and vehicle-to-everything communications.

5G NR, and in particular its future deployments in the 6 GHz band (subject to satisfactory sharing studies) can help to address the future increased demand for capacity in mobile networks in city-wide (urban/suburban) environments, as well as for FWA outside the cities to bring the best broadband experience everywhere. In addition, it can be used for industry applications which require ultra-reliable low-latency communication (uRLLC) and guaranteed quality of service (QoS).

In September 2020, 3GPP approved a work item to specify 5G NR in the 6 GHz band, covering 5925-7125 MHz and 6425-7125 MHz[11].

4.3. 3GPP 6 GHz 5G NR-U (5G New Radio Unlicensed)

In December 2018, 3GPP agreed to start a work item on NR-U, which will define how 5G New Radio is introduced in licence-exempt spectrum. The work item covers various scenarios with functionalities such as Carrier Aggregation, Long Term Evolution (LTE) anchor in licensed spectrum, 5G NR anchor in licensed spectrum, uplink only in licensed spectrum, downlink only in licence-exempt spectrum, as well as standalone operation. 3GPP technology submission for IMT-2020 to ITU-R does not currently include 5G NR-U.

In particular, 3GPP Rel-16 defines NR-U operation in the 5 GHz band (n46) and the 6 GHz (5925-7125 MHz) band (n96), noting that n96 is applicable to the USA only[12]. Additionally, RAN#89 meeting (September 2020) approved a new release 17 work item to define performance requirements for NR-U operation in the 5925-6425 MHz frequency range in Europe.

5. Data Traffic Volume and Growth

Cisco's Visual Networking Index (VNI)[13] considers the impact that users, devices and other trends will have on global Internet protocol (IP) networks over a five-year period. By 2022, more IP traffic will cross global networks than in all prior "internet years" combined up to the end of 2016. In other words, more traffic will be created in 2022 than in the 32 years since the internet started. By 2022, 60% of global population will be internet users. More than 28 billion devices and connections will be online; video will make up 82% of all IP traffic.

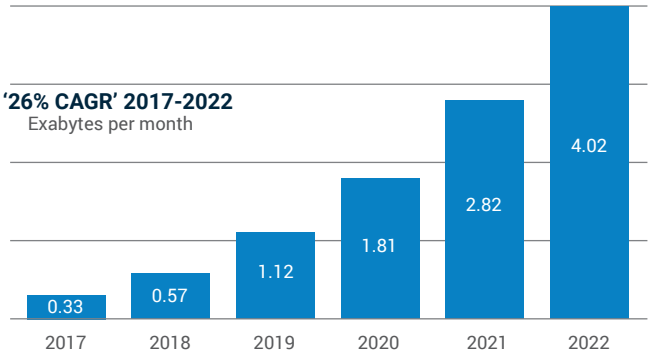

Figure 2: Global IP Traffic Forecast[14]

From 2017 to 2022, Cisco's VNI predicts –

- Global IP traffic will more than triple
- Number of connected devices will be more than three times global population
- Global internet users will make up 60% of the world's population
- Global networked devices and connections will reach 28.5 billion
- Consumer segment will be nearly 75% of total devices and connections
- Global broadband, Wi-Fi and mobile speeds will double or more
- Regional IP traffic growth details (2017-2022) -
  - Asia and the Pacific: 32% Compound Annual Growth Rate (CAGR), four-times growth
  - North America: 21% CAGR, three-times growth
  - Western Europe: 22% CAGR, three-times growth
  - Central and Eastern Europe: 26% CAGR, three-times growth
  - Middle East and Africa: 41% CAGR, six-times growth
  - Latin America: 21% CAGR, three-times growth
- Video, gaming and multimedia will make up more than 85% of all traffic
- M2M connections will be 50% of the global connected devices and connections -
  - connected home applications will have the largest share (48%)
  - connected car will be the fastest growing application type (30% CAGR)
- 5G will be over 10% of global mobile devices and connections; 1.4 billion
- Wi-Fi hotspots will grow four-fold to nearly 628 million
- Wi-Fi 6 hotspots will grow 13-fold and will be 11% of all public Wi-Fi hotspots

5.1. Wi-Fi Data Traffic Volume Annual Growth

Wi-Fi currently delivers more than half of all internet traffic and by 2022, 71% of total IP traffic will be wireless (Wi-Fi and Mobile); a 26% CAGR between 2017-2022[13].

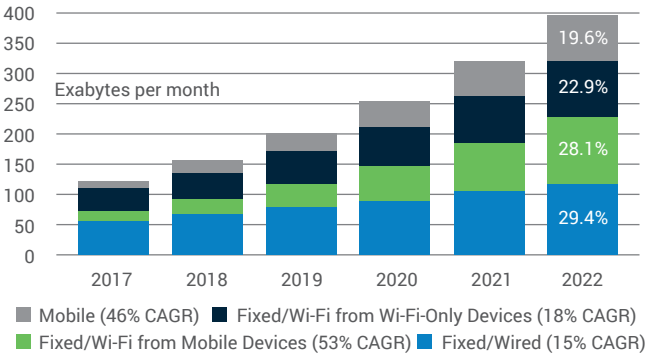

Figure 3: Global IP traffic by Local Access Technology[15]

5.2. Mobile Traffic Offload to Wi-Fi or Small-Cell Mobile Networks

From 2G to 3G, from 3G to 4G and now moving towards 5G, Wi-Fi offload continues to increase in importance and Cisco anticipates that approximately 70% of 5G offloaded traffic will be on Wi-Fi or small-cell networks as shown in figure 4.

Note: Offload pertains to traffic from dual-mode devices (excluding personal computers) over Wi-Fi or small-cell networks.

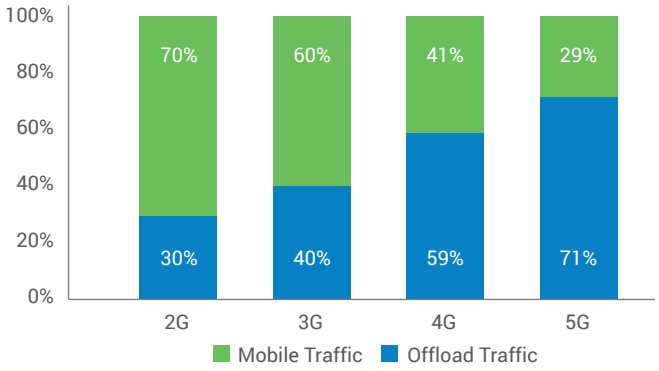

Figure 4: Mobile and Offload Traffic from Mobile Connected Devices[16]

One of the solutions to address the demands made on cellular networks due to the increasing demand for bandwidth has long been leveraging Wi-Fi networks, which enables operators to scale capacity to meet their subscribers' needs.

As indicated in a study by Coleago consultant[17]:

"Where the capacity and speed of mobile networks is low and / or prices for mobile data are high, smartphone users often log onto a Wi-Fi network rather than using the mobile network. This is referred to as "Wi-Fi offload". This is the traditional way in which people look at the complementarity of mobile (IMT) and Wi-Fi."

However, according to Coleago: "Wi-Fi offload is declining. The key factors in the trend away from Wi-Fi offload are the better 4G and 5G mobile user experience in terms of speed, the proliferation of unlimited data plans, and user convenience:

- 5G mobile offers a fibre-like user experienced data rate while most Wi-Fi connections are not connected to Fiber to the Home (FTTH) and hence offer a lower speed. This is borne out by real world measurements: "5G offers faster average download speeds than Wi-Fi in seven out of eight leading 5G countries".
- The launch of 5G has ushered in a trend for unlimited data plans, with South Korea, one of the world's most advanced 5G nations, being a prime example. This means smartphone users no longer ration their mobile data usage and stay connected to a mobile network even when free of charge Wi-Fi access is available.
- Mobile broadband networks provide ubiquitous connectivity and allow users to move around without logging onto location-specific Wi-Fi access points. This is extremely convenient to users. In other words, 5G delivers a level of user convenience which Wi-Fi cannot."

In short, Wi-Fi offload will remain important, however, there is qualitative evidence that suggest that it may not grow significantly:

- The cost per bit of mobile broadband provisioning is going down[18],[19],[20], which may make the business case of operator offloading less appealing.
- As unlimited (or >100GB) data packages and high speed networks become widespread[21], consumer demand for WiFi off-loading may decrease.

There is also quantitative evidence in support of the above. Data[22] made available by the Ministry of Science and Technology of South Korea shows that as of November 2020 the traffic carried by Korean

Mobile Network Operators (MNOs) has grown from 130,000 TB/month to 680,000 TB/month since 2015. However, the same data also shows that the proportion of this traffic that operators offload to their Wi-Fi networks has decreased steadily in the same period (from 6% to 2%). In absolute terms, offloaded traffic reached a maximum in 2019 and has started to decrease slowly while the cellular traffic has increased substantially.

5.3. 5G NR-U Traffic Volume

Currently there is very little experience of 5G NR-U and therefore there is no consistent information as yet.

6. Mid-Band Spectrum Requirements

Wi-Fi is at a crunch point since networks are growing increasingly congested as demand for device connectivity and throughput rises exponentially. The Wi-Fi industry needs new mid-band spectrum to improve user experience and deliver huge innovation and economic opportunities for Europe in the medium and long-term.

The issue of a significant shortfall in licence-exempt mid-band spectrum is not new and has been under consideration in Europe and worldwide for number of years including two World Radiocommunications Conference four-year study periods[23].

Some stakeholders expressed the view that mid-band spectrum in the 5925-7125 MHz range should be made available for licence-exempt WAS/RLAN such as Wi-Fi, 5G NR-U.

While others believe it is important that mid-band spectrum is made available for licensed mobile systems such as 5G NR.

There are efforts ongoing for a possible IMT[24] identification of the 6425-7125 MHz band at the World Radiocommunications Conference 2023 (WRC-23) via Agenda Item 1.2[25] within Region 1 (Europe, Middle East and Arica). The IMT identification of the upper 100 MHz (7025-7125 MHz) is being considered on a global basis again via WRC-23 Agenda Item 1.2.

For a successful implementation of IMT 5G NR, timely and adequate availability of spectrum is necessary in all three types of spectrum bands: low, mid and high-band, as each comes with its own characteristics, responding to different objectives and use cases: providing coverage in lower bands, capacity and coverage in mid-bands, and extreme high data rates for specific

use cases in high bands. When assessing the spectrum needs for the 2025-2030-time frame and beyond, it is important to associate them with the scenarios of the future, and their applications, of which some are not yet being realized /deployed.

