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To: CPfrequencesmobiles@arcep.fr September 22, 2022

Re: "Réponse à la consultation publique "Preparing for the Future of Mobile Networks"

Dear Colleagues,

Broadcom welcomes the opportunity to comment on the ARCEP consultation "Preparing the Future of Mobile Networks". We estimate that over 99.9% of all internet traffic crosses at least one of our chips. End-to-End network capacity is a critical metric that Broadcom monitors.

Indoor wireless data demand has never been greater and is the area where we see the greatest constraints. Indoor wireless data consumption has increased rapidly over the past five years, and continues to grow rapidly. Operators and Enterprises are rapidly adopting Wi-Fi 6E to meet the indoor capacity needs of their subscribers and users. As a result, Broadcom has now shipped over 1.3 billion of its most advanced Wi-Fi semiconductor solutions (Wi-Fi 6 and Wi-Fi 6E products). Spectrum available to meet RLAN demand must keep pace.

Broadcom does not believe that IMT operating in the 6425-7125 MHz will effectively address the EU's needs where demand is strongest. We strongly recommend that as a common policy approach the EU Member States should support "no change" and not support identification for IMT of the frequency band 6425-7125MHz.

About Broadcom

Broadcom is a worldwide leader in wired and wireless semiconductor solutions for a wide range of communications products that serve retail, service provider, and enterprise end markets segments. As indicated above, we estimate that 99.9% of all internet traffic crosses at least one Broadcom chip.

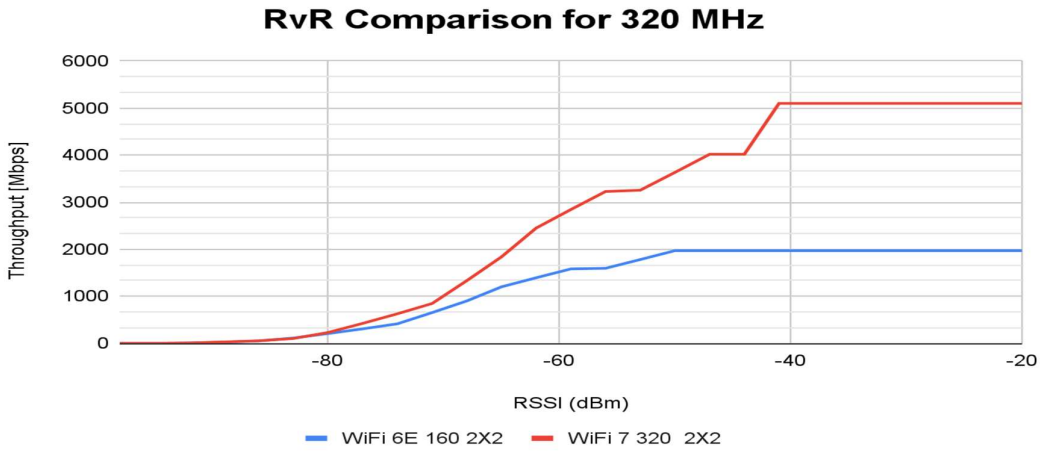
Among these product segments are Wi-Fi semiconductors, used to create Radio Local Area Networks (RLANs) and Broadband interconnects. For broadband, Broadcom produces fibre interconnects (G-PON, 10GPON), DOCSIS 3.x/4.0, and G-FAST, RF front ends for 5G networks, network switches, industrial products, and a variety of other semiconductor and software products. RLANs are primarily used for the wireless extension of broadband networks indoors. Broadcom's operator customers are quickly migrating to more capable gigabit + broadband, to future proof their networks and pairing Wi-Fi 6E access points with the broadband modem.

Broadcom comments on selected questions

Question 2. ***What are the most significant developments brought by 5G Release 18, 6G, and Wi-Fi 7? What is the timeline for these developments to become available on networks and devices? If applicable, what new frequency requirements will these developments generate?***

Wi-Fi 6E, is ideal for enabling 5G services in the 6 GHz band that require gigabit speeds and very low latencies. Low power indoor and very low power portable devices will quickly enable residential gigabit services and mobile AR/VR. Wi-Fi 7 will provide for even higher speeds/throughput and wider coverage than 6E with the availability of 320MHz channels as seen by the following Rate vs Range (RvR) analysis of 2x2 devices which shows:

- Significant coverage improvement: multi-Gigabit whole home Wi-Fi
- 15+ dB improvement for 2 Gbps RvR



Wi-Fi 7's 320 MHz channels will not only substantially increase throughput, but will provide a wide variety of other benefits, such as improved location accuracy for on premises navigation and shopping.

