TELSTRA CORPORATION LIMITED

RLAN use in the 5 GHz and 6 GHz bands

Public Submission

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01 Introduction

We welcome the opportunity to provide our views to the ACMA's consultation on RLAN use in the 5 GHz and 6 GHz bands (IFC 12/2021). Since the start of the COVID-19 pandemic last year Australians have become more reliant than ever on Wi-Fi to stay in touch with family and friends or to work and school from home. Wi-Fi has become an indispensable part of our daily lives and is essential to the country's economic and social prosperity.

We support the ACMA's preliminary view[1] that the lower 500 MHz (5925–6425 MHz) should be made available for use in Australia under the LIPD class licence and we further believe the case exists for the upper 700 MHz (6425-7125 MHz) to also be made available for indoor and very low power (VLP) RLAN use under the LIPD class licence. We also propose that the Effective Isotropic Radiated Power (EIRP) limit for Low Power Indoor (LPI) devices could be up to 6 dB higher than those contemplated in the ACMA's preliminary view (without increasing the Power Spectral Density (PSD) limits) and that higher-power outdoor 'standard' devices can be accommodated in the lower 500 MHz sub-band.

At the same time, we consider it essential that incumbent services including the fixed satellite service and fixed links are protected, not just for services currently deployed, but also for future deployment of these apparatus licensed services.

Our submission to this consultation contains five key recommendations for the ACMA's consideration:

1. The full 1200 MHz (5925-7125 MHz) of the 6 GHz band should be made available for RLAN use under the LIPD class licence in Australia;
2. Higher EIRP power limits for LPI devices can be accommodated (although the PSD limits should be capped) and to the extent possible, indoor deployment should be enforced for LPI in the 6 GHz band (5925-7125 MHz);
3. 'Standard' devices (operating at 30 dBm to 36 dBm) can also be accommodated, including deploying such devices outdoors, but only in the lower sub-band (5925-6425 MHz). Automatic Frequency Control (AFC) should be mandatory and the ACMA should develop deployment guidelines for these devices;
4. Power levels should be increased for indoor use of the 5150-5250 MHz segment of the 5 GHz band, as contemplated under Resolution 229 (Rev. WRC-19); and
5. The 5600-5650 MHz segment of the 5 GHz band should be made available for both indoor and outdoor class-licensed Wi-Fi equipment in Australia.

Our submission is structured as follows:

- Section 2 demonstrates the case for the whole 1,200 MHz to be made available under the LIPD class licence for RLAN use in Australia;
- Section 3 contains our analysis of sharing studies and our thoughts on protecting incumbent services;
- Section 4 contains our views on emerging potential IMT use for the band;

[1] Consultation paper, p.11

- Section 5 contains our views on the likely attributes for class licensed RLANs in the 6 GHz band, including characteristics such as power levels and indoor/outdoor deployment;
- Section 6 contains comments on changes we believe can be made to the 5 GHz band; and
- Appendix 1 contains answers to the ACMA’s six specific consultation questions.

02 The case for more spectrum for class licensed RLAN use

We agree with and support the ACMA's preliminary view and rationale for making the lower 500 MHz (5925–6425 MHz) available under the LIPD class licence. Expanding the ACMA's preliminary view beyond just the lower 500 MHz, we consider the case exists for the full 1200 MHz (5925-7125 MHz) to be made available for RLAN use.

Demand for Wi-Fi continues to increase as the ACMA observes in the consultation paper by citing the Communications Report 2018-19, research from the Wi-Fi Alliance, and a range of international developments in the 6 GHz band. In this section of our submission, we firstly add to that body of evidence with research from our Wi-Fi optimisation partner AirTies. From there, we offer information based on practical experience with our customers related to congestion in dense urban residential and business settings, supply-side factors that are likely to see demand increase, and finally industrial deployment factors driving demand to complement the residential factors.

2.1. COVID-19 has set a 'new normal' for demand in the residential environment

The ACMA observes "*The ever-increasing demand for … Wi-Fi networks has been accelerated by the ongoing COVID-19 pandemic, which has resulted in more people working, learning and socialising from home*." We agree home Wi-Fi capacity has been stretched to limits not seen before. A recent report[2] by Telstra's consumer Wi-Fi optimisation partner AirTies using data sourced globally from 25 million end users identifies several key findings, including:

- During lockdown, the number of actively used Wi-Fi devices within each home increased from 5.9 to 6.6 on average.
- During lockdown, not only were more devices in use, but they were being used simultaneously. An average of up to 5 simultaneously connected devices were being used every day of the week. This is a 30% to 40% increase on the pre-lockdown working day, where an average of only three devices per home, with a peak of four on weekday evenings and weekends was observed.
- Between the working hours of 9am and 5pm, Wi-Fi activity increased, ranging between 70% to 94% higher than pre-lockdown levels.
- During lockdown, the volume of average Wi-Fi data rose to over 11GB per home, for every day of the week. This compares to pre-lockdown when data consumption was around 6.5GB during the week to over 8GB at the weekends. In other words, average data volumes increased by 62%.
- Propelled by an increase in video conferencing and online file sharing/storage usage, the volume of upstream traffic more than doubled, with an increase of 116% during the lockdown period.

Wi-Fi traffic has increased and remains at a "new normal" level of about 20% higher compared to pre-COVID levels measured 16 months ago. Wi-Fi link activity has also reached a new normal level of about 30% higher

2 AirTies. *The Catalyst Effect: Understanding the Impact of Lockdown on Residential Wi-Fi and Future Implications*. January 2021. Available at: https://insights.airties.com/catalyst-effect-whitepaper

than pre-COVID levels. While Wi-Fi activity will always increase year over year, 2020 caused a step increase in traffic volumes, as shown in Figure 1.