When considering mid-band spectrum availability for IMT 5G NR in Europe, it is worth noting that despite the harmonisation of a large spectrum range in the C-band (3.4-3.8 GHz), in many countries the band is either only partially made available, or is made available in a fragmented way, or is not yet made available at all. The mobile industry recommends the availability of 100 MHz per MNO by 2021, with further additional mid-band spectrum needed in the 2025-2030 timeframe.

6.1. Licence-exempt Mid-Band Spectrum Studies

So far, two studies were undertaken that attest the need for additional mid-band spectrum for Wi-Fi; one by Quotient Associated Limited on behalf of the Wi-Fi Alliance and the other by Qualcomm.

No studies have yet been undertaken to justify mid-band spectrum for 5G NR-U.

The maximum amount of spectrum available for WAS/RLAN in the 2.4 GHz and 5 GHz bands that could be made available, subject to no national regulatory restrictions, would be 688.5 MHz (83.5 MHz in 2.4 GHz + 200+255+150 in 5 GHz = 688.5 MHz max). Figure 5 shows the existing spectrum allocations available for Wi-Fi[26].

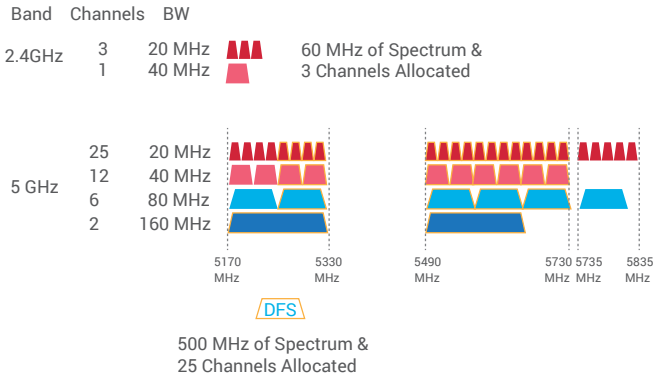

Figure 5: Existing 2.4 GHz and 5 GHz Spectrum for Wi-Fi[26]

6.1.1.Licence-exempt WAS/RLAN Mid-Band Spectrum Requirements – WFA Study

The Wi-Fi Alliance (WFA) points out that the increasing number of Wi-Fi devices combined with growing demand for Wi-Fi connectivity will exceed the existing spectrum capacity in the near future. The "Wi-Fi Spectrum Needs Study"[27] (undertaken by Quotient Associates Limited) concluded that by 2020, Wi-Fi networks around the world would need access to significantly more mid-band spectrum than currently available in the 2.4 GHz and 5 GHz bands to satisfy expected growth in data traffic, assuming that the fixed infrastructure is not the bottleneck.

The WFA study undertook a comprehensive analysis to determine the number of channels required to support Wi-Fi traffic by taking into consideration existing and future Wi-Fi device capabilities and deployment needs for business, residential and public locations. The study evaluated two demand scenarios: "expected traffic growth" and "potential

unexpected increase that may come from novel applications". The findings include -

- The ever-growing number and diversity of Wi-Fi devices along with increased connection speeds and data traffic volumes will exceed the capacity of spectrum currently available in the 2.4 GHz and 5 GHz bands by 2020;
- Between 500 MHz and 1 GHz of additional mid-band spectrum (additional to the 2.4 GHz and 5 GHz bands) in various world regions may be needed to support expected growth in Wi-Fi by 2020;
- If demand for Wi-Fi exceeds expected growth, then between 1.3 GHz and 1.8 GHz more mid-band spectrum may be required by 2025; and
- Wi-Fi spectrum needs to be sufficiently contiguous to support 160 MHz wide channels, which are required to support a growing number of bandwidth-intensive applications and to allow maximum Wi-Fi benefits to be attained.

WFA Spectrum Needs study new spectrum required per region as shown in Figure 6.

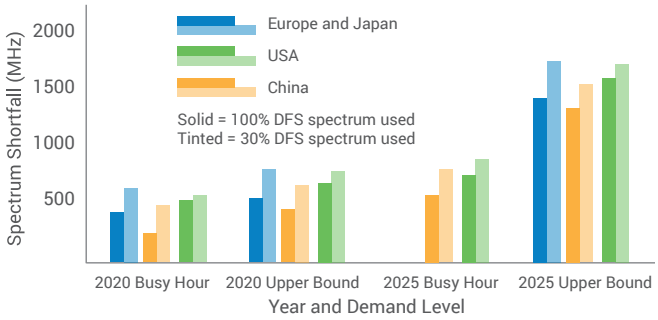

Figure 6: Illustration of mid-band spectrum shortfall per region, by year and demand level[28]

The amount of new mid-band spectrum required varies by geographical region. It is important that new contiguous spectrum is made available to allow wide channels of 160 MHz to be deployed.

6.1.2. Licence-exempt WAS/RLAN Mid-Band Spectrum Requirements – Qualcomm Study

Another spectrum needs study performed by Qualcomm[29], conducted a top down, engineering driven analysis to identify the amount of wireless spectrum required to achieve sustained 1 Gbps throughput, under various networking topologies in dense residential and enterprise deployment scenarios. The analysis shows that in dense environments that primarily rely on WLAN networking, a total amount of approximately 1280 MHz of spectrum is required centred around the 5 GHz band.

6.1.3. Licence-exempt Mid-Band Spectrum Requirements Conclusions

No studies have yet been undertaken to justify mid-band spectrum for 5G NR-U.

Currently the spectrum available for WAS/RLAN is typically in the 2.4 GHz and 5 GHz bands. The maximum amount of spectrum in these bands that could be made available, subject to no national regulatory restrictions, would be 688.5 MHz.

It is important to recognise the consistency of the two studies conclusions even though entirely different methodologies and models were applied. WFA Study concludes that between 500 MHz and 1 GHz of additional mid-band spectrum (in addition to the 2.4 GHz and 5 GHz bands) may be needed to support expected growth in Wi-Fi by 2020 while the Qualcomm study concludes that approximately 1280 MHz of spectrum is required centred around, and including, the 5 GHz band, assuming the appropriate channel bandwidths can be supported to meet throughout requirements. This assumed that demand for Wi-Fi did not exceed expected growth otherwise more spectrum would be required.

Achieving the goal of turning Europe into a Gigabit society by 2025[30], depends very much on the ability to fully deploy the next generation WAS/RLAN capabilities which can be realised with adequate access to licence-exempt mid-band spectrum access.

Access to the lower 6 GHz (5925-6425 MHz) plus upper 6 GHz (6425-7125 MHz) frequency bands will be essential for meeting the mid-band licence-exempt spectrum needs which were identified by the independent studies.

6.2. Licensed Mobile System Mid-Band Spectrum Studies

There are various reasons why access to additional mid-bands spectrum is needed for IMT 5G NR:

- A substantial growth of mobile data usage over the last years[31]; and this trend will continue for eMBB. New applications will also increase the mobile data usage, for example in smart cities.
- New applications that require a combination of high capacity city-wide and continuous coverage of urban and suburban areas are important drivers of IMT 5G NR use of mid-bands spectrum.
- City-wide applications, e.g., high-quality audio-visual mobile communications, in-vehicle entertainment including High Definition (HD) video streaming, and mobile streaming of HD videos in a variety of popular urban and suburban locations, will

all require a combination of coverage and capacity that can only be delivered in an economically feasible manner through the use of mid-bands.

- Applications for safe and smart cities for video surveillance, Vehicle-to-Network (V2N) communications for advanced driver assistance and autonomous vehicles, information sharing for traffic management, augmented reality (AR) for public safety, sensor networks, etc. have similar requirements for high coverage combined with high capacity.
- Industry 4.0 relies on connectivity to networks with high capacity and coverage; the more capacity is available at affordable prices, the easier the realisation of optimised operations, coverage of campuses, AR overlay for remote maintenance, and so on.
- FWA based on IMT 5G NR that can help bridge the digital divide, for both residential and business users, needs mid-band spectrum for capacity and to bring the number of serving FWA base stations down to an economically viable level. In particular, achievement of Europe's goal of a Gigabit society by 2025 depends on the ability to secure fixed infrastructure to all households and FWA is key to helping to deliver this at an affordable cost[32].

The Digital Economy and Society Index (DESI) 2020[33] indicates that European Union (EU) harmonised radio spectrum underpins future wireless digital services within the EU. The EC have identified the following bands as 5G "pioneer bands":

- 700 MHz band: 60 MHz (703-733 MHz and 758-788 MHz)
- 3.6 GHz band: 400 MHz (3400-3800 MHz)
- 26 GHz band: 24.25-27.5 GHz

Successive WRCs have identified specific frequency bands for deployment of IMT (IMT-2000, IMT-Advanced and IMT-2020).

Note: An IMT identification does not preclude the use of this band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. In effect, it is up to each country to determine which bands will be made available for IMT in each country/region depending on national/regional requirements.

If frequency bands already identified for IMT above 4990 MHz are excluded then the spectrum that has been identified for IMT (IMT-2000, IMT-Advanced and IMT-2020) which includes 5G NR (IMT-2020) is as detailed in Table 2. It should be noted that not all of the bandwidth identified for IMT is actually available for use by IMT networks, as these include duplex gaps (in Frequency Division Duplex bands), and also include frequencies used by the public sector (such as the military).

Total Amount of Spectrum Identified for IMT between 450-4990 MHz		
ITU-R Region 1	ITU-R Region 2	ITU-R Region 3
1348 MHz	1886 MHz	1786 MHz

Table 2: Total Amount of Spectrum between 450-4990 MHz Identified for IMT per ITU-R Region

The low, mid, and high bands are complementary and not substitutable, due to their widely different radio propagation characteristics. Thus, availability of low and high bands do not replace the need for mid-band spectrum (even if available).

In what follows, two studies highlight the mid-bands spectrum needs of licensed IMT mobile networks, one by consultants Coleago (endorsed by GSMA) and the other by the 5GAA.

6.2.1. IMT Mid-bands Spectrum Needs 2025-2030 - Coleago Study

A recent study[34] by Coleago Consulting provides an analysis of the future spectrum needs for IMT based on area traffic density demand for the 2025-2030 timeframe. The study shows that the currently available mid-bands in Europe (including fully availability of 3.4-3.8 GHz for 5G) are not sufficient for the citywide delivery of the ITU-R IMT-2020 requirements for a user experienced data rate of 100 Mbit/s on the downlink and 50 Mbit/s on the uplink in an economically viable manner, and that – depending on the population density – between 1000 to 2000 MHz of additional mid-bands spectrum is required for this purpose.

