At sixes and sevens: sharing opportunities (or battles) in 6 GHz

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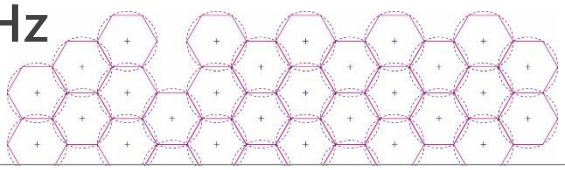

A hot topic at WRC 23 was identification of further bands for International Mobile Telecommunications (IMT) under Agenda Item 1.2. Discussions and negotiation resulted in identification for IMT through a footnote to the Radio Regulations of the band 6425-7025 MHz in Region 1, and 7025-7125 MHz in Region 3[i]. Both of these identifications exist alongside wireless access systems (WAS[ii]). It remains to be seen what the outcome will be in practice of this decision for the Upper 6 GHz (6425-7125MHz) band – will sharing between the two services (IMT and Wi-Fi) be feasible within a country, or will it be necessary to segment the band or identify a single technology? Also, will there be a split between countries, with some supporting the introduction of IMT and others Wi-Fi6 technologies – requiring the need for co-ordination at country borders?

Prior to the latest World Radio Conference, Article 5 of the Radio Regulations (Edition 2020) identified the allocations for the 5925-7145 MHz bands as follows:

Frequencies (MHz)	Allocation in Regions 1, 2 and 3
5925-6700	FIXED 5.457 FIXED SATELLITE (E-s) 5.457A, 5.457B MOBILE 5.457C 5.149, 5.440, 5.458
6700-7075	FIXED FIXED SATELLITE (E-s)(s-E) 5.441 MOBILE 5.458, 5.458A, 5.458B
7075-7145	FIXED MOBILE 5.458, 5.459

Whilst there were primary mobile allocations in all the bands listed above the main use was for fixed point-to-point links, which is extensive in some countries, and fixed satellite service.

At WRC-23 there was a mix of views regarding the U6 GHz (6425-7125 MHz) band – for example China, Russia and France were in favour of IMT having exclusive use of the band. The outcome was that through footnote 5.6A12, 6425-7125 MHz in Region 1 and 7025-7125 MHz in Region 3 were identified for the terrestrial component of IMT. The frequency bands are also identified for wireless access systems (WAS) including radio local area networks (RLANs).

In addition, in Cambodia, Lao P.D.R and the Maldives, 6425-7025 MHz is also identified for IMT (footnote 5.6B12) and in Brazil and Mexico for IMT subject to agreement with neighbouring countries, as well as WAS (footnote 5.6C12). Only in Region 1 has the whole U6 GHz band been identified for both IMT and WAS.

IMT or WAS (Wi-Fi)

It is important to consider the competing demands for this spectrum. As data traffic demand increases, the need for high bandwidths requires users to move to higher frequencies, in turn reducing the effective distance that signals can travel. In the past, mobile services tended to use spectrum at 2.1 GHz or below, and Wi-Fi used the 2.4 GHz band, as these had favourable propagation. However, as demand for higher speeds rose, mobile services started to move to the 2.6 GHz and 3.5 GHz bands, while Wi-Fi increasingly used 5 GHz.

The 6 GHz band, with shorter wavelengths, means antenna elements are small and allows MIMO or massive MIMO to be implemented that much more easily which makes the band attractive. This in conjunction with the available bandwidth makes it ideally suited to provide the necessary capacity and coverage needed to support 5G and 6G high power terrestrial mobile networks. While higher than the current 3.5 GHz allocations, 6 GHz is still considered as part of the mobile 'mid-band' spectrum, being significantly lower frequency than mmWave bands.

The GSMA has argued[3] that the 6 GHz band is needed to provide sufficient mid-band spectrum capacity. *"Constrained mid-band spectrum risks network densification, higher carbon emissions, increased capex and higher consumer tariffs. Without access to 6 GHz capacity, 5G networks will be slower and more expensive – consumers will pay more while commerce that relies on Industry 4.0 capabilities of 5G will be less competitive. The benefits for the global economy and tax revenue that governments will receive from 5G will be lower."* GSMA's studies assert that *"by 2030, 5G can be responsible for 0.68% of global GDP"* but "*without enough mid-band spectrum, the 2030 GDP impact will be reduced to 0.42% of global GDP"*.