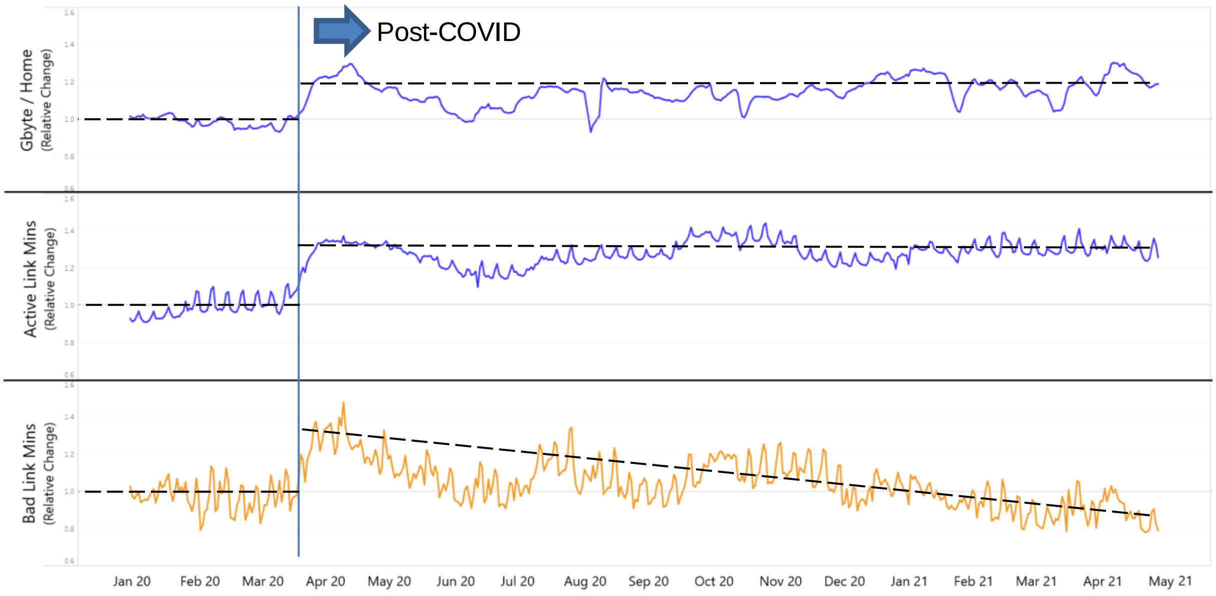

Figure 1: The "New Normal" for Wi-Fi Traffic[3]

Figure 1 above shows:

- **Top Chart**: Relative change in average gigabytes (GBytes) download per home;
- **Middle Chart**: Relative change in Active Link Minutes (ALM) per home; and
- **Bottom Chart**: Relative change in Bad Link Minutes (BLM) per home.

Using this evidence, alongside the other evidence cited in the consultation paper, we agree with the ACMA there is a clear case for action, and it is timely to review arrangements for RLANs in these bands in Australia.

2.2. Residential RLAN congestion in dense urban areas results from insufficient channels

Returning to the AirTies report, the sixth and final finding speaks to global homeowners' measurable Wi-Fi quality of experience (QoE):

- Before lockdown, approximately 19% of homes experienced measurable Wi-Fi coverage issues in their homes, but this rose to almost one third (32%) of homes during the confinement period.

That is almost a 70% increase in the number of homes experiencing Wi-Fi coverage issues resulting from lockdown. This is a consequence of a phenomenon AirTies call the "**Catalyst Effect**". The findings show that

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3 Source: AirTies, April 2021. This graph (Figure 1) is developed using only Wi-Fi devices on Telstra's network.

when under pressure, Wi-Fi performance does not worsen in a linear fashion correlated with the increase in usage, but rather that it deteriorates in an exponential way as shown in Figure 2 below.

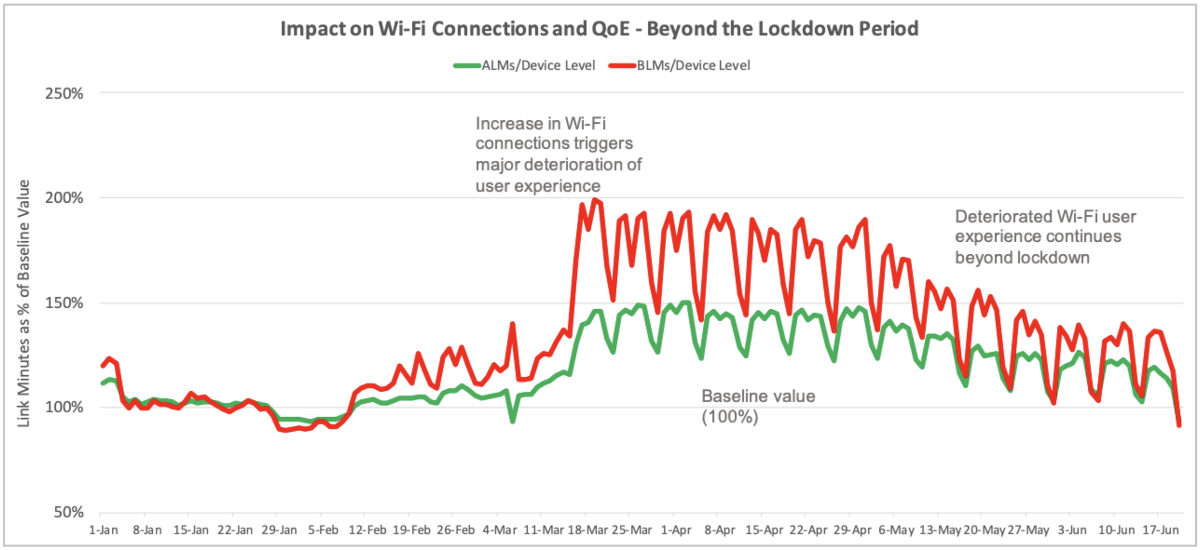

Figure 2: “Catalyst Effect”: Wi-Fi connection peaks triggering deteriorated QoE during lockdown[4]

Figure 2 shows the increase in Wi-Fi activity by calculating the amount of time a connected device is active on the Wi-Fi, measured as Active Link Minutes (ALMs), shown by the green line. The red line shows the volume of Bad Link Minutes (BLMs) and as can be seen, for an increase in ALMs of between 30%-50%, the BLMs rose by an average of 60% with peak increase in BLM reaching double the baseline level.