The study states that: "The analysis of future needs clearly shows the importance of additional mid-bands spectrum for 5G-NR and its evolution. The findings of our study point towards the following conclusions:

- In areas with a population density greater than 9,000 per km2, using an additional 1000 to 2000 MHz of upper mid-bands spectrum would enable operators to deliver the required citywide "speed coverage" with a 100 Mbit/s user experienced downlink data rate and a 50 Mbit/s uplink data rate in an economically feasible manner.
- Today's mobile networks cannot deliver the 100 Mbit/s downlink and 50 Mbit/s uplink user experienced data rates. However, it is economically feasible to deliver these data rates if the additional upper mid-bands spectrum is made available to mobile operators and mobile operators also make substantial investments in MIMO upgrades, upper mid-bands small cells, and high bands. In areas with a population density below 9,000 per km2, using the additional spectrum would still deliver benefits. The benefit would either be a lower site density or a higher experienced data rate. A lower site density translates into a lower cost per bit which in turn will translate into lower retail prices.
- Using these 2000 MHz of additional mid-bands spectrum for 5G FWA would reduce the average cost of bringing 100 Mbit/s connectivity to the remaining unconnected rural households in Europe by 79% compared to FTTH. It would also ensure that fibre-like speed FWA is a long-term solution capable of supporting Very High Capacity Networks (VHCN) at speeds above 100 Mbit/s.
- Substantial capacity is required on roads to serve the connected car and smart road use cases. Additional mid-bands spectrum would substantially reduce the number of sites that would otherwise be required to cover Europe's extensive motorway network."

In addition, the report concludes that the use of such additional mid-bands spectrum for FWA would reduce by €42 billion (compared to FTTH access) the cost of achieving European Union's 2025 connectivity target of 100 Mbit/s broadband for all households, and may reduce or even eliminate the need for public subsidies.

6.2.2. Licensed Mobile System Mid-Band Spectrum Requirements – 5GAA Study

In its recently published roadmap[35], the 5GAA sets out a consolidated view of the automotive and telecommunications industries on the evolution of communication technologies, their application to automotive connectivity, and the deployment of advanced driving use cases up to 2030, which include advanced safety and automated driving.

In this roadmap, the 5GAA identifies a number of promising advanced driving use cases, which can be supported by Cellular Vehicle-To-Everything (C-V2X) technologies[36]– LTE-V2X and 5G-V2X – for direct communications (between road users) and/or mobile network-based communications. These two modes of communications are illustrated in Figure 7.

Direct: V2V/V21/V2P in ITS bands (e.g. ITS 5.9 GHz) independent of cellular network

Network based: V2N/12N/P2N in bands designated for mobile communication networks

Figure 7: Direct and mobile network based communications modes supported by C-V2X[37]

As explained in 5GAA's spectrum needs study[38], the identified use cases can be classified as:

- "use cases which involve direct communications among road users or between road users and ITS roadside infrastructure (so-called V2V, V2I, V2P) as supported by the C-V2X (PC5) interface in the 5.9 GHz band harmonised globally for ITS, and
- use cases which involve network-based communications between road users and mobile network base stations (so-called V2N) as supported by the C-V2X (Uu) interface in bands designated and licensed for use by mobile communication networks,

where the term "road user" includes vehicles and pedestrians."

Based on the results of its spectrum needs study, the 5GAA concludes that:

"The current spectrum allocations available to mobile operators are not sufficient to support the advanced mobile network-based communications anticipated by the automotive industry. It is the view of the 5GAA that national and regional administrations address this with the following complementary actions:

- At least 50 MHz of additional service-agnostic low-band (< 1 GHz) spectrum be made available for mobile network operators to provide advanced automotive V2N services in rural environments with affordable deployment costs.

- At least 500 MHz of additional service-agnostic mid-band (1 to 7 GHz) spectrum be made available for mobile network operators to provide high capacity city-wide advanced automotive V2N services.

In the above, the term "additional" means availability of spectrum in addition to the bands that are currently identified for IMT use by mobile communication networks."

The 5GAA finally states that it "… places a high value on the importance of communications between road users and mobile network infrastructures in enabling future advanced driving use cases, as supported by the Uu interface of C-V2X. Accordingly, the 5GAA recommends that national and regional administrations ensure the availability of sufficient spectrum for mobile communication networks in the so-called low-bands and mid-bands for the support of services, including ITS, in the coming decade."

7. Economic Value Considerations

The increase in GDP from enabling new technologies, applications, and services is significant.

7.1. Licence-exempt WAS/RLAN Economic Value

In 2018, Wi-Fi economic value was nearly $2 trillion[39], and is expected to grow to almost $4.9 trillion by 2025. Wi-Fi has become a key complementary technology for enterprise and carrier networks and an essential part of the home, and this value will only raise when next generation products and deployments become available. Currently, there are more than nine billion Wi-Fi devices in use, and individuals, families, governments, and global organisations depend on Wi-Fi every day.

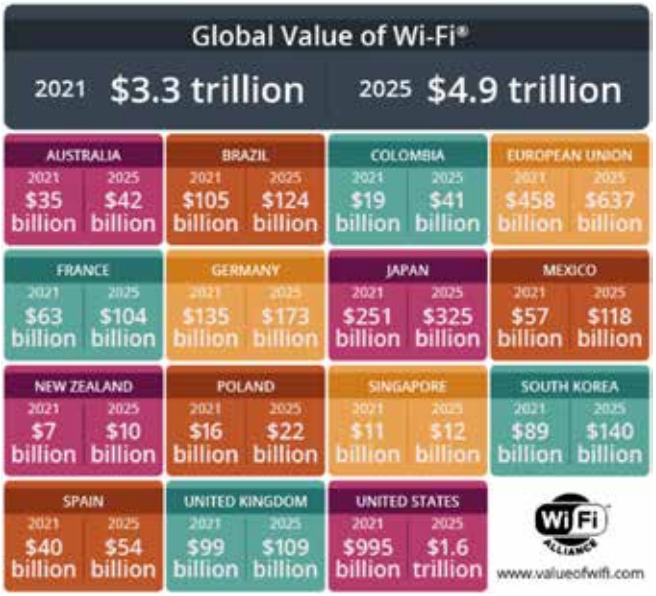

Figure 8: Global Economic Value of Wi-Fi and Selected Markets[40]

7.2. Licensed Mobile Broadband Economic Value

In 2019, mobile technologies and services generated 4.7% of GDP across the globe – a contribution that amounted to $4.1 trillion of economic value added. The mobile ecosystem also supported 30 million jobs (directly and indirectly) and made a substantial contribution to the funding of the public sector, with $490 billion raised through general taxation. By 2024, mobile's contribution will grow by $820 billion (approaching $5 trillion), accounting for 4.9% of GDP, as countries around the world increasingly benefit from the improvements in productivity and efficiency brought about by the increased take-up of mobile services.

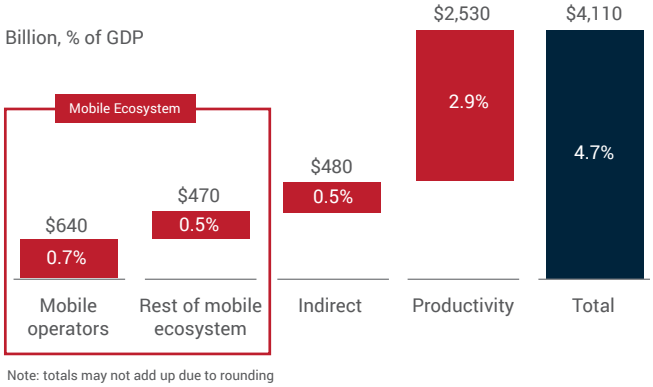

Figure 9: Additional indirect and productivity benefits bring the total contribution of the mobile industry to $4.1 trillion (4.7% of GDP)[41]

8. Overview of Spectrum Authorisation and Sharing Options[42]

The framework by which the use of spectrum is authorised has evolved in the UK from a command and control regime, which means Ofcom determines who is assigned spectrum and for what purpose, to a market-based approach, in which spectrum is offered to the market and those successful in obtaining it choose how it should be used (within the constraints of the terms and conditions of the authorisation approach). This has primarily been driven by the growing demand for spectrum (particularly for mobile networks as well as WAS/RLAN) and the complexities of determining who should have access to the spectrum, whilst ensuring that authorised users are appropriately protected from harmful interference depending on their requirements.

The authorisation approach adopted depends on a number of factors including the types of service, the frequency band being assigned and demand for access to spectrum; decisions regarding which approach to adopt are made by Ofcom which makes its decision in consultation with industry on a pre-defined set of proposals and in a final decision (Statement) once all stakeholder feedback has been considered.

Broadly speaking, there are two approaches to authorisation for the use of spectrum, namely licence exemption and licensing which are described below noting that authorisations for the use of spectrum in the UK (and Europe) are always technology neutral.

8.1. Licence-Exempt / General Authorisation

Some equipment does not require a licence as its use has been exempted by regulations. Ofcom[43] makes regulations to exempt equipment from licensing if its installation or use is not likely to:

- Involve undue interference with wireless telegraphy
- Have an adverse effect on technical quality of service
- Lead to inefficient use of the spectrum
- Endanger safety of life
- Prejudice the promotion of social, regional or territorial cohesion; or
- Prejudice the promotion of cultural and linguistic diversity and media pluralism

Users of licence-exempt devices should be aware that there may be congestion at certain locations and/or times. If users experience problems from other authorised devices it should be noted that they are offered no protection from interference. The ability of equipment to withstand interference may depend on its design, quality and robustness.

WAS/RLAN technologies (such as Wi-Fi and 5G NR-U) are based on physical (PHY) layer and medium access control (MAC) mechanisms specifically designed for operation on a licence-exempt basis.

In the UK the regulatory conditions for licence-exempt use of spectrum are typically described in exemption regulations and “interface requirements” published by Ofcom and must be adhered to by all relevant users.

8.2. Licensed Authorisation

8.2.1. Individual licensing

Individual licences give the individual holder of the licence the right to use a specific range of frequencies within a pre-determined geographic area, subject to the conditions set out in the licence. Any incumbent services which use the said frequencies may or may not continue to use those frequencies; i.e., individual licensing does not necessarily imply exclusive use of spectrum, and spectrum sharing with other services is not precluded.

Individual licences may be in the form of national licences, where the spectrum usage rights apply to the entire area of the country (with possible exclusion areas for protection of certain other services). Such national licences are typically awarded to mobile network operators for the deployment of public mobile networks.

Individual licences may also be in the form of geographic licences, where the spectrum usage rights apply to specific areas that are defined in the licence. Examples of such licences include the Ofcom shared access licences which are currently available in four spectrum bands -

- 1800 MHz band: 1781.7 to 1785 MHz paired with 1876.7 to 1880 MHz;
- 2300 MHz band: 2390 to 2400 MHz;

- 3800 to 4200 MHz band; and
- 24.25-26.5 GHz (only available for indoor low power licences)

as well as local access licences (in all mobile bands), both introduced by Ofcom in 2019[44]. Other examples include regional licences for the provision of fixed wireless access (e.g., in the 28 GHz band in the UK).