At the same time, the Wi-Fi community has been lobbying for further spectrum, noting the lack of new frequencies over a

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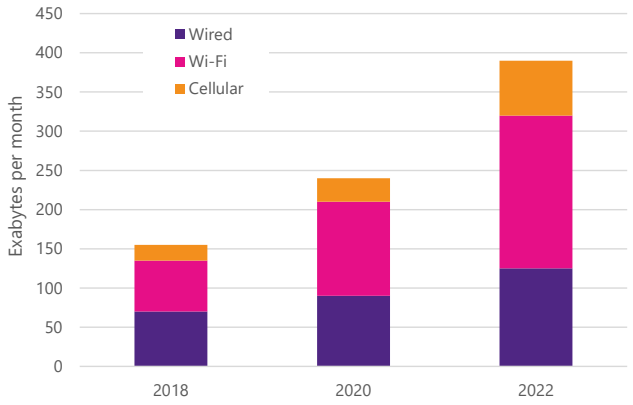
significant time beyond the 2.4 and 5 GHz bands, and increase in traffic as shown below.

Figure 1: Global data traffic (Cisco VNI, 2017-2022)



A recent report from the Wi-Fi Alliance[4] states: "*Without Wi-Fi access to 6.425 to 7.125 GHz — the frequency range that 5G/IMT proponents are targeting — consumers and enterprises will not realize the full benefits of Wi-Fi 6E, Wi-Fi 7, and future generations of Wi-Fi technologies. Access to less than the entire 6 GHz band (i.e., 5.925 to 6.425 GHz and 6.425 to 7.125 GHz) would substantively increase Wi-Fi latency and reduce data throughput. Importantly, there are no alternative frequency bands that adequately address expanding Wi-Fi spectrum requirement*". Limiting the available spectrum to the Lower 6 GHz (500 MHz in total), as currently in Europe, makes it less likely that the larger channel bandwidths will be utilised. As shown in Figure 2 below the full 6 GHz band can support an increased number of larger bandwidth channels.

Figure 2: Comparison of channels and bandwidth

Europe (L6 GHz)		US (6 GHz)	
Number of channels	**Bandwidth (MHz)**	**Number of channels**	**Bandwidth (MHz)**
24	20	59	20
12	40	29	40
6	80	14	80
3	160	7	160

Given these competing demands, and the existing use of the spectrum in various countries for fixed links or satellite communications, it is worth considering whether there is a possibility of the band being shared.

It will also be important to consider the anticipated demand for Wi-Fi and IMT and whether, for example, the U6 GHz band is required to meet user requirements in dense urban areas to meet universal gigabit connectivity to homes.

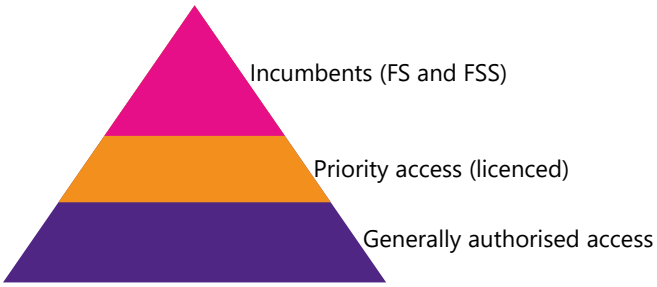
Potential for sharing the U6 GHz band

There are two key sharing considerations relating to the U6 GHz band:

- In those countries where there is significant use of fixed links how can sharing be achieved with IMT or Wi-Fi?
- Is it feasible for IMT and Wi-Fi to share?

To deal with the first situation here, would sharing such as implemented for CBRS in the United States be feasible? In this instance the incumbents would be fixed satellite service (FSS) and fixed service (FS) where the locations of the transceivers are known, so there can be a separation by frequency and geography from priority access users.

Figure 3: Tiered access



With regards IMT, a spectrum access system (SAS) could combine all sources of information and take into account the necessary protection requirements and margins to enable sharing between IMT and incumbents. The big concern is the protection needed by large numbers of fixed links will provide limited opportunity for sharing with outdoor IMT macro cells. This could require fixed links to be migrated from the band.

For Wi-Fi, mitigation may be challenging, as device locations are generally unknown and devices are already available that cover the whole 6 GHz band. In the US for the 6 GHz band, to facilitate sharing, two different types of Wi-Fi access points (APs) are supported in different parts of the spectrum: low power for indoor use, and standard power. Automated Frequency Coordination (AFC) is used for standard power APs to protect fixed links. The AFC system provides to the AP a list of channels that it may use for a range of different powers[5].