The “Catalyst Effect” occurs due to increased congestion on the Wi-Fi channels. Wi-Fi channels can be shared by several devices in a home, especially in dense urban environments where neighbouring Wi-Fi access points are “visible” between residential premises. Wi-Fi access points compete for scarce channels, and then aggregate multiple devices onto the available channels. As the number of devices per channel increases, Wi-Fi uses a mechanism called carrier sense multiple access with collision avoidance (CSMA/CA) to manage traffic on the Wi-Fi channels. CSMA/CA requires devices to listen before they talk and if a collision occurs, the device must then wait a random length of time before trying again. As traffic levels increase beyond a threshold tipping point, a cascade failure occurs resulting in the disproportionate increase in BLMs.

Returning to Figure 1 (derived using Telstra end points) we notice the BLM trend (bottom chart) agrees with the AirTies graph in Figure 2 (reproduced from the AirTies report using global data) showing that in both cases, BLM has now returned to pre-COVID levels. Given activity levels have not returned to normal, it is evident that Telstra and its customers were able to improve the Wi-Fi performance to compensate for the increased demand using a combination of optimisation techniques such as the introduction of new more

4 Reproduced with permission. See Figure 12, p.17 of *The Catalyst Effect: Understanding the Impact of Lockdown on Residential Wi-Fi and Future Implications*. Produced by AirTies. January 2021 using globally sourced data on 25 million end users. Available at: https://insights.airties.com/catalyst-effect-whitepaper

capable Wi-Fi Routers, deployment of mesh Wi-Fi solutions, software optimizations, improvements in customer support flows and self-care tools. End users may also have upgraded their Wi-Fi clients to newer Wi-Fi technologies and/or adapted their behaviour patterns to use Wi-Fi in more optimal locations at home, as evidenced by the fact that on Telstra's network today, over half (55%) of Wi-Fi devices are now dual-band (2.4 GHz and 5 GHz), with just over one-third (35%) being legacy single band (2.4 GHz) devices.

However, once these optimisation techniques are exhausted, the only solution available to relieve poor customer QoE is to increase capacity by making more spectrum available for class licensed RLAN use.

2.3. Residential RLAN may become the bottleneck in the future

Multiple 4K resolution video streams requiring in the order of 50-100 Mbit/s[5] and/or 8K video streams (requiring four times the data speed of 4K resolution) will require high reliable throughput in residential and potentially business settings in the future. Where mesh networks are used to support this throughput a home, the mesh backhaul links will need the wider channels to support backhauling this aggregate traffic. Further, new technologies requiring higher bitrates such as augmented reality and virtual reality headsets are becoming more commonplace[6]. This demonstrates that existing Wi-Fi 5 capability could quickly become the bottleneck in the future.

While it is true today that NBN only has the capability to supply access services with bitrates above 100 Mbit/s downstream to a subset of addresses, efforts will continue to be directed to increasing the availability of access services above 100 Mbit/s. Further, fixed wireless access services using 5G technology on mm-wave will also supply access services in excess of 100 Mbit/s. Higher speed access services, coupled with local storage of high bitrate content on home media servers will, in the future, mean that content can be supplied onto residential Wi-Fi networks at rates that exceed the capability and capacity of the 2.4 GHz and 5 GHz Wi-Fi bands.

2.4. 6 GHz RLAN uses in overseas jurisdictions will create a device ecosystem

The consultation paper observes that the US[7] and the UK[8] have made the full 6 GHz band and the lower 6 GHz band available for unlicensed RLAN use respectively. The scale of these markets will drive a device ecosystem for the band, which in turn will stimulate demand for the 6 GHz band for Wi-Fi in Australia. We expect the device ecosystem to include both residential and industrial applications, with the latter including factory machinery, tracking devices and automation within warehouses, to name just a few.

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[5] https://en.wikipedia.org/wiki/4K_resolution#Bit_rates

[6] IT Brief story quoting IDC's worldwide quarterly AR and VR headset tracker observes CAGR of 81.54% between 2020-2024: https://itbrief.com.au/story/idc-ar-vr-market-will-still-see-eventual-growth-in-2020

[7] Consultation paper, top of p.21

[8] Consultation paper, top of p.24

2.5. Industrial RLAN and outdoor use of 'standard' devices

Enterprise and industrial Wi-Fi deployments are also starting to run out of capacity in the 5 GHz band creating demand for additional spectrum in the 6 GHz band. From our experience, we observe:

- Wi-Fi access points are often deployed with the default vendor settings of 80 MHz channels meaning this channel size must be accounted for even if a well-designed network seeks to use 20 or 40 MHz channels to reduce co-channel interference;
- Enterprise deployments typically have at least 10-20 access points and there are only 4-5 non-overlapping 80 MHz channels to use – even less in proximity to maritime operations (e.g. Sydney Harbour), airports and weather radar where DFS leaves only 3 x 80MHz channels available – meaning interference often becomes an issue;
- Airports and large industrial sites have additional factors such as many sources of RF noise and the impact of radar that further reduce the number of usable channels for Wi-Fi and their performance. Even with 20 MHz operation, there may only be 10-15 clear channels which is not sufficient to meet current and future needs for high-speed edge connectivity; and
- Wi-Fi access points are being deployed in increasing density. This is not just to support higher capacity data services driven by increasing higher-speed devices and services, but is also for additional types of services like real-time location services (e.g. in healthcare) and retail analytics services that require higher density Wi-Fi deployments for best performance, as well as in-filling coverage gaps in the home or office as wireless devices become ubiquitous. This further impacts available capacity.