8.2.2. Concurrent licensing

In concurrent licensing, multiple licensees are given the right to use a specific range of frequencies within a pre-determined geographic area, subject to the conditions set out in the licence. Any mutual interference between the licensees is managed by the licensees themselves (or by a party on their behalf) and is typically assisted through the registration of the licensees in a database.

Like individual licensing, concurrent licences may be national or apply to specific geographic areas. Examples of national concurrent licences include those issued by Ofcom in 2006 for the use of the DECT guard band, although these were subsequently made obsolete as the band was changed to a shared access band with individual local licences in 2020.

Concurrent licences are also sometimes referred to as a category of light licensing, on the account that no specific coordination mechanisms are specified, and the responsibility for mitigating any harmful interference is with the licensee.

8.2.3. Licence Award Process

Licenses are awarded to users in a number of ways as outlined below.

8.2.3.1. Beauty Contests

Beauty contests are administrative approaches in which the regulatory authority issues spectrum licences to the candidates that are considered to best meet a number of criteria such as financial resources, industry experience, technology and rollout plans and, in some cases, price offers.

A particular problem of such administrative assignment is the risk that successful applicants are unable to fulfil their offers particularly if market or technologies forecasts prove incorrect. Licensing authorities should set out in advance what penalties will be imposed.

This type of assignment process is no longer used in the UK.

8.2.3.2. First-come-first-served

This refers the case where individual licences are issued on a first come first served basis, and in many cases through detailed technical coordination. In this approach, the conditions set out in any new licence must ensure the adequate protection of existing licensees from harmful interference, e.g., fixed microwave links, or shared access licences (1800 MHz, 2390-2400 MHz, 3800-4200 MHz, and 24.25-26.5 GHz) introduced by Ofcom in 2019.

8.2.3.3. Spectrum Auctions

Spectrum auctions refer to the case where the regulator uses an auction to award the rights to use a specific range of frequencies to the highest bidder in a competitive process.

GSMA "Best practice in mobile spectrum licensing"[45] dated September 2016 summarised the advantages and disadvantages of auctions as shown in Figure 10.

	Advantages	Disadvantages
AUCTIONS	• Well-designed auctions result in spectrum being assigned to the operators who value it most and will generally therefore put it to use in the way that generates the greatest benefits to society • Seeks to discover the market value of spectrum and obtain a fair return on a vital national asset • Specific non-price objectives can be targeted through licence conditions but these should only be imposed following careful consideration and where other measures have been ruled out • Outcome is typically transparent and generally legally robust	• Poor auction design can lead to spectrum being assigned inefficiently or in way that harms competition in communications markets (including as a result of high reserve prices limiting participation) • Inflated prices risk restricting the licensee's ability to invest in high quality networks with widespread coverage
ADMINISTRATIVE ASSIGNMENT	• Enables a range of criteria to be taken into account and for authorities to balance the trade-off between objectives • Authorities can select the level of the licence fee which may improve operators' ongoing financial viability and assist in raising capital for network investment • Ability to set network investment or coverage requirements to focus on delivering high quality services rather than raising state revenues • Can be quick and cheap to organise and is appropriate where spectrum demand does not exceed supply	• Licences may be assigned to the candidate that presents an attractive proposal rather than the candidate that can make best use of the spectrum. Where operators fail to meet commitments after the auction, authorities may face difficult choices as to whether to cancel the licence or otherwise penalise the operator • Administrative assignment is vulnerable to bias or corruption and even the perception of such can lead to protracted legal disputes that delay spectrum being put to good use

Figure 10: Advantages and Disadvantages of Auctions[46]

9. World Radiocommunication Conferences (WRC)

9.1. WRC-19 Agenda Item 1.16 Outcome

The World Radiocommunication Conference 2019 (WRC-19) Agenda Item 1.16[47] considered additional spectrum for WAS/RLAN –

> to consider issues related to wireless access systems, including radio local area networks (WAS/RLAN), in the frequency bands between 5150 MHz and 5925 MHz, and take the appropriate regulatory actions, including additional spectrum allocations to the mobile service, in accordance with Resolution 239 (WRC-15)

WRC-19 concluded that it is not possible to specify any appropriate mitigation techniques and/or operational compatibility and sharing conditions that would allow WAS/RLANs to be operated in 5350-5470 MHz while ensuring relevant protection of incumbent services.

9.2. WRC-23 Agenda Item 1.2

Another outcome from WRC-19, under Agenda Item 10, was the creation of WRC-23 Agenda Item 1.2 (Mid-band IMT): to consider possible identification of the frequency bands 3300-3400 MHz, 3600-3800 MHz, 6425-7025 MHz, 7025-7125 MHz and 10.0-10.5 GHz for IMT, including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 245 (WRC-19).

Agenda Item 1.2 describes the following bands for sharing and compatibility studies:

- 3600-3800 MHz and 3300-3400 MHz (Region 2)
- 3300-3400 MHz (amend footnote in Region 1)
- 6425-7025 MHz (Region 1)
- 7025-7125 MHz (Globally)
- 10000-10500 MHz (Region 2)

ITU geographical Region 1 consists of Europe, Middle East, and Africa as shown in Figure 11.

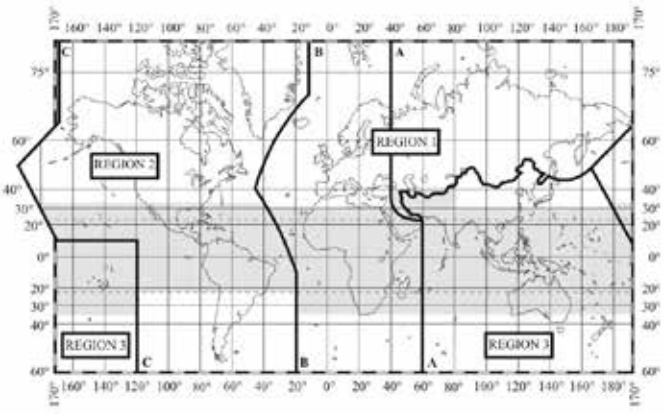

Figure 11: ITU Geographical Regions[48]

Agenda Item 1.2 potential IMT identification

• 7025-7125 MHz (100 MHz) Globally (Region 1, Region 2 and Region 3)

• 6425-7025 MHz (600 MHz) Region 1 (EMEA)

The WRC-23 is a key opportunity to harmonise spectrum and respond to the growing data demand for 5G. Engagements in WRC-23 process (Agenda Item 1.2), in particular on 6 GHz, should ensure sufficient spectrum will be made available for balanced coverage and capacity for 5G under an IMT Identification.

10. 6 GHz Frequency Allocation Tables

10.1. 6 GHz European Common Allocation Table

The European Common Allocations Table (ECA Table) in ERC Report 25[49] and the ECO Frequency Information System (EFIS), show a mobile allocation for 5925-6700 MHz but there is no mobile allocation for 6700-7125 MHz.

Frequency band	Allocations
5925MHz - 6700MHz (5.149)(5.440)(5.458)	Mobile Fixed Fixed-Satellite (Earth-to-space) Earth Exploration-Satellite (passive)
6700MHz - 7075MHz (5.458)(5.458A)(5.458B)	Earth Exploration-Satellite (passive) Fixed-Satellite (Earth-to-space) (space-to-Earth) (5.441) Fixed
7075MHz - 7145MHz (5.458)	Earth Exploration-Satellite (passive) Fixed

Table 3: 5925-7145 MHz European Common Allocations Table (ECA Table)[50]

It is understood that the ECO are reviewing this discrepancy since the number of European Conference of Postal and Telecommunications (Administrations) (CEPT) countries with mobile allocations in the 6 GHz band (from EFIS) is as shown in Table 4.

Band	Primary	Secondary
5925 MHz - 6425 MHz	3	
5925 MHz - 6700 MHz	15	2
6425 MHz - 6700 MHz	4	
6700 MHz - 7075 MHz	19	2
7075 MHz - 7145 MHz	17	1
7075 MHz - 7250 MHz	1	1

Table 4: 5925-7145 MHz European Mobile Allocations (EFIS)[51]

10.2. 6 GHz ITU Radio Regulations Frequency Allocation Table

The ITU Radio Regulations Frequency Allocation Table for the 5925-6425 MHz and 6425-7125 MHz frequency ranges shows the existing allocations and confirms that there is mobile allocation from 5850-7145 MHz.

Frequency band	Allocations
5850MHz - 5925MHz (5.150)	Fixed Fixed-Satellite (Earth-to-space) Mobile
5925MHz - 6700MHz (5.149)(5.440)(5.458)	Mobile (5.457C) Fixed (5.457) Fixed-Satellite (Earth-to-space) (5.457A)(5.457B)
6700MHz - 7075MHz (5.458)(5.458A)(5.458B)	Mobile Fixed-Satellite (Earth-to-space) (space-to-Earth) (5.441) Fixed
7075MHz - 7145MHz (5.458)(5.459)	Fixed Mobile

Table 5: 5925-7145 MHz ITU (Region 1) Frequency Allocation[52]

11. European Commission (EC) 6 GHz (5925-6425 MHz) Mandate

In 2013 the EC submitted a Mandate[53] to CEPT to study and identify harmonised compatibility and sharing conditions for WAS/RLAN in the 5 GHz extension bands 5350-5470 MHz and 5725-5925 MHz. CEPT Report 64[54] (dated November 2016) in response to the EC Mandate concludes that considering the results of the studies performed

under tasks of the EC Mandate it is not possible to specify any appropriate mitigation techniques and/or operational compatibility and sharing conditions that would allow WAS/RLANs to be operated in the bands 5350-5470 MHz and 5725-5925 MHz while ensuring relevant protection of incumbent services in these bands.

The issue of additional spectrum for WAS/RLAN was also considered by the World Radiocommunication Conference 2015 (WRC-15) and was on the agenda for WRC-19 (under Agenda Item 1.16)[55]. This Agenda Item was limited to 5150-5925 MHz but would not deliver any additional new spectrum required for future WAS/RLAN traffic which is estimated to be in the region of 500 MHz - 1 GHz[56].

In December 2017, the EC issued[57] a "Mandate to CEPT to study feasibility and identify harmonised technical conditions for Wireless Access Systems including Radio Local Area Networks in the 5925-6425 MHz band for the provision of wireless broadband services".