Wi-Fi 7 also allows for increased capacity, reduced latency, determinism and other benefits:

- **Capacity – 5x increase**;[1]
- **Latency – 100x Improvement in worst case latency**;[2] and
- **Determinism 15x improved AR/VR latency performance** for the latency set up above.

[1] Scenario described in IEEE 11-13/1081r0. 20 apartments on a single floor, 1 AP and 1-4 WLAN devices per apartment; compares 80 MHz Wi-Fi 6/6E devices vs 320 MHz/MLO capable Wi-Fi 7 devices

[2] Congested 20 apartment scenario which compares best effort latencies for Wi-Fi 6 and MLO-capable Wi-Fi 7 client; simulation comparison is improvement in number of times latency requirements are not met due to traffic congestion

Wi-Fi 6E and Wi-Fi 7 can achieve the results mentioned above at the same power levels that were allowed by the EC decision covering the lower 6 GHz. In addition, ETSI have already created a Systems Reference Document (TR 103 524) up to 6725 MHz and a Technical Report (TR 103 631) up to 7125 MHz to support such work. Given that the incumbents in the 6425-7125MHz band are mostly the same as in the lower 6GHz much of the work from the CEPT studies already performed up to 6425 MHz can be leveraged during the ongoing CEPT SE45 studies for the 6425-7125MHz band under work item SE45_04.[3]

In April 2022, Broadcom released a full ecosystem of Wi-Fi 6E and Wi-Fi 7 chips made for portable client devices, residential access points, and enterprise access points, which we are currently sampling to our customers, see the response to question 9 for more details on product availability. In addition, in September Broadcom and Intel conducted the first cross vendor Wi-Fi 7 trial demonstrating 5 Gigabits per second using a Broadcom reference Access Point and an Intel reference PC. [4] This demonstrates that the technology has truly arrived.

Wi-Fi 6E and Wi-Fi 7 products are currently designed to operate over the entire 6GHz band (5925-7125MHz). Constraining these products to only operate in the 5925-6425 MHz frequencies would increase product costs, reduce capability, and may lead to supply shortage for certain markets.

Limiting the capability of equipment requires additional engineering, which increases costs. With less bandwidth, then the channels that can be used in enterprises, stadiums, and residences are less than those in markets where all 1200 MHz of the 6 GHz band is available. If France decides to limit RLANs to only 5945-6425 MHz, then enterprises in France will be less capable and competitive to those operating in South Korea, United States, Canada, and other such countries that have made the whole band available. For Example, LG Electronics has adopted Wi-Fi 6E access points at its headquarters in Seoul, South Korea.[5] LG Electronics will have access to 80MHz and 160 MHz channel configurations even in the densest areas. If France only allocates the lower 500 MHz, then its industry would only have access to 20MHz or 40 MHz channels in typical enterprise settings. In addition, having a large common market reduces overall equipment costs, and reduces supply chain complexity making it easier to meet the demand in multiple markets. The 6425-7125 MHz frequency range is ideal to support next generation Wi-Fi networks because the propagation characteristics are very similar to the 5 GHz band, so existing infrastructure can be upgraded without the deep costs associated with deploying new backhaul nodes to support such networks.

We acknowledge that 5G is a critical building block of the European digital economy in the next decade. But we stress that the vision of IMT 2020 can only be realized through a combination of

[3] https://eccwp.cept.org/WI_Detail.aspx?wiid=795

[4] https://www.businesswire.com/news/home/20220908005373/en/Intel-and-Broadcom-Achieve-Major-Wi-Fi-7-Industry-Milestone

[5] https://www.businesswire.com/news/home/20220727005292/en/Extreme-Networks-Reports-Fiscal-Year-and-Fourth-Quarter-2022-Financial-Results