Emerging industrial RLAN use cases need the higher throughput, higher reliability and lower latency that the new spectrum in the 6 GHz band can provide. Examples include: replacing signalling cabling used for real-time control with wireless connections; using AR to overlay operational and troubleshooting information; reliable voice and video communications across a site; video streaming and analytics; and large file transfers.

- These use cases require the end device to use 80 MHz or wider channels to achieve the necessary bitrate. 80 MHz channels are the minimum size needed for end users to use the high-speed edge connectivity available from NBN. Most end user devices only support 1 or 2 spatial streams due to physical limitations on the number and size of antennas meaning that 80, 160 (or 320 MHz in future) channels are the only way for them to get high peak speeds. Practical use of 80, 160 or 320 MHz channels requires allocation of the whole 1.2 GHz for RLAN use.
- Allocating new spectrum in 6 GHz for Wi-Fi 6E and later technology also enables delivering high performance WLAN services at industrial sites by removing the negative impact of co-existence with legacy Wi-Fi protocols.

We consider it important that outdoor use of 'standard' power devices are accommodated in the lower 6 GHz sub-band (only) to support 80 MHz (or wider) channels for wireless backhaul links in LAN extension or outdoor site coverage (e.g. university campuses, train stations, etc).

2.6. Supporting practical use of wider channels and higher bitrates

Medium to high density deployments of RLAN in venues such as convention centres, hotels, lecture theatres, airports, offices and dense residential settings can deliver much more robust throughput with access to multiple channels. Making 1,200 MHz available for LPI devices will sufficiently increase the number of wider channels available so that they can be used in these environments[9]. For example, there would be 14 x 80 MHz channels available with 1,200 MHz rather than 6, or 7 x 160 MHz channels rather than 3.

Allocation	Number of channels for given channel width[10,11,12]				
	20 MHz	40 MHz	80 MHz	160 MHz	320 MHz
5925-6425 MHz	24	12	6	3	1
5925-7125 MHz	59	29	14	7	3

This is particularly evident for 160 and 320 MHz channels. The current Wi-Fi standard (IEEE 802.11ax, Wi-Fi 6/6E) specifies channel bandwidths of up to 160 MHz, while the next amendment under consideration (IEEE 802.11be Extremely High Throughput) will specify channel bandwidths of up to 320 MHz[13], which will only be supported in the 6 GHz band. While the ACMA's preliminary view of a 500 MHz allocation for RLAN would enable one 320 MHz channel, we believe it unnecessarily limits the band's potential for indoor applications, and consider the whole 1,200 MHz should be made available for indoor (and VLP) use so all three 320 MHz channels can be used.

03 Incumbent services must be protected

This section contains our views on maintaining protection for incumbent service types, including allowing for new deployments of these service types. Our view is that the EIRP level for LPI devices can be increased to 30 dBm/occupied channel so long as the PSD is retained at 11 dBm/MHz, and that for 'standard' devices (higher-power allowed to be deployed outdoors) Automatic Frequency Control is required to maintain protection for incumbent services including Fixed Services and Fixed Satellite Services.

9 For example, Ofcom, "Improving spectrum access for Wi-Fi - Spectrum use in the 5 GHz and 6 GHz bands", 24 July 2020, clause 3.20, p12, notes enterprises "generally design their deployments using 20 and 40 MHz bandwidths to increase the number of non-overlapping channels available". This Cisco Meraki design guide recommends only using 20 MHz channels (in 2.4 and 5GHz bands) to avoid interference, whereas having more channels available would allow this restriction to be eased. https://documentation.meraki.com/Architectures_and_Best_Practices/Cisco_Meraki_Best_Practice_Design, Accessed 22 Apr 2021.

10 CEPT ECC Report 302, 29 May 2019, p.22. https://docdb.cept.org/download/cc03c766-35f8/ECC%20Report%20302.pdf

11 Broadcom, https://www.broadcom.com/media/1211237528236/wi-fi-6-frequency-bands.jpg, accessed 23 Apr 2021

12 Intel, "Next Generation Wi-Fi – Wi-Fi 7 and beyond", July 2020 https://www.intel.com/content/dam/www/public/us/en/documents/pdf/wi-fi-7-and-beyond.pdf, accessed 22 Apr 2021, p. 9

13 Intel, Next Generation Wi-Fi – Wi-Fi 7 and beyond, July 2020 https://www.intel.com/content/dam/www/public/us/en/documents/pdf/wi-fi-7-and-beyond.pdf, accessed 22 Apr 2021, p. 8,9

3.1. Fixed Services (P2P Links)

Telstra currently operates around 660 fixed links across both the lower and upper 6 GHz sub-bands. The lower sub-band is very important because it is now the lowest frequency bands available for Point-to-Point (P2P) microwave links thereby offering benefits in range and diversity improvement over the other available bands. The upper sub-band is also very important for P2P links as it has the ability for greater capacity and can be used to carry higher bitrate services where distance and/or diversity is a less demanding requirement. It is important to us that all these links are protected from interference from class licensed RLAN devices, both from single device operation and in aggregate.

Regarding interference prevention, we note the consultation paper's reference[14] to sharing studies conducted by the European Conference of Postal and Telecommunications Administrations (CEPT), in particular, European Electronics Communications Commission (ECC) Reports 302 and 73. ECC Report 73 summarises the three sharing studies in Report 302 and notes that only the third study ("Study C") concluded[15] that allowing APs to operate outdoors at higher power would cause interference to fixed links: "…*allowing* ***outdoor*** *WAS/RLAN operating with an e.i.r.p. of 1 W* ***would*** *create interference from a large area around the FS link, depending on the terrain profile*."[16] (emphasis added).