The "purpose" of the EC 6 GHz Mandate to CEPT was as follows:

> "The objective of the Mandate is to study feasibility and identify harmonised technical conditions for a sustainable and efficient use on a coexistence basis of the 5925-6425 MHz band for wireless access systems including radio local area networks (WAS/RLANs). Based on the results of the compatibility and coexistence studies covering the 5925-6425 MHz band to be carried out under this Mandate, the relevant harmonised technical conditions should enable the coexistence with other systems in this and adjacent frequency bands."

The "Tasks" of the EC 6 GHz Mandate to CEPT were as follows:

> **Task 1 – Assessment and study of compatibility and coexistence scenarios in the band 5925-6425 MHz**
>
> "To study and assess compatibility and coexistence scenarios for WAS/RLANs in the 5925-6425 MHz band and identify relevant parameters and coexistence conditions to be implemented in the regulatory framework in order to enable coexistence between existing usages and WAS/RLAN systems without constraining incumbent uses in various Member States in and adjacent to the band 5925-6425 MHz including at the outer EU border.
>
> For each compatibility/coexistence scenario, the risk of interference, the deployment assumptions of all applications, the geographical extent of usage and consequential restrictions in WAS/RLAN deployment should be identified as well as requirements for implementing such scenarios, e.g., in terms of harmonised technical parameters or in terms of other regulatory and operational aspects which support the implementation of a coexistence framework."

Task 2 – Development of harmonised technical conditions

"Taking into account the results of task 1, for the band 5925-6425 MHz develop appropriate mitigation techniques and/or operational compatibility/coexistence conditions. In the light of experience, these conditions should in particular identify the harmonised technical parameters that would be needed to ensure in the internal market consistent harmonised conditions for WAS/RLANs operating on a coexistence basis, if technically feasible. This should be developed in close cooperation with European Telecommunications Standards Institute (ETSI) which is working on harmonised standards which include operational coexistence conditions for WAS/RLANs with other systems in the band and in adjacent bands.

It is assumed in this Mandate that WAS/RLANs could operate on the basis of a general authorisation only. With a view to achieving a scope for worldwide harmonisation of additional spectrum for WAS/RLAN that would strengthen the economies of scale for manufacturers of RLAN equipment and thereby benefit all end-users, the work carried out under this task should take into account developments in other ITU Regions, e.g., through the organisation of a workshop."

The EC 6 GHz Mandate to CEPT is explicit in highlighting the positive impact access to mid-band spectrum for WAS/RLAN will have in the context of the Digital Single Market Strategy and Digital Agenda for Europe. The EC cites studies that state between 500 MHz and 1 GHz of additional spectrum in various world regions may be needed to support expected growth in WAS/RLAN usage by 2020. The relevant parts of the EC 6 GHz Mandate to CEPT are as follows:

> "In view of the above broadband connectivity objectives as part of the Digital Single Market Strategy and Digital Agenda for Europe and considering the steadily increasing amount of data traffic delivered through fixed broadband networks, the Commission considers WAS/RLAN frequency bands as part of the solutions for the provision of internet-based services. It is therefore necessary to ensure that sufficient spectrum resources are made available on a harmonised basis to support a long-term future for new generations of WAS/RLAN technologies that will provide increasing data capacity and speed.
>
> Recent studies carried out by WAS/RLAN industry point to the ever-growing number and diversity of devices for WAS/RLAN along with increased connection speeds and data traffic volumes will exceed the capacity of spectrum currently available in the 5 GHz band by 2020.

Between 500 MHz and 1 GHz of additional spectrum in various world regions may be needed to support expected growth in WAS/RLAN usage by 2020. Additional spectrum identified for WAS/RLAN should support wide channels which are required for a growing number of applications which need a large bandwidth to achieve Gigabit speeds.

The Commission focuses on the 5925-6425 MHz band as a promising alternative to 5 GHz where spectrum currently available for WAS/RLAN cannot be extended given the outcome of the previous Mandate (2013).

CEPT should work in cooperation with ETSI and take into account international harmonisation, as appropriate, in order that any opportunities for even greater economies of scale for manufacturers of WAS/RLAN equipment can be realised.

In the work carried out under the Mandate, the overall policy objectives of the RSPP, such as effective and efficient spectrum use and the support for specific European Union policies shall be given utmost consideration. In implementing this Mandate, the CEPT shall, whenever relevant, take utmost account of EU law applicable and support the principles of service and technological neutrality, non-discrimination and proportionality insofar as technically possible."

12. 6 GHz Coexistence Studies

12.1. CEPT Studies

Due to the EC 6 GHz Mandate to CEPT being restricted to the 5925-6425 MHz range the WAS/RLAN coexistence studies undertaken to date within CEPT are limited to this range.

Currently, no WAS/RLAN coexistence studies have been undertaken within CEPT for the 6425-7125 MHz range, but the incumbents are similar for both the lower 6 GHz (5925-6425 MHz) and upper 6 GHz (6425-7125 MHz).

12.1.1. WAS/RLAN and Incumbents Coexistence Studies (5925-6425 MHz)

Coexistence between WAS/RLANs and incumbents needs to be taken into consideration fully before new spectrum identifications, designations, allocations, and/or access can be achieved. This work has progressed over the past few years culminating in November 2020 with the approval of CEPT Report 75[58] "to study feasibility and identify harmonised technical conditions for Wireless Access Systems including Radio Local Area Networks in the 5925-6425 MHz band for the provision of wireless broadband services; Report B: Harmonised technical parameters for WAS/RLANs operating on a coexistence basis with appropriate mitigation techniques and/or operational compatibility / coexistence conditions, operating on the basis of a general authorisation."

The executive summary of this report states[59]:

"This CEPT Report contains technical conditions for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the 5945-6425 MHz band. This is in response to Task 2 of the Mandate from the European Commission (EC) to CEPT (see Annex 2).

The recommended framework distinguishes the following use cases for use by WAS/RLAN in the 5945-6425 MHz frequency band:

- Low power indoor (LPI) use, max 200 mW e.i.r.p., with no outdoor use allowed;
- Very low power (VLP) portable use, max 25 mW e.i.r.p., that may operate both indoor and outdoor.

CEPT considered in its investigations the possible use of the 5925-6425 MHz band for the provision of wireless broadband services. However, in the course of the technical considerations, it was proposed that WAS/RLAN transmissions should be constrained to above 5945 MHz to take into account operations of Urban Rail Intelligent Transport Systems (ITS).

According to the studies conducted, CEPT concludes that coexistence between WAS/RLAN operating in the 5945-6425 MHz band and existing services and systems within the band and in adjacent bands would be technically feasible under the generic technical conditions detailed in Annex 1.

It should be noted that the -45 dBm/MHz out-of-band (OOB) limit below 5935 MHz for VLP would allow VLP initial market to take up. CEPT also agreed that this OOB limit should be valid in time only until 31 December 2024 and be re-examined with regard to an opportunity to relax it based on the real IEEE and Direct Sequence Spread Spectrum (DSSS) Urban Rail interference situation. In absence of the justified evidence, a value of -37 dBm/MHz, for the OOB limit below 5935 MHz, will be adopted from 01/01/2025.

In addition, to maintain the protection of point-to-point FS, national administrations should consider an effective enforcement of the indoor restriction for LPI.

WAS/RLAN use under these conditions is expected to be exempt from individual licensing. The harmonisation on an EU basis would support EU Directive 2014/53/EU [3] of the European Parliament and of the Council of 16 April 2014 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity. Additionally, CEPT has developed a ECC Decision (20)01 to foster wider regional harmonisation of the use of the frequency band 5945-6425 MHz by WAS/RLAN devices."

12.1.2. Studies of coexistence among WAS/RLAN Technologies (5925-6425 MHz)

ETSI will define the European Harmonised standard (EN 303 687[60]) such that it addresses all WAS/RLAN technologies equally. It should be noted that currently EN 303 687 only addresses the 5925-6425 MHz range, in line with decisions in CEPT.

12.1.3. WAS/RLAN and Incumbents Coexistence Studies (6425-7125 MHz)

Currently, no WAS/RLAN coexistence studies have been undertaken in the CEPT for the 6425-7125 MHz range, but the incumbents are similar for both the lower 6 GHz (5925-6425 MHz) and upper 6 GHz (6425-7125 MHz).

12.1.4. IMT and Incumbents Coexistence Studies (6425-7125 MHz)

Currently, no IMT (5G NR) coexistence studies in CEPT have been undertaken for the 6425-7125 MHz range.

12.1.5. IMT and WAS/RLAN Coexistence Studies (6425-7125 MHz)

Currently, no studies have been undertaken on coexistence between IMT (5G NR) and WAS/RLAN for the 6425-7125 MHz range.

12.2. ITU-R Studies

The ITU-R undertook coexistence studies between IMT-Advanced and the incumbent services, the Fixed Service and the Fixed Satellite Service. For the Fixed Service, studies apply for the 5925-6425 MHz and are contained in Report ITU-R F.2326-0[61] published November 2014. For the Fixed Satellite Service, studies apply for the 5850-6425 MHz and are contained in Report ITU-R S.2367-0[62] published in and June 2015.

Since WRC-15, IMT technology has evolved and ITU has also improved radio propagation and clutter loss models. All these elements are yet to be studied within ITU-R and their impact on coexistence with incumbents has yet to be determined.

12.2.1. WAS/RLAN and Fixed Service Coexistence Studies (5925-6425 MHz)

ITU-R has not studied this.

12.2.2. WAS/RLAN and Fixed Satellite Service Coexistence Studies (5925-6425 MHz)

ITU-R has not studied this.

12.2.3. IMT and Fixed Service Coexistence Studies (5925-6425 MHz)

Report ITU-R F.2326-0 (11/2014)[63] "Sharing and compatibility study between indoor International Mobile Telecommunication small cells and fixed service stations in the 5925-6425 MHz frequency band" concluded that coexistence, with one IMT base station, could be achieved operating co-channel with point-to-point FS receivers at distances of 20 to 200m in most directions, except for the main and first side lobes of the antenna pattern. In the main lobe direction of the antenna pattern this distance corresponds to 8 to 50km, depending on the value of additional losses due to local clutter shielding, which could

be present in an IMT urban environment. These results are derived based on a single interferer and do not consider the cumulative effect, which could lead to different values.

When detailed information on point-to-point link deployment is available, more detailed planning of IMT systems could be performed to possibly reduce the separation distances mentioned above.

12.2.4. IMT and Fixed Satellite Service Coexistence Studies (5925-6425 MHz)

Report ITU-R S.2367-0 (06/2015) "Sharing and compatibility between International Mobile Telecommunication systems and fixed-satellite service networks in the 5850-6425 MHz frequency range" concluded that sharing and compatibility between IMT systems and Fixed Satellite Service networks in 5850-6425 MHz frequency range is feasible if deployment of IMT systems are only indoors with reduced power (around 10-15 dBm EIRP).