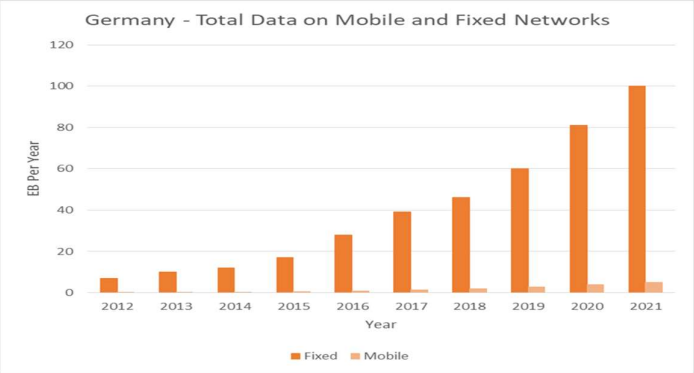
technologies, fibre and DOCSIS 3.1/4 deployments, 5G cells providing coverage outdoors, and WAS/RLANs indoors to meet the needs of consumers in France and Europe. Both IMT and Wi-Fi 6E/7 are therefore critical parts of the solution.

With an aim to extend fibre to home connectivity throughout the country by the year 2025[6] France's deployment of broadband infrastructure in conjunction with next generation Wi-Fi is well placed to achieve the maximum benefits to its consumers.

Question 3. Have you identified other developments in mobile technologies for specific uses that could generate new frequency needs, e.g. communications between devices or broadcasting/multicasting? If so, which and for what uses?

Demand for indoor wireless broadband is robust based on strong EC actions on digital initiatives (as envisioned in the gigabit connectivity targets in the Commission's "2030 Digital Compass: the European way for the Digital Decade"[7]). Fixed broadband demand is increasing and is projected to increase 3x by 2025.[8] Over 90% of all fixed broadband traffic is distributed over Wi-Fi in Europe according to measured data provided by ASSIA.[9]

According to data provided in the Bundesnetzagentur telecommunications 2020/21 Activity Report[10] fixed networks process more than 19 times more data than mobile networks in Germany.



[6] https://digital-strategy.ec.europa.eu/en/policies/broadband-france

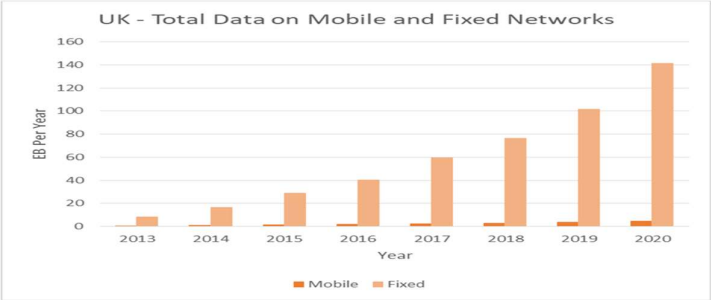
[7] https://eur-lex.europa.eu/resource.html?uri=cellar:12e835e2-81af-11eb-9ac9-01aa75ed71a1.0001.02/DOC_1&format=PDF

[8] https://www.increasebroadbandspeed.co.uk/average-home-monthly-internet-usage-forecast

[9] https://dynamicspectrumalliance.org/wp-content/uploads/2022/06/DSA-WhitePaper-How-do-Europeans-connect-to-the-Internet.pdf

[10] https://www.bundesnetzagentur.de/SharedDocs/Mediathek/Berichte/2021/TTB2020.pdf?__blob=publicationFile&v=1

According to data provided by the UK Ofcom Communications Market Report 2021[11], there is a similar trend in the UK.



Broadcom is seeing significant demand for Wi-Fi 6E converged gateways that combine the broadband modem with the access points so that broadband service providers are able to deliver broadband at the capabilities purchased by their subscribers throughout the home and enterprise. We expect to see strong demand for Wi-Fi 7 as operators move from 1-2 Gbps broadband plans to 5-10 Gbps plans. Without the wide channels offered by Wi-Fi 6E and Wi-Fi 7 (160 MHz and 320 MHz channels respectively), users would not be able to achieve the fully capabilities to which they are subscribing to. In short, without multiple wide channels extending these broadband networks, the wireless interface becomes the bottleneck in the user experience.

The RLAN industry has standardized IEEE 802.11be (also known as Wi-Fi 7) to operate in 320 MHz and 160 MHz channels in the 6 GHz band in order to meet the rapidly increasing broadband capabilities in Europe. These technologies were designed to provide a high degree of reliability and determinism so that they are not just capable of providing extremely high broadband throughput,[12] but also provide reliable low latency to enable remote learning, advanced R&D in universities,[13] healthcare modernization,[14] and much more.