At first pass, any study showing interference would be created is concerning to Telstra. Closer inspection of Study C[17] however, shows that while interference was indeed predicted by the modelling, it was not the outdoor deployment that was of such concern per se. Study C notes that in all three links modelled (Clermont, Dijon and Marseille in France), the long-term protection threshold[18] of exceeding I/N of -10 dB for more than 20% of the time was not exceeded by Monte Carlo simulations of outdoor APs at 1 W (Dijon was the worst by exceeding the I/N > -10 dB threshold for 4% of the time, Clermont for only 1.89% and Marseille only 0.11%). What was, however, of concern to the study authors was exceeding the short-term protection threshold.[19] Here, two of the three links (Clermont and Dijon) exceeded the short-term protection threshold (the third link was not modelled) for a fairly significantly period of the time (Clermont 0.002% and Dijon 0.0152%), and importantly, the short-term criteria was also exceeded by **indoor** APs. Section 6.4.5 of ECC Report 302 observes "*these simulations also show that within close proximity of some FS stations, the short-term protection threshold of 19 dB is exceeded (**even in the indoor case**). This appears to be more critical compared to the long term criterion*." (emphasis added). Subsequent to this conclusion, ECC Report 316 shows that for a combination of VLP outdoor and LPI indoor in both dense urban (20,000 pop/km^2) and rural

14 Consultation, Appendix B.

15 For completeness, the other two studies do also show the *potential* for interference, based on exceeding I/N of -10 dB; the difference is that only Study C is bold enough to say outdoor APs would cause interference. Study A (the keyhole-diagram study) shows I/N = -10 dB is exceeded, and at a PSD of 17 dBm/MHz (i.e., 1 W into a 20 MHz channel), the circle radius from indoor use (700m) compared to the circle radius for outdoor use (1000m) is not a substantial increase (roughly twice the area). Study B concludes that for over 250,000 simulations on two real-world scenarios in the UK and the Netherlands, only 0.540% of scenarios in the UK and 0.460% in the Netherlands had an aggregate I/N exceeding -10 dB. It is important to note that exceeding I/N of -10 dB isn't a *guarantee* of interference; it just means the protection criteria has been exceeded. Interestingly, while Study C concurs with both Study A and Study B that I/N of -10 dB *can* be exceeded (for short durations), only Studies B and C mention the long term protection criteria in ITU-R Recommendation F.758 and both these studies conclude that the long term protection criteria is not exceeded.

16 CEPT ECC Report 73, section 3.1.2, p.10. https://docdb.cept.org/download/0d0696a1-89ae/CEPT%20Report%2073.pdf

17 CEPT ECC Report 302, section 6.4, p.76-82

18 The long-term protection threshold is defined as exceeding I/N greater than -10 dB for more than 20% of the time, as advised by Recommendation ITU-R F.758

19 The short-term protection threshold is defined as exceeding I/N greater than +19 dB for more than $4.5{\cdot}10^{-4}$% of the time, advised in Recommendation ITU-R SF.1650-1. To put this into perspective, $4.5{\cdot}10^{-4}$% is 19.44 mins/month (30 day month).

(2,000 pop/km^2) settings, the short-term criteria is met[20], alleviating the concern that the short-term criteria will be breached.

Hence, we arrive at a position that while higher-power RLAN devices in the 6 GHz band may exceed the protection criteria of I/N ≤ -10 dB, the long-term criteria of not exceeding an I/N of -10 dB for more than 20% of the time is not exceeded (the long-term protection criteria is not exceeded by the presence of outdoor devices). Further, while Study C finds that the short term criteria (an I/N > +19 dB exceeded for more than $4.5 \cdot 10^{-4}$% of the time) is breached by outdoor devices, the study notes that the short term protection criteria is also breached by the presence of indoor devices.

Here, Study A can help us understand the implications of higher power to the interference risk profile. Study A addresses power spectral density (PSD). A lower EIRP of 24 dBm into a single 20 MHz Wi-Fi channel produces the same PSD (11 dBm/MHz) as 30 dBm (four times the power) into an 80 MHz Wi-Fi channel (four times the bandwidth). Figure 3 below (reproduced from Study A) shows the separation distance (radius) from the P2P receiver required to meet an I/N of -10 dB (blue line) and an I/N of -20 dB (orange line) as the PSD increases. What this means is that if we allowed the PSD to increase above 11 dBm/MHz, the cull distance where indoor devices could affect P2P links also rapidly increases. At an increase of only 6 dB (i.e., to a PSD of 17 dBm/MHz), the radius has doubled from 400m at 11 dBm/MHz to 800m at 17 dBm/MHz. However, as we outline in section 5.2, while we recommend EIRP limits be increased for LPI devices, we consider PSD for these devices should be retained at 11 dBm/MHz to avoid increasing the radius where devices could affect a P2P link.