12.2.5. ITU-R 6 GHz IMT Coexistence Studies for WRC-23 (6425-7125 MHz)

ITU-R will undertake further coexistence studies as part of the WRC-23 Agenda Item 1.2 for possible future IMT identification in a number of frequency bands:

> to consider identification of the frequency bands 3300-3400 MHz, 3600-3800 MHz, 6425-7025 MHz, 7025-7125 MHz and 10.0-10.5 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 245 (WRC-19)[64]

The responsible entity will be ITU-R WP 5D (IMT Systems)[65] with ITU-R WP 5A (Land mobile service excluding IMT; amateur and amateur-satellite service)[66], and as appropriate other working parties responsible for other services, as contributing groups.

The possibility of IMT operations in the band 6425-7025 MHz (Region 1) and 7025-7125 MHz (worldwide) and their impact on incumbent services in the band and in adjacent bands therefore needs to be studied in detail under WRC-23 Agenda Item 1.2 before any conclusion can be taken on a possible IMT identification or deployment in these bands.

13. 6 GHz (5925-6425 MHz) Technical Requirements

CEPT has completed work on the technical requirements applicable to the 5925-6425 MHz as part of the deliverables requested under the European Commission 6 GHz Mandate to CEPT.

CEPT did not consider higher powers which would typically be between 1W to 4W for outdoor deployments.

The agreed regulations for WAS/RLAN in 5925-6425 MHz are as detailed in Table 6 and Table 7 overleaf from the recently approved ECC Decision ECC DEC(20)01[67] "On the harmonised use of the frequency band 5945-6425 MHz for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN)".

Parameter	Technical conditions
Permissible operation	Restricted to indoor use only (including trains where metal coated windows (note 1) are fitted and aircraft) Outdoor use (including in road vehicles) is not permitted.
Category of device	An LPI access point or bridge that is supplied power from a wired connection, has an integrated antenna and is not battery powered. An LPI client device is a device that is connected to an LPI access point or another LPI client device and may or may not be battery powered.
Frequency band	5945-6425 MHz
Channel access and occupation rules	An adequate spectrum sharing mechanism shall be implemented.
Maximum mean e.i.r.p. for in-band emissions (note 2)	23 dBm
Maximum mean e.i.r.p. density for in-band emissions (note 2)	10 dBm/MHz
Maximum mean e.i.r.p. density for out-ofband emissions below 5935 MHz (note 2)	-22 dBm/MHz

Note 1: Or similar structures made of material with comparable attenuation characteristics.

Note 2: The "mean e.i.r.p." refers to the e.i.r.p. during the transmission burst, which corresponds to the highest power, if power control is implemented.

Table 6: Low Power Indoor (LPI) WAS/RLAN devices[68]

Parameter	Technical conditions
Permissible operation	Indoors and outdoors Use on drones is prohibited
Category of device	The VLP device is a portable device
Frequency band	5945-6425 MHz
Channel access and occupation rules	An adequate spectrum sharing mechanism shall be implemented.
Maximum mean e.i.r.p. for in-band emissions (note 1)	14 dBm
Maximum mean e.i.r.p. density for inband emissions (note 1)	1 dBm/MHz
Narrowband usage maximum mean e.i.r.p. density for in-band emissions (note 1) (note 2)	10 dBm/MHz
Maximum mean e.i.r.p. density for outof-band emissions below 5935 MHz (note 1)	-45 dBm/MHz (note 3)

Note 1: The "mean e.i.r.p." refers to the e.i.r.p. during the transmission burst, which corresponds to the highest power, if power control is implemented.

Note 2: Narrowband (NB) devices are devices that operate in channels bandwidths below 20MHz. Narrowband devices also require a frequency hopping mechanism based on at least 15 hop channels at a PSD value above 1 dBm/MHz.

Note 3: ECC will study the appropriateness of this level of OOBE by 31/12/2024. In absence of the justified evidence, a value of -37 dBm/MHz will be adopted from 01/01/25.

Table 7: Very Low Power (VLP) WAS/RLAN devices[69]

14. European Standardisation

There are a number of ETSI deliverables that pertain to the whole 6 GHz (5925-7125 MHz) frequency range. These range from System Reference Documents to Technical Reports, ultimately resulting in a European Harmonised Standard. The published and ongoing ETSI deliverables related to the 5925-7125 MHz range are detailed in the subsequent sub-paragraphs.

14.1. ETSI System Reference Document and Technical Reports

The relationship between various ETSI deliverables relating to the 5925-7125 MHz frequency range, ETSI System Reference Document (SRDoc), Technical Report (TR), Harmonised Standards (EN), and the EC Mandate to CEPT, is as shown in Figure 12.

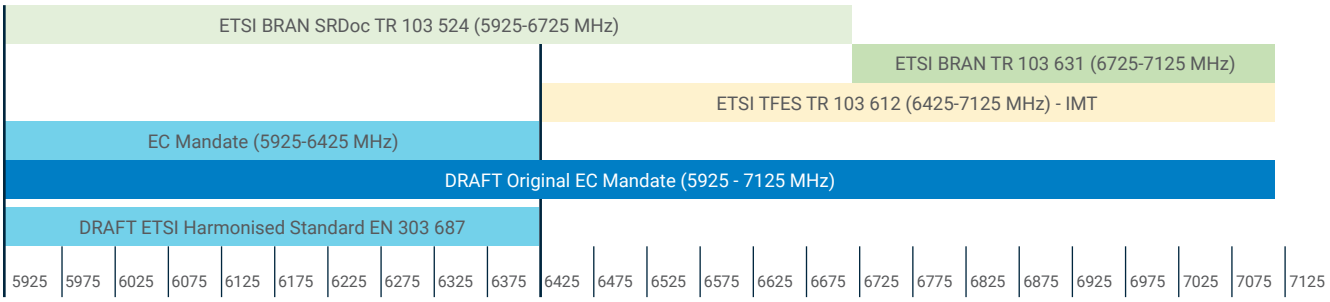

Figure 12: Relationship between ETSI Deliverables and EC 6 GHz Mandate[70]

The ETSI deliverables are -

- **ETSI TR 103 524** V1.1.1 (2018-10) "System Reference document (SRDoc); Wireless access systems including radio local area networks (WAS/RLANs) in the band 5925 MHz to 6725 MHz"
- **ETSI TR 103 631** V1.1.1 (2019-03) "Wireless Access Systems including Radio Local Area Networks (WAS/RLANs) in the band 6 725 MHz to 7 125 MHz"
- **ETSI TR 103 612** V1.1.1 (2019-12) "IMT cellular networks; Mobile/Fixed Communication Network (MFCN) in the frequency range 6 425 - 7 125 MHz"
- **EC Mandate to CEPT** to study feasibility and identify harmonised technical conditions for Wireless Access Systems including Radio Local Area Networks in the 5925-6425 MHz band for the provision of wireless broadband services
- **Stable Draft ETSI EN 303 687** V0.0.11 (2020-12) "6 GHz RLAN Harmonised Standard for access to radio spectrum"

ETSI BRAN 5925-6725 MHz System Reference Document (TR 103 524), ETSI BRAN 6725-7125 MHz Technical Report (TR 103 631), EC 6 GHz Mandate to CEPT, and draft ETSI BRAN (5925-6425 MHz) Harmonised Standard (EN 303 687) are technology neutral.

ETSI TFES 6425-7125 MHz Technical Report (TR 103 612) is not technology neutral and only considers IMT.

14.2. ETSI 6 GHz Harmonised Standard EN 303 687

Work started on production of a European Harmonised Standard, EN 303 687[71] "6 GHz RLAN Harmonised Standard for access to radio spectrum", on 3 June 2019.

The scope of EN 303 687 states:

> "This harmonised standard will specify technical characteristics and methods of measurements for Wireless access systems including radio local area networks (WAS/RLANs) operating in the band 5 925 MHz to 6 425 MHz and as further described in ETSI TR 103 524 and ECC Report 302[72]."

EN 303 687 has been uploaded by the Rapporteur as a "stable draft" on the ETSI BRAN portal but is not publicly available.

Citation in the Official Journal of the European Union is anticipated for 7 March 2023. Four years from conception to publication may seem rather excessive but the ETSI Rules of Procedure must be respected. In the meantime, it is possible to place products on the European market via Notified Bodies under the Radio Equipment Directive (RED).

3GPP and IEEE will work together within ETSI to progress the technology neutral ETSI European Harmonised standard (EN 303 687). It should be noted that currently EN 303 687 only addresses 5925-6425 MHz range.

15. Equipment compliance under the Radio Equipment Directive

As well as the adhering to the terms and conditions of the licence or licence-exempt regulations, a licensee or user needs to ensure that they are using compliant equipment. Often the end user of the equipment is in no position to know whether the equipment is operating within the limitations of the licence or licence-exempt regulation (for example whether it is giving out spurious emissions, which may affect other radio users). The Radio Equipment Directive (2014/53/EU)[73] is a European framework for the placing on the market and putting into service radio equipment.

To determine whether radio equipment is compliant the transmitter (and its packaging and accompanying documents like instructions) must carry the familiar “CE” mark (and the other required marking and labelling). Radio equipment that does not have the “CE” mark is not compliant with the directive.

16. Product Availability

Important to provide guidance on product availability for all 6 GHz technologies.

16.1. IEEE Wi-Fi (Wi-Fi 6E) Product Availability

A broad range of WAS/RLAN products are becoming available for the 5925-7125 MHz frequency range in line with market demand. Chipset suppliers are committed to supporting the 5925-7125 MHz frequency range.

Wi-Fi Alliance certification and deployment of Wi-Fi 6 technology has started and will play a highly significant role in enabling transformative wireless services in many sectors from 2020 onwards.

In January 2021, Wi-Fi Alliance announced[74] the availability of certification for Wi-Fi 6E as part of the Wi-Fi CERTIFIED 6™ certification program. The first certified products are from: Broadcom, Intel, MaxLinear, MediaTek, ON Semiconductor and Qualcomm. A list of certified Wi-Fi 6E devices are available - List of certified devices[75]

A key aspect for WAS/RLAN industry is to achieve global and regional harmonisation, so as to enable economy-of-scale advantages. Enabling global and regional scale provides confidence to operators, vendors and businesses to invest at an early stage in the development of new WAS/RLAN deployments and the creation of the new ecosystem. This helps develop a competitive market with a wide range of products and services with the benefit to all, including consumers and a nation’s productivity and competitiveness. From a regulatory perspective, such harmonisation also helps agencies in charge of market surveillance by creating a common platform for product compliance that is understood uniformly by all market players.