In addition, Broadcom's customers are requesting very low power portable device operations to provide local area distribution from a compute device (e.g., mobile phone, laptop computer, gaming systems) to other local devices (e.g., TVs, AR/VR glasses). We expect that some of this VLP traffic will be in addition to LPI AP traffic distributed from a fixed broadband network. Broadcom have demonstrated prototype VLP operations on a Google Pixel 6 Pro at the SE45#17 working group meeting in Copenhagen. [15] Sufficient channel diversity so that VLP can operate on a different network than the Fixed/Wi-Fi network will be necessary for some applications.

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[11] https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2021/interactive-data

[12] https://www.intel.com/content/www/us/en/wireless-network/spectrum-needs-of-wi-fi-7.html (last visited 15 July 2022).

[13] https://edscoop.com/university-michigan-first-6e-network/

[14] https://www.eweek.com/networking/wi-fi-6e-healthcare-modernization/

[15] https://cept.org/Documents/se-45/72987/se45-22-043_draft-minutes-of-se4517-meeting

We appreciate the EC Decision to open 5945-6425 MHz frequency range for WAS/RLAN use, but want to stress that this spectrum on its own is insufficient to address the demand we see in Europe for wireless broadband. Without the inclusion of the 6425-7125 MHz frequency range, the spectrum in the 6 GHz band is insufficient to provision the number of channels necessary to meet the demand in residential, enterprise, and stadium deployments. Allowing RLAN usage in the entire 6 GHz band will allow enterprises and broadband service providers to future proof broadband networks in the EU. In short for consumers in France to realize the benefits of their gigabit broadband, they will need access to the entire 5945-7125 MHz frequency range.

Furthermore, if the EU Member States specify "No IMT identification" per at the WRC-23, then there is the potential for 6425-7125 MHz to be harmonized, which will greatly reduce the costs of wireless broadband in France. With over 31% of the world's GDP already allowing RLANs in the 6425-7125 MHz frequency range creating a large common market with Brazil, Canada, the United States, Republic of Korea, Saudi Arabia, and many more. IMT can never be internationally harmonized, but RLANs still can be harmonized.

Broadcom strongly supports global harmonization of the 6425-7125MHz band for RLAN usage.

Question 5. In what ways do new network architectural changes require (if any) changes to how access to spectrum resources is managed (frequency license holders' identity, quantities assigned, etc.)?

Broadcom believe that 6 GHz is not practical for outdoor IMT 2020 or 2030 and an IMT designation leads to inefficient use of valuable spectrum. IMT should not be assigned the 6425-7125MHz band for the reasons listed below.

Building attenuation will only increase for 6 GHz signals

First, the vast majority of wireless broadband traffic in Europe is consumed indoors and this is expected to continue for the foreseeable future. Europeans spend 90% of their time indoors which generates the bulk of internet traffic.[16] In some locations and some seasons 90% significantly underestimates the time people spend indoors.

Outdoor IMT base stations cannot meet the IMT Key Performance Indicators (KPIs) for indoor operation. Provisioning 100+ Mbps to a single user indoors from an outdoor base station is not reliable because of building attenuation, especially as you go deeper inside a building. This is because wireless throughput decreases and latency increases as a wireless signal attenuates. Outdoor IMT cannot achieve high throughput and low latency indoors without operating at high power levels which will impact coexistence with existing FS and FSS operations.

According to the CEPT studies upon which the EC Decision was made for the lower 6 GHz band, the power level of 6 GHz wireless signal attenuation when entering or leaving a building is reduced

[16] https://www.evia.eu/indoor-air-quality/#:~:text=Europeans%20spend%2090%25%20of%20their,higher%20than%20those%20found%20outside

by approximately 100 times what it was before going in or out of the building. This was based on an estimate that 30% of building construction is energy efficient and 70% is traditional. The building attenuation for 6 GHz signals is expected to increase over the coming years to meet environmental standards for energy efficiency in buildings, [17] not decrease, making it even harder to achieve good performance indoors in 2030 or 2040 than it is today. With EU buildings becoming greener as they are retrofitted or when new buildings are built,[18] it is reasonable to forecast that over the next 5-10 years, 6 GHz signals could be made 300-500 times weaker indoors when coverage is provided by an outdoor IMT cell.

The 6 GHz band can never be harmonized for IMT

The upper 6 GHz can never be globally harmonized for IMT since countries representing over 31% of the World's GDP have already enabled it for RLANS, and another 10% of the world's GDP is considering enabling the upper part of the 6 GHz band for RLANs but have not yet finalized their decision. However, the upper 6 GHz band can still can be harmonized for RLANs.