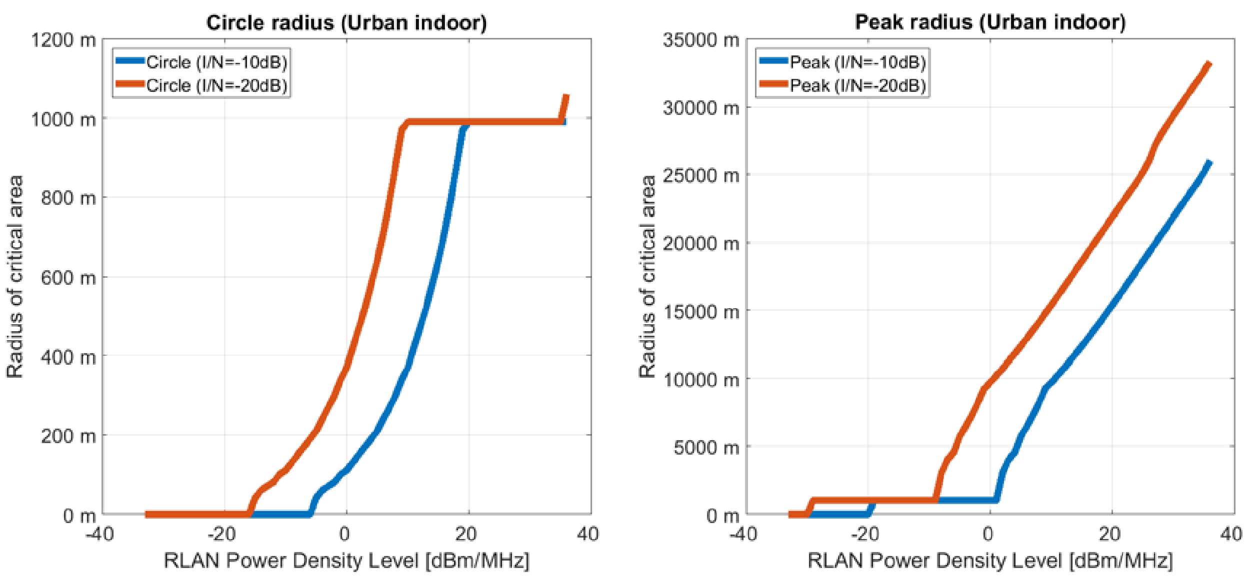

Figure 3: Dependency of critical radii on the WAS/RLAN power density indoors (*Reproduced from Figure 21 of ECC Report 302*[21])

[20] CEPT ECC Report 316, section 4.2.4.2, p.19, Figures 2 and 3 respectively.

[21] CEPT ECC Report 302, section 6.4, p.60

In summary, based on our review of the sharing/co-existence studies prepared by the European Commission (CEPT), we consider that P2P links can be protected, even with the increase in EIRP we propose for LPI devices in section 5.2 (noting that PSD should not be increased).

Unfortunately, the CEPT studies do not assess ‘standard’ devices (i.e., higher-powered devices in the range of 1-4 W) deployed outdoors. While we are advocating for outdoor deployment of higher-powered devices in the lower sub-band (5925-6425 MHz) as noted in section 2.5, we are somewhat concerned about the risk of interference occurring, especially when installed at height, for example on poles, towers, water towers or other structures, as these deployments are likely to be at similar heights to P2P links, which can commonly be deployed from as low as 4m above ground level.

As such, we consider that standard devices must incorporate a mechanism such as the Automatic Frequency Coordination (AFC) mechanism developed for the USA market (although not necessarily the same mechanism), which we outline in section 3.3 below, and that the ACMA must develop deployment guidelines to protect incumbent services and comply with Resolution 229 (Rev. WRC-19) as outlined in section 3.4 below.

3.2. FSS Earth stations

Telstra currently operates around 80 C-band teleports with up links in the lower 6 GHz band. The two coexistence studies in ECC Report 302 show there is little risk of aggregate interference to satellites from the combined indoor and outdoor deployment of Wi-Fi APs (98%:2% ratio). As such, we consider there are no additional measures (beyond those described in section 3.1 to protect P2P fixed links) required to protect FSS operations.

3.3. AFC can assist with protection of incumbent services for ‘standard’ devices

The ACMA’s preliminary view is only to introduce LPI and VLP devices for the 6 GHz band. We are of the view that demand also exists for higher-power outdoor devices (so-called ‘standard’ devices), and while co-existence studies generally do not consider co-existence of devices operating above 30 dBm EIRP, we consider that interference effects can largely be prevented through the introduction of an Automatic Frequency Coordination (**AFC**) system for standard devices designed to operate outdoors. Such a system would require standard devices to disable channels that would cause interference to apparatus or future spectrum licensed services (both incumbent and future) such that the possibility of interference would be mitigated. All standard devices would need to periodically (e.g., daily) update itself from the AFC database, which would mean that ‘air-gapped’ RLAN systems (i.e., not connected to the public internet) would still need to obtain updates in order to be permitted to operate.

We acknowledge the ACMA’s comment that “… *the ACMA would not develop and manage the DSA/AFC system and would instead look to industry to provide this service*”, and while we are comfortable with that position, we consider that the ACMA would need to play a role in regulating (mandating) the use of such a system, to ensure that 'standard' devices capable of operating at or above 30 dBm regardless of whether they are deployed indoors or outdoors are required to use and comply with the AFC system.

3.4. Deployment guidelines are required to protect incumbent services

We recommend the ACMA should issue deployment guidelines to advise on optimal outdoor deployment for 'standard' devices, including details of elevation pointing restrictions[22]. This should include factors such as discouraging installation at height where possible (and providing some simple guidelines as to what this means), while encouraging down-tilt / elevation masks, and attempting to make use of terrain shielding wherever possible. This would facilitate deployment at outdoor locations such as stadiums, train stations, mines, machinery plants and other industrial settings. We would be pleased to assist the ACMA in developing appropriate deployment guidelines for outdoor deployment of Wi-Fi APs.

04 Potential IMT use in the 6 GHz band

This section contains our views on possible future recommendation from ITU-R for an IMT allocation in the (upper) 6 GHz band.