16.2. 3GPP 5G NR Product Availability

Over 100 commercial 5G networks have now launched worldwide. The number of announced 5G devices has also surpassed 400 million devices in the second half of 2020. This figure has continued to grow rapidly[76, 77].

There are currently no IMT 5G NR equipment or devices available on the market for the 6 GHz band. This is partly because there is currently no IMT identification for the 6 GHz band in the ITU-R Radio Regulations. However, as described in Section 4, in light of the WRC-23 Agenda Item 1.2 on the possible IMT identification of the upper 6 GHz band, 3GPP approved a work item to specify IMT 5G NR in the 6 GHz band (5925-7125 MHz) in September 2020. This was followed in December 2020 by a statement from over 20 mobile network operators, vendors and ecosystem partners recommending "…policy makers and stakeholders to carefully assess the opportunity of IMT identification at the WRC-23 within the 6GHz band..."[78]. Tests and field trials of IMT 5G NR at 6 GHz are expected by the industry from H2-2021 in support of 3GPP standardization.

16.3. 3GPP 5G NR-U Product Availability

No input was provided.

17. 6 GHz Spectrum Authorisation Options for WAS/RLAN and Mobile Systems

It should be noted that the authorisation options for the bands 5925-6425 MHz and 6425-7125 MHz depend, in part, on the other services using these bands and the ability for WAS/RLAN or mobile systems to share with those other services. The potential for mobile systems to operate in the band 6425-7125 MHz is expected to be addressed under WRC-23 Agenda Item 1.2 and currently the scope of mobile systems to operate in this band is uncertain and would need to be addressed before any decision on the preferred authorisation option could be taken.

17.1. Licence-Exempt WAS/RLAN use of 5925-6425 MHz and 6425-7125 MHz

European regulators will implement a licence-exempt approach for the 5925-6425 MHz frequency range as have been done for the existing 5 GHz WAS/RLAN frequency ranges. The Wi-Fi Alliance also has the view that a licence-exempt regulatory regime is essential for 6425-7125 MHz.

A harmonised European approach for 5925-6425 MHz would greatly influence rapid deployment of licence-exempt equipment throughout Europe capitalising on product availability in other regions.

However, access for WAS/RLAN to 6425-7125 MHz will be impacted due to the WRC-23 Agenda Item 1.2 on possible IMT Identification as this will introduce additional delays.

There are some Administrations outside Europe that have made, or are planning to make, available the whole 5925-7125 MHz for licence-exempt use, e.g., Brazil, Chile, Guatemala, Japan, South Korea, USA.

The licence-exempt regime for the 5925–6425 MHz band is intended to be technology neutral, certainly in the UK, and in principle could be available for Wi-Fi as well as other technologies (e.g., 5G NR-U) that meet the relevant technical criteria for the licence-exemption.

17.2. Licensed Mobile Systems use of 6425-7125 MHz

The GSMA[79] and some others in industry have the view that the 6425-7125 MHz band is essential for mobile communication systems and the delivery of a wide range of high-capacity citywide (urban/suburban) use cases, as well as the provision of economically viable fixed wireless access solutions, through the deployment of IMT technologies (5G NR and its evolutions) by mobile network operators.

The availability of 6425-7125 MHz for use by IMT technologies in Europe is coupled closely with the WRC-23 Agenda Item 1.2. This addresses the possible IMT identification of 6425-7125 MHz and 7025-7125 MHz in Region 1 and globally, respectively.

Given that the lower 6 GHz band (5925-6425 MHz) will be made available for WAS/RLAN on a licence exempt basis in Europe, the European administrations will wait until the conclusion of the coexistence studies at ITU-R and the relevant decisions at WRC-23 before considering possible future use of the upper 6 GHz band (6425-7125 MHz) for IMT. Outside Europe, China MIIT (Ministry of Industry and Information technology) is planning to revise the National Frequency Allocation Table (to identify 5925 7125 MHz for IMT) and is considering licensing of spectrum to facilitate 5G tests and trials in the 6 GHz band. Furthermore, the RCC Administrations are in favour of the identification of all or part of the frequency band 6525–7025 MHz for IMT systems, taking into account the results of the compatibility studies.

The IMT identification of 6425-7125 MHz is a high priority for the GSMA, as evidenced by a recent survey of its members on 6 GHz which concluded that[80]:

- 6425-7125 MHz IMT identification is a high priority for the GSMA.
- GSMA members hold significant backhaul assets throughout the band. Fixed backhaul networks must be considered when bringing new services into this band.

GSMA members from all three ITU Regions were surveyed on the 6 GHz band and 90% of MNOs' responses placed the band 6425-7125 MHz as a high priority for IMT, whether in a new IMT identification at WRC-23 (Region 1). While this band is an important one for fixed links, MNOs will be able to manage the sharing between access and backhaul allocations adaptively.

18. Pros and Cons of Licence-exempt Authorisation for WAS/RLAN

This section is intended to discuss the pros and cons of licence exemption as applicable to WAS/RLAN (Wi-Fi, 5G NR-U) and predominately focusses on 6425-7125 MHz noting that 5925-6425 MHz has already been made available for licence-exempt devices in the UK.

18.1. Pros for Licence-exempt Authorisation for WAS/RLAN

6 GHz More than Doubles the Existing Available Mid-Band Spectrum: Up to 1.2 GHz of additional mid-band spectrum could be made available if the whole 6 GHz band (5925-7125 MHz) was made available under a licence-exempt regulatory regime; effectively doubling the existing spectrum available to WAS/RLAN (Wi-Fi, 5G NR-U) today. High-density deployments, such as stadiums, airports, conference halls, and other venues suffering from congestion, will benefit greatly from this additional capacity given that they are provided with a high speed broadband connection (high speed fixed wireless access, fibre or similar), while availability of 160 MHz channels in the 6 GHz band will enable low-latency multi-gigabit connectivity to better support a number of advanced use cases.

6 GHz is a New Band for Wi-Fi: From an IEEE perspective Wi-Fi 6E (and its future evolutions) will be deployed in the whole 6 GHz band; it is not anticipated that older versions of Wi-Fi will be deployed. In essence, a 6 GHz Access Point (AP) will only be able to talk with Wi-Fi 6E and its evolution and will not be sharing airtime and bandwidth with legacy generations of Wi-Fi, such as Wi-Fi 5. This keeps the band free of older versions of Wi-Fi.

From a 3GPP perspective, NR-U is also expected in the 6 GHz band. Wi-Fi, NR-U and any other WAS/RLAN technologies are expected to co-exist, and in this spirit, any relevant European regulations should be technology neutral.

Improved Legacy Networks: Without the availability of the 6 GHz band, 5 GHz will become more congested over time. The availability of 6 GHz will also bring benefits to the legacy clients operating in 5 GHz particularly as 6 GHz will be absorbing much of the high-performance use cases currently on 5 GHz.

Improved Backhaul and Multi-AP Systems: 6 GHz could enable guaranteed multi-gigabit throughput throughout the entire home by leveraging the band as the backhaul technology for multi-AP mesh deployments, assuming that the network providing broadband to the home allows for such speeds (e.g., fibre to the home). While it may take some time for 6 GHz clients to become mainstream, existing WAS/RLAN devices could potentially take advantage of 6 GHz back-haul throughout the home via 6 GHz networking equipment. This could lead to multi-gigabit throughput coverage throughout the home, leading to better user experiences across a wide range of high-performance applications, from video streaming to gaming and Augmented Reality (AR) / Virtual Reality (AR) inside the home.

Reliability: Wi-Fi 6E will likely provide much more reliable and consistent performance than Wi-Fi 5.

Some enterprise deployments have held back on transitioning to wireless technologies due to latency and bandwidth requirements. Now, enterprises can move to Internet Protocol (IP) phones and support certain low-latency collaborative applications or other key services over Wi-Fi, rather than costlier and less flexible wired Ethernet solutions.

Quality of Service: Wi-Fi Alliance announced[81] the new Wi-Fi CERTIFIED QoS Management™ certification program. Wi-Fi QoS Management™ delivers a consistent end-to-end Quality of Service (QoS) treatment in Wi-Fi® networks by enabling devices, applications, and network managers to prioritize traffic flows. This ensures appropriate traffic prioritization for time sensitive applications and services, resulting in enhanced quality of experience for end users in residential, enterprise, and public networks.

Application-Specific Deployments: The 6 GHz band could allow specific applications to be leveraged; AR and Virtual Reality (VR) applications at home could be transferred to 6 GHz Wi-Fi 6E to ensure reliability and performance. Likewise, backhaul could shift to 6 GHz for higher throughput. For industrial applications, mission-critical machinery and equipment could leverage this band for guaranteed performance and low-latency services in some circumstances, with appropriate guaranteed quality of service.

Low-Latency, High-Throughput Non-Line-of-Sight Performance: AR and VR using headsets require increasing amounts of throughput, while maintaining extremely low latency. 6 GHz could potentially enable some non-line-of-sight AR/VR applications. It could also provide better casting performance than 5 GHz Wi-Fi, potentially allowing low-latency display sharing or screen mirroring from mobile devices or game consoles.

Incumbents in upper 6 GHz similar to lower 6 GHz: European Commission Mandate to CEPT for the lower 6 GHz (5925-6425 MHz) has evaluated the coexistence environment to ensure protection of incumbents. The upper 6 GHz (6425-7125 MHz) has the same incumbents and a similar regulatory regime could be applied. This would assist meeting the requirements for access to spectrum suitable for WAS/RLAN (Wi-Fi, 5G NR-U, and any other licence-exempt technologies).

Mobile Allocation: Existing co-primary mobile allocation allows technology neutral implementation of mobile applications and services. An IMT identification is not a prerequisite to enable IMT 5G NR access to 6 GHz, but it is essential for the building of an IMT ecosystem. It should be also emphasised that a licensed authorisation is a pre-requisite to enable IMT 5G NR access to 6 GHz.

Economies of Scale: Recognising that licence-exempt spectrum for WAS/RLAN will be important to complement implementation of IMT (5G NR) in licensed spectrum, some administrations are creating new opportunities for the next-generation licence-exempt (e.g., Wi-Fi 6E, 5G NR-U) in the 5925-7125 MHz band outside of Europe so an ecosystem will be available thus maximising economies-of-scale.

18.2. Cons for Licence-exempt Authorisation for WAS/RLAN

A licence-exempt regulatory regime generally means that licensed use for IMT (5G NR) would not be possible but would allow 5G NR-U deployment.

19. Pros and Cons of Individual Licensing Authorisation for Mobile Systems

19.1. LS Telcom Report for UK Spectrum Policy Forum on Exclusive use of Spectrum

The LS Telcom report for the UK Spectrum Policy Forum titled "Study on the characteristics which justify exclusive use of spectrum"[82] dated December 2019, provides a good summary on the pros and cons of exclusive licenses.