Notwithstanding the technical arguments on building attenuation and IMT 2020 key performance indicators (KPIs) listed above, from an economic perspective it does not make sense to seek 6425-7125 as an IMT 2030 band. The 6425-7125 MHz can never be globally harmonized in some early adopter markets such as the United States, Republic of Korea, and Canada for 6G.

See also the response to Q36, 37, 91, 92

Question 8. What other expected future applications and features can you identify?

See responses to Q2 and Q3.

Question 9. Which markets would be targeted by these applications? What is their development outlook and timeline?

Broadcom has released a full ecosystem of Wi-Fi 6E and Wi-Fi 7 chips for residential/enterprise access points and portable client devices as seen on the following links:

- Wireless LAN Infrastructure ICs;[19]
- WLAN/BT Combo Wi-Fi 7 IC; and[20]
- WLAN/BT Combo Wi-Fi 6E IC.[21]

[17] https://ec.europa.eu/info/news/focus-energy-efficiency-buildings-2020-lut-17_en
[18] https://ieeexplore.ieee.org/abstract/document/6477638
[19] https://www.broadcom.com/products/wireless/wireless-lan-infrastructure
[20] https://www.broadcom.com/products/wireless/wireless-lan-bluetooth/bcm4398
[21] https://www.broadcom.com/products/wireless/wireless-lan-bluetooth/bcm4389

As of April 2022 over 180 Wi-Fi 6E products (including smartphones, routers, Laptops, Smart TVs, PCs and modules) have already been released – and the ecosystem of products are growing rapidly. The vast majority of these devices are capable of operating over the entire 6 GHz band.

According to the Wi-Fi Alliance, over 350 million Wi-Fi 6E devices are expected to enter the market in 2022.[22]

Question 10. Among these applications, are some more likely to develop specifically within a fixed environment, e.g. indoors, or rather in a mobile situation? If so, for what reasons?

See response to Q5.

Question 12. What new frequency requirements have you identified to enable these applications using existing technologies and, if applicable, with the introduction of new technologies? For what reasons (capacity, speed, coverage...)?

See responses to Questions 2 and 3.

Broadcom strongly recommends a position of "No IMT identification" per for the frequency range 6425-7125 MHz at WRC23 to enable next generation Wi-Fi.

In addition, many new applications (e.g. digitally immersive experiences in education, healthcare, workplace and home entertainment) would be supported by implementation of LPI client-to-client operation as covered by SE45 co-existence studies in CEPT Report 302 and allowed under ECC/DEC/(20)01 and Commission Implementing Decision (EU) 2021/1067.

LPI client to client operation could be enabled by decoding of an enabling signal at an appropriate level in conjunction with introduction of a TPC requirement as was previously largely agreed in ETSI EN 303 687 draft v0.0.18.

Question 13. What outlook does 5G offer for France's economic and industrial fabric? To what extent will the expected advances (lower latency, massive number of connected objects, faster speeds) be necessary to enabling all of the technology's planned business applications? What size market do these advances represent? What economic benefits can be expected from verticals' appropriation of these new services, in general, and/or by your sector in particular?

IMT is not an efficient use of 6GHz spectrum. First, the spectrum already allocated for 5G is not being fully used. According to the 2022 Digital Economy and Society Index (DESI),[23] only 56 percent of the 5G spectrum available has been assigned by EU Member States. Furthermore, 60

[22] https://www.wi-fi.org/beacon/alex-roytblat/wi-fi-6e-insights-q1-2022-editorial
[23] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_4560

percent of 5G base stations currently operate using 4G or 3G spectrum rather than the 5G pioneer bands.

Second, GSMA has identified other bands for IMT which would be more appropriate and avoid inefficient use of the 6GHz spectrum by limiting it to IMT usage. The RSPG Strategic Roadmap Towards 5G for Europe Opinion focused on some of those bands identified by GSMA.[24] Broadcom recommends that the EU consider enabling those other identified bands with sufficient technical rules to enable economical deployment of 5G/6G networks.

Designating the upper 6 GHz band for IMT will simply take the focus off efficient use of bands that are already allocated, and bands the RSPG and GSMA have already identified for IMT. It cannot be used in the near term, and there are many WiFi-6E products that are designed to operate over the entire 6 GHz band right now.