4.1. Potential allocation of exclusive area-wide licensing for IMT in the upper 6 GHz band

WRC-23 agenda item 1.2 is considering making a recommendation for exclusive area-wide licensing (spectrum licensing) for IMT in Region 3 at the top of the upper 6 GHz band (7025-7125 MHz). It is over two and a half years before the outcomes of WRC-23 will be known and it is our position that this should not delay the whole of the upper 6 GHz band being made available for LPI and VLP class licensed RLAN use in Australia, and the as the demand for addition spectrum for class licensed RLAN use is evident. Note that we consider that standard power outdoor devices shouldn't be permitted in the upper 6 GHz band.

In the event WRC-23 resolutions make provision for an IMT allocation in the range 7025-7125 MHz, we consider a combination of mechanisms identified by the ACMA could be used to limit aggregate levels of interference in the future, thereby making the operation of IMT in this range possible. Such mechanisms include:

- Retaining a limit on the PSD of LPI devices at 11 dBm/MHz (despite allowing EIRP to increase to 30 dBm/occupied channel);
- Not permitting standard power outdoor devices in the upper 6 GHz band; and
- We understand the forthcoming update to IEEE 802.11AX will contain a mechanism for "Channel Puncturing" which allows a subset of a larger channel to be disabled. This would allow, for example,

[22] Resolution 229 (Rev. WRC-19) Resolve 5 is a good example. While Resolve 5 is specifically required for devices operating outdoor in the range 5250-5350 MHz, we consider it to be a useful proxy for the 6 GHz band.

just 20 MHz in an 80 MHz channel to be disabled (not used), which could be used in conjunction with AFC to allow a portion of larger channels (160 MHz today and 320 MHz under the future 802.11BE standard) to be used while affording protection to future spectrum-licensed IMT services, should part of the band be re-allocated in the future.

05 Attributes for the 6 GHz RLAN for Australia

This section contains our views on aspects such as power limits for proposed RLAN use in the 6 GHz band and considerations for indoor and outdoor deployment. We start by making the case for a higher power limit to resolve indoor coverage issues and then explain the attributes we consider to be appropriate for both LPI and 'standard' (higher power) outdoor devices.

5.1. Higher indoor power can resolve in-home coverage issues

In this section, we demonstrate how higher EIRP levels can resolve indoor coverage issues.

Figure 4 below shows the results of laboratory testing[23] on the Received Signal Strength Indicator (RSSI on the left-hand axis) and the throughput (right-hand axis) for a common Telstra Smart Modem. The graph shows the effect of increasing the power into a channel. The two orange lines (dotted for RSSI and solid for throughput) are the results for Channel 36 (CH36) which is 5170-5190 MHz, and hence limited to 24 dBm EIRP. The two green lines are the results for Channel 100 (CH100) at 5490-5010 which can operate at 30 dBm EIRP. At the bottom of the chart, the horizontal blue line represents at 16 Mbit/s data rate (against the right-hand axis) that would be required to sustain a (reasonably compressed) 4K video stream such as Netflix. As the attenuation increases (horizontal axis), the RSSI and throughput both decease to the point where the RSSI reaches the noise floor, and the throughput drops below the level required to sustain the video stream.

What Figure 4 effectively shows is that the extra 6 dB of power (available on CH100) allows the Wi-Fi user to sustain an extra 6 dB of attenuation; CH36 effectively drops the video stream at 59 dB attenuation, whereas CH100 only drops the video stream after 65 dB attenuation. While there are no surprises in that statement, what it translates to in practice is an extra room or two coverage in a typical brick home. This may not seem like much, but in many cases, it is the difference between needing an extender or not needing one. Every extender added to the home adds to general Wi-Fi noise (which in turn further reduces Wi-Fi capacity), additional cost to the consumer, more points of failure in the home LAN, additional power use and e-waste creation.

[23] Telstra conducts testing at the Octoscope lab https://octoscope.com/English/Customers/Customers.html. Testing of the Telstra Smart Modem Gen 2 (DJA0231) was conducted using a 20 MHz width channel with no interference, in a semi-anechoic chamber with 4x4 MIMO client (as would be found in a high-end extender). These tests are not intended to simulate real-world deployment, but rather test the Received Signal Strength Indicator (RSSI) and throughput in a test environment to determine the effects of free-space loss.