The example of exclusive use of spectrum include:

- "Ability to secure and operate safety of life networks (i.e., for air travel and maritime);
- Certainty required to enable continued evolution and expansion of mobile networks;
- Ability to secure and operate critical national infrastructure for railways, public safety and utility networks;
- Wrt spectrum auctions, the ability to secure higher licence revenues for treasury."

The LS Telcom report indicated that the fundamental reasons, criteria and conditions for justification of exclusive use of spectrum are as follows:

- "Where protection from harmful interference is strictly required;
- Where QoS provision to users is required to be assured for the application/use;
- Where full occupancy of spectrum is more likely and is necessary (to avoid spectrum underutilisation);
- To retain certainty for investors in the competitive market, to deploy their network."

Table 8 summarises the benefits of using exclusive spectrum and considers whether these benefits would be lost, if that same spectrum was shared with other users.

"The pros of exclusive use would mostly be lost if shared access to spectrum was considered. Similarly, not all the cons of exclusive use will be fixed when considering shared access to spectrum. Depending on the perspective of the user or type of use, the case of satisfying certain requirements for protection from interference or certainty for investment and over a defined area, the benefits of exclusive use are important for ongoing business operations and network expansion. Unless an alternative approach is developed that can satisfy those requirements without using exclusive use of spectrum it might be assumed that exclusive use is a necessary approach to address demand and operational needs of certain users."

Benefits of Exclusive Use	Do you lose the benefits with shared access to spectrum?
Ability to secure and operate safety of life networks for air travel and maritime	Yes - due to the potential for interference into these services in the areas they are used
The certainty required to enable the evolution and expansion of mobile networks	Yes - due to reduced uncertainty of access to spectrum for a mobile operator overlapping usage rights could undermine the business case and impact network roll-out
Ability to secure and operate critical national infrastructure for railways, public safety and utility networks	Yes- due to the potential for interference into these services in the areas they are used which is widespread and could be nationwide
In the case of spectrum auctions the ability to secure higher license revenues for treasury	Yes - as much of the value of the spectrum in auctions comes from its 'exclusive' availability

Table 8: Benefits of Exclusive Use of Spectrum[83]

The LS Telcom report indicated that the cons of exclusive use of spectrum include:

- "Challenge and potentially prohibitive cost to deliver full ubiquitous mobile coverage;
- Denies access to other users in the context of spectrum efficiency;
- Locked into specific long-term technology family ;
- Limited opportunity for innovation with respect to different types of use and users."

Table 9 captures the negatives associated with exclusive spectrum and considers whether these would be rectified if that same spectrum was shared with other users.

Cons of Exclusive use	Do you fix the cons with shared access to spectrum?
Operators unable to deliver full ubiquitous nationwide mobile coverage due to economic constraints	No - as there is no incentive or requirement for existing or new operators to roll out nationwide or in a timely manner that will satisfy all mobile subscribers at every location
Operators unable to deliver full ubiquitous nationwide mobile coverage in a timely manner	
Denies access to other users and uses in the context of spectrum efficiency	Yes - other users and uses could be introduced but may have to be implemented in carefully coordinated and predictable interference environment
Locked into specific long term technology family with limited opportunity for innovation with respect to different types of use and users	Yes - shared access would allow introduction of new technologies and potentially create new ecosystems for frequency bands that have been traditionally used for single technologies or services

Table 9: Cons of Exclusive Use of Spectrum[84]

19.2. Pros for Individually Licensed Mobile Systems

Subject to sharing constraints with other services, licensed use might enable higher power use as the control of any potential interference will be handled by the system and the operator/licensee. In contrast licence-exempt use is typically associated with lower power to avoid interference between uncoordinated systems.

Citywide mobile communications: The availability of 6425-7125 MHz is necessary for the delivery of high-capacity citywide (urban/suburban) mobile communications subject to satisfactory sharing and compatibility studies. This is primarily driven by the growing demand for high data rate video consumption on the move, which requires access to wide channel bandwidths at mid-band frequencies, and which cannot be accommodated only in the 5G pioneer mid-band spectrum at 3.4-3.8 GHz. The efficient delivery of such video communications over wide areas across cities requires IMT (5G NR) networks, as these support user mobility, and – on account of being specifically designed to operate in licensed spectrum – allow the efficient sharing of the radio resource among large numbers of users per cell/sector through deterministic scheduling.

Fixed Wireless Access for broadband: The EU has a target of delivering "… access for all European households to Internet connectivity offering at least 100 Mbps" by 2025[85]. Ofcom has an even more ambitious and defines "ultra-fast broadband" as download speeds of 300 Mbit/s or more. The achievement of such targets via fibre-to-the-home is not economically viable in many circumstances, and FWA via IMT technologies plays an increasing role in less densely populated areas. The business case for FWA relies on the ability of a base station to serve sufficiently large numbers of households, which in turn requires the favourable propagation conditions, wide bandwidths, and guaranteed QoS offered through licensed authorisation of 6425-7125 MHz.

Vertical use cases: The licensed authorisation of 6425-7125 MHz would also allow the use of IMT networks for the support of vertical services with demanding requirements on data rate, reliability and low latency, which are indeed not feasible to achieve with licence exempt spectrum. These include, among others, advanced driver assistance and autonomous driving use cases which involve the delivery of video and vast

quantities of sensor data from road users to the mobile network infrastructure, and industry applications for which predictability of spectrum bandwidth and interference is critical.

Guaranteed QoS: Individual authorisation, in all its various flavours, is essential for the delivery of a guaranteed quality of service by allowing the operator to control the number of users accessing the airways, and therefore to efficiently distribute the radio resource among them in a deterministic manner. It is precisely for this reason that IMT technologies are designed to operate subject to individual licensing authorisation regimes in order to deliver the challenging technical targets set out by the ITU-R. It should be emphasised that individual licensing does not preclude the sharing of the spectrum with other existing services in the band, where factors such as geographic/angular separation permits; i.e., individual licensing does not necessarily imply exclusive use of the band.

Potential for sharing of spectrum with incumbents: The 6425-7125 MHz range is allocated on a co-primary basis to the Mobile Service, FS and the FSS by the ITU-R. The ability to control the number of radio equipment operating in the band and to have publicly available a record of their locations and characteristics – both inherent features of individual licensing authorisation regimes – implies that a) coordination between IMT networks and the fixed links of the FS can be performed readily and efficiently, and b) the extent of aggregated emissions from IMT networks towards geostationary satellites of the FSS can be quantified accurately.

Economies of scale: WRC-19 approved an agenda item to consider possible identification of the band for IMT at WRC-23. One of the aims of this is to leverage the certainty which such identification would bring to establish regional/global economies of scale in IMT equipment noting that IMT is designed for operation in licensed spectrum. The band 6425-7025 MHz is considered for identification in Region 1, while the band 7025-7125 MHz is considered for a IMT identification globally.

19.3. Cons for Individually Licensed Mobile Systems

A licensed authorisation regime in the 6425-7125 MHz band as required for the operation of IMT technologies would mean that licence-exempt WAS/RLAN technologies such as Wi-Fi and 5G NR-U could not be deployed in this band if and when IMT was present.

20. Conclusions

There are a range of preferences with some advocating for licence-exempt access for WAS/RLAN in both the lower 6 GHz (5925-6425 MHz) and upper 6 GHz (6425-7125 MHz), while some others generally accept a licence-exempt approach for WAS/RLAN in the lower 6 GHz (5925-6425 MHz) in Europe but advocate for a licensed approach for use of mobile systems in the upper 6 GHz (6425-7125 MHz). A tabular representation of this is shown in Table 10.

Frequency Band	View 1: Licence-exempt WAS/ RLAN	View 2: Licensed Mobile Systems
5925-6425 MHz Lower 6 GHz	Wi-Fi and 5G NR-U (precludes 5G NR)	N/A
6425-7125 MHz Upper 6 GHz	Wi-Fi and 5G NR-U (precludes 5G NR)	5G NR (precludes Wi-Fi and 5G NR-U)

Table 10: Options for the 6 GHz band[86]

Noting that 5G NR (which is an IMT technology) and 5G NR-U (which is not an IMT technology) are specified at 3GPP and Wi-Fi is at IEEE.

Annex: List of Acronyms and Abbreviations

3GPP	3rd Generation Partnership Project
5GAA	5G Automotive Association
5G	Fifth Generation
5G NR	5th Generation New Radio (read licensed)
5G NR-U	5th Generation New Radio-Unlicensed
AR	Augmented Reality
CEPT	European Conference of Postal and Telecommunications (Administrations)
C-V2X	Cellular Vehicle-To-Everything
DSSS	Direct Sequence Spread Spectrum
ECA Table	European Common Allocations Table
EC	European Commission
ECO	European Communications Office
ECC	Electronics Communications Committee
EFIS	ECO Frequency Information Systems
eMBB	Enhanced Mobile Broadband
EN	European Norm (Standard)
ETSI	European Telecommunications Standards Institute
EU	European Union
FS	Fixed Service
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access
GSMA	Global System for Mobile Communications Association
HD	High Definition
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications
IP	Internet Protocol
ITU	International Telecommunication Union
ITU-R	International Telecommunications Union - Radiocommunication Sector
LTE	Long Term Evolution
LPI	Low Power Indoor
MAC	Medium Access Control
MNOs	Mobile Network Operators
OoB	Out-of-band (OOB)
PHY	Physical layer
QoS	Quality of Service
RED	Radio Equipment Directive
RLAN	Radio Local Area Network
SRDoc	System Reference Document
TR	Technical Report
uRLLC	ultra-Reliable Low Latency Communication
VHCN	Very High Capacity Networks
VLP	Very Low Power
VR	Virtual Reality
WAS	Wireless Access Systems
WFA	Wi-Fi Alliance
WLAN	Wireless Local Area Networking
WRC-15	World Radiocommunication Conference 2015
WRC-19	World Radiocommunication Conference 2019

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About the Licence-exempt Shared Spectrum Working Group

The working group is part of techUK's Communications and Infrastructure and Services programme. It will develop responses to relevant UK Ofcom consultations; highlight the importance and value of licence-exempt spectrum (including 4G/5G offload); collate an evidence base of international use cases, prioritising the bands outlined in the group's scope.

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FOR WHAT COMES NEXT

About techUK

techUK is a membership organisation that brings together people, companies and organisations to realise the positive outcomes of what digital technology can achieve. We collaborate across business, Government and stakeholders to fulfil the potential of technology to deliver a stronger society and more sustainable future. By providing expertise and insight, we support our members, partners and stakeholders as they prepare the UK for what comes next in a constantly changing world.

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