The next consideration is whether it is possible to facilitate sharing between IMT and Wi-Fi. There have been proposals that low-power licence-exempt use could be authorised indoors and medium- to high-power licensed mobile networks used outdoors, with necessary rules to protect the indoor use. This would allow for mobile network offload to Wi-Fi but not the need for mobile coverage indoors (around 70% of mobile traffic

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is generated indoors and often served by outdoor base stations although this is less likely in the 6 GHz band due to building propagation losses). It is therefore unlikely that geographic sharing will be a viable solution.

There are a lot of unanswered questions in regards potential solutions and whether sharing will be feasible or it will be necessary to either use the U6 GHz band for IMT or Wi-Fi or segment the band. The identification of the U6 GHz band for both IMT and WLANs at WRC-23 might be considered premature but it does bring the focus within the International Telecommunications Union (ITU) to consider the technical options to facilitate sharing. Studies will need to be undertaken to address the different sharing options such as those already underway in the Electronic Communications Committee (ECC) in Europe. Industry will have an important input in developing innovative ideas such as the adoption or adjustments of access protocols to allow sharing. Where database sharing is implemented this requires agreement of the necessary rules for who can use the spectrum.

If Wi-Fi were to use the U6 GHz band it would be reasonable to expect that this would be on a licence exempt basis as for the 2.4 and 5 GHz bands. This would mean that it would be difficult to refarm the band at a later date, for other services, due to the widespread presence of unlicensed devices at unknown locations. This may have implications for some national administrations as well as the loss of potential revenue from licence fees if licence exempt.

European developments

Work has started in ECC PT1 looking at the feasibility of shared use in the 6425-7125 MHz band. Document ECC PT1 (24)036 rev 1 provides more information including the sharing scenarios being considered:

1. Indoor and outdoor sharing: mobile / fixed communications networks (MFCN) restricted to outdoor, and Wi-Fi indoor only
2. Geographical sharing: either MFCN or Wi-Fi prioritised in a particular area (e.g. towns and cities)
3. Temporal splits: where MFCN or Wi-Fi could be prioritised in a location for the duration of particular events or parts of day.

It then identifies some potential interference management mechanisms:

- Wi-Fi sensing of MFCN Base Station;
- MFCN handset sensing of Wi-Fi; and
- Database control.

Licensing to date

A number of countries have already decided on the authorisation of the 5925-7125 GHz band. In the US all the band has been allocated for unlicensed use –*"it will deliver higher speeds, low latency and service levels that are equivalent to 5G networks and be able to support the widespread, low-cost, use of advanced business, industrial and consumer applications"*[6].

When Saudi Arabia issued new regulations in March 2021 to release the full 6 GHz band for Wi-Fi for licence-exempt technologies, it was reported that South Korea, Chile, Guatemala, Honduras, and Brazil had adopted a similar approach. Canada has also released the full 6 GHz band.

Other countries, such as Australia, Hong Kong and Japan have only released the lower 6 GHz band (5925-6425 MHz) on an unlicensed basis.

In the UK an Ofcom consultation on access to the upper 6 GHz band[7] indicated they were exploring options that would enable the introduction of both Wi-Fi and licensed mobile use of the band in relatively close proximity – referred to as "hybrid sharing".

The different approaches to licensing the U6 GHz band raise another problem as Wi-Fi devices will be made which use the whole band. Countries which decide to implement IMT will need to prevent the use of these devices to avoid interference. The only way of preventing this would be to ban imports of electronics without certification of what bands they use. This is why licence exempt spectrum is best defined globally.

Conclusions

There are large economic benefits from all potential uses of the 6 GHz band – including the incumbent fixed links and satellite. National governments need to investigate their own demands and carry out sharing studies. Use will differ from country to country which will lead to inefficiencies from an ecosystem point of view but there may be opportunities to harmonise the technical framework(s).

The WRC outcome is currently the worst of all worlds with no clear direction on what should be prioritised. It will be interesting to see how the licensing of the upper 6 GHz band progresses and whether sharing options are developed to allow both IMT and Wi-Fi to have access to the same spectrum.

[i] Footnote 5.6A12
[ii] The expectation is Wi-Fi6 will be the deployed wireless access system
[3] https://www.gsma.com/spectrum/wp-content/uploads/2022/07/6-GHz-in-the-5G-Era.pdf
[4] https://www.wi-fi.org/system/files/6_GHz_Wi-Fi_Connecting_to_the_future_202210.pdf
[5] https://www.5gtechnologyworld.com/new-regulations-for-unlicensed-6-ghz-operation-explained/
[6] https://www.telecoms.com/spectrum/fcc-unanimously-votes-to-make-6-ghz-band-available-for-unlicensed-use
[7] https://www.ofcom.org.uk/__data/assets/pdf_file/0031/263776/condoc-upper-6-GHz-review-June23.pdf

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