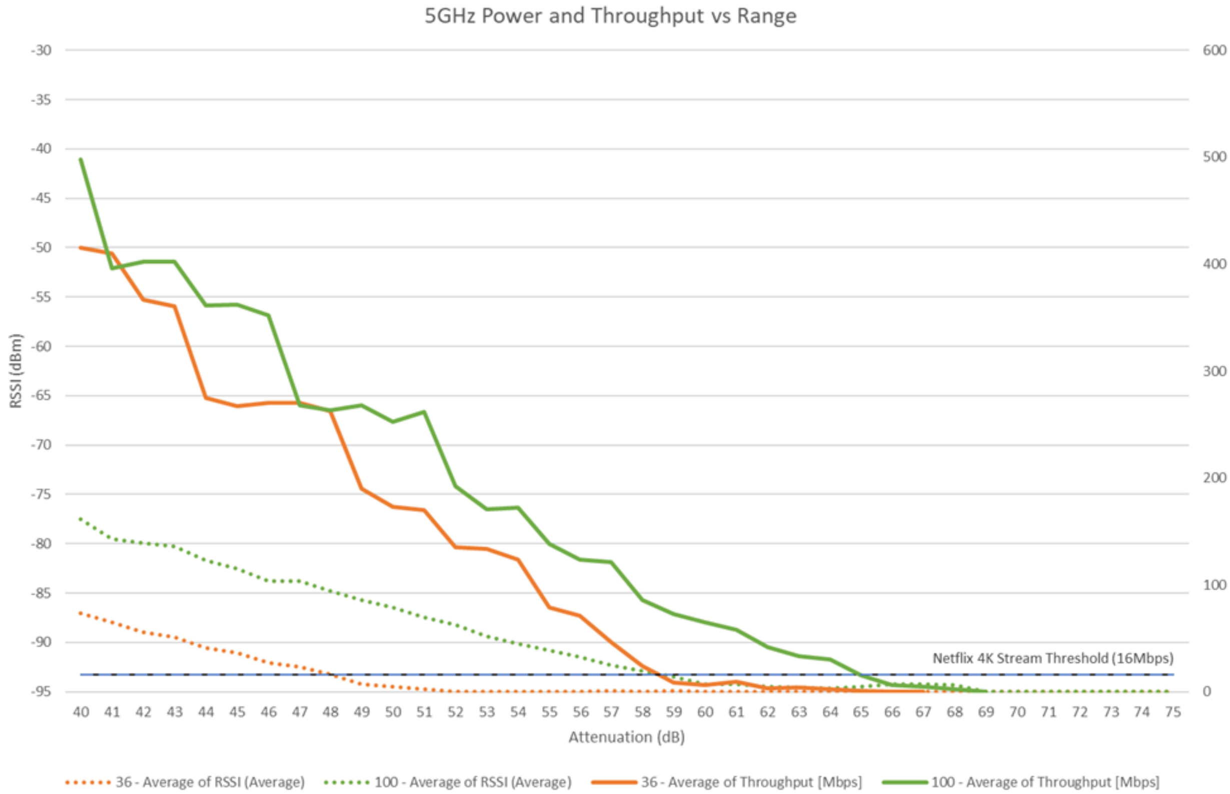

Figure 4: Received Signal Strength Indicator (RSSI) and Throughput versus Range in the 5 GHz band

Taking the laboratory testing into a real-world setting, the difference in coverage between 24 dBm EIRP and 30 dBm EIRP in a typical home can be seen in the following two RSSI plots from our real-world test house at Kemps Creek. Figure 5 shows usable Wi-Fi coverage around the house on CH100 (at 30 dBm EIRP). The Wi-Fi signal strength is poor but usable in Bed 5, Bed 6, Mudroom and Bath 2. By contrast, Figure 6 shows what happens when CH36 is used (a 20 MHz channel in the range 5150-5250 MHz limited to 24 dBm EIRP). In Figure 6, the signal drops below a usable level (i.e., below RSSI of -85 dBm) in these locations.[24]

[24] The astute reader will observe that Figure 4 shows the 16 Mbit/s Netflix stream still operating at an RSSI of about -93 dBm, whereas in Figures 5 and 6 (the Kemps Creek test house), we're saying it needs to be above -85 dBm for the Netflix stream to continue operating. The difference is that the client device we used in lab (Figure 4) is using 4 spatial streams with large antennas, which is not what you would find on a typical laptop or smartphone with 2 spatial stream and tiny antennas trying to reach the Wi-Fi access point.

Figure 5: Kemps Creek test house - Poor but still usable Wi-Fi coverage on a 20 MHz channel (CH100)

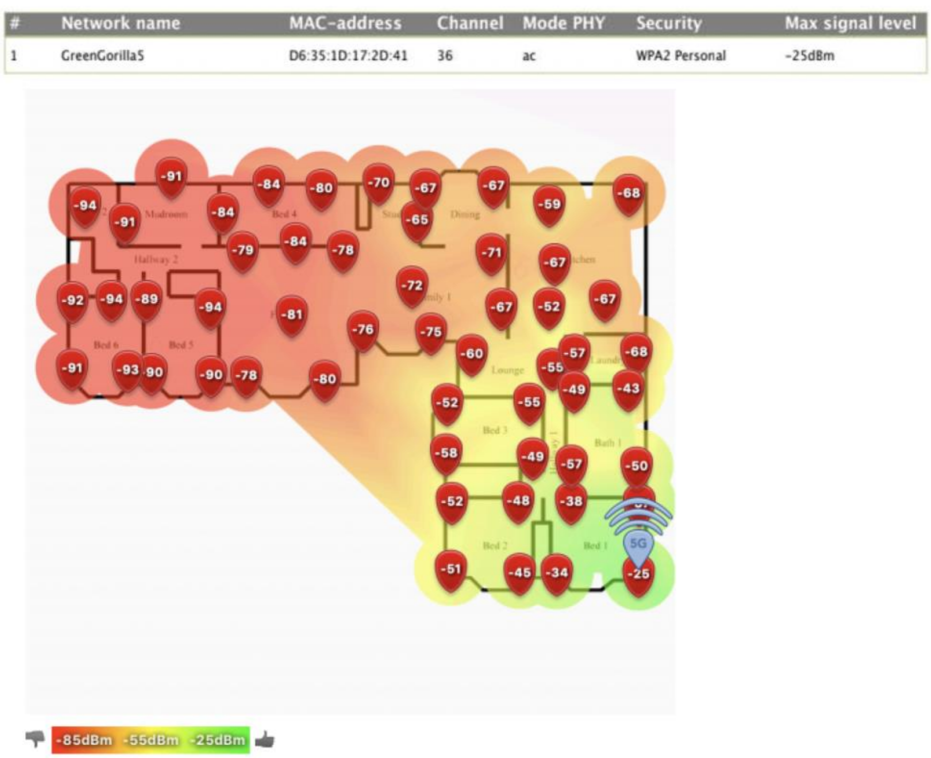

Figure 6: Kemps Creek test house - Unusable Wi-Fi coverage (below -85 dBm RSSI) on CH36 at 24 dBm EIRP

5.2. Higher EIRP power with capped PSD limit for LPI

The consultation paper observes that internationally, jurisdictions are introducing or proposing a combination of some or all of three different power limits, broadly along the lines of (some of the figures vary between jurisdictions):

- very low power (VLP) devices – commonly 14 dBm
- low power devices, indoor use only (LPI) – ranges from 23 to 30 dBm in different jurisdictions and may also require lower limits for client terminals
- higher ('standard') power, requiring use