In our view there is no justification for designating 6425-7125 MHz frequency range for IMT.

We believe that to enable sufficient coverage for 5G, and to reduce costs of 5G deployments, a mix of indoor RLAN technologies (within the 5945-7125MHz band) plus outdoor IMT technologies (in other bands) is necessary. For the reasons specified in these comments, Broadcom strongly recommends that France support a position of "No IMT identification" for the frequency range 6425-7125 MHz at WRC23.

See also responses to Q3 and Q5.

Question 26. What role does Wi-Fi play in all of the solutions for providing service indoors? If applicable, are there uses for which Wi-Fi is not technologically appropriate, and for what reasons?

See responses to Q3 and Q5 for justification why Wi-Fi is the ideal solution for providing services indoors.

Question 29. Do you have any proposals (levers for action, means, strategies, etc.) to share regarding spectrum management or frequency assignments that would help reduce networks' environmental impact, and help promote digital sustainability in general? What demands or prerequisites would be needed to activate this lever, if possible (availability of data, methodological consistency, monitoring/a posteriori audit, etc.)?

See response to Q5.

Question 34. Of all the frequency bands listed above and detailed below, which rank highest for their ability to meet your needs?

[24] RPSG16-032-Opinion_5G.pdf (rspg-spectrum.eu)

The 6425-7125 MHz band is the only new band identified to support next generation Wi-Fi for the reasons expressed in the previous comments. There is simply no other band identified by the RLAN community for expansion. This band in addition to the 5925-6425 MHz band will allow for the innovation and performance to business and consumers in France that is already available to regions that have adopted this band.

Question 36. Among the frequency bands that are the subject of questions below, which would seem to be the most appropriate for local assignments? For reuse for secondary purpose?
Question 37. If applicable, if these frequency bands were used for coexisting mobile and other uses (satellite, fixed link …), what sharing methods seem advisable to you?
Question 91. What is your assessment of the development outlook for these uses (Wi-Fi, IMT16)? Can you identify other uses that are likely to develop in this band?
Question 92. What rules for cohabitation with existing uses (microwave transmission, satellite services) in this band would be necessary?

<u>IMT is not designed for sharing spectrum</u>

Whereas WAS/RLAN has mechanisms and politeness protocols such as Listen Before Talk to ensure fair sharing of spectrum this is not the case for IMT outdoor. Although no coexistence studies have been performed between high power IMT outdoors and WAS/RLAN it is clear that co-channel operation could only be achieved by large separation distances or a re-design of the IMT channel access mechanism. Enabling WAS/RLAN use indoors and IMT outdoors will lead to poor performance in both networks because of variance in building attenuation from the median value and the predominant IMT dense urban usage deployments where WAS/RLAN densities are also highest. A re-design of the IMT channel access mechanism has already been accomplished by the WAS/RLAN variant of 5G called 5G-NRU. An IMT identification is not required to use 5G-NRU technologies.

<u>6GHz IMT will require costly spectrum re-farming</u>

While there are substantial disagreements on whether 6 GHz IMT can coexist with fixed satellite service (FSS) operations, there is resounding agreement that it cannot coexist with fixed service (FS) without enormous separation distances. While many of these fixed links are used for operator backhaul that may be migrating to fibre and other broadband backhaul, public safety, utilities, public broadband cooperatives, and some financial services use these links to provision service. These links cannot simply stay in the same location if they are migrated to 10 or 12 GHz frequencies because the additional signal attenuation and the fact that such bands are subject to other fading phenomenon will mean that the distance between links must be greatly reduced. This requires the construction of new towers, new backhaul to be constructed, and the purchase of new equipment. This is non-trivial and would take many, many years to be accomplished with disruption to those existing services.

Question 93. Do you think the 6425-7125 MHz band is a good candidate for implementing dynamic spectrum sharing to handle the planned uses for it?

Dynamic spectrum sharing is not required for LPI and VLP devices as allowed under ECC/DEC/(20)01 and Commission Implementing Decision (EU) 2021/1067 for 5945-6425MHz and should not be required to enable these types of devices in the 6425-7125MHz band. Higher power applications across the full 1180MHz would be subject to future co-existence studies where automated frequency co-ordination (AFC) systems could be considered as a means of spectrum sharing to enable multiple new outdoor or enhanced indoor applications.

Sincerely,

/s/ David Boldy	*/s/ Christopher Szymanski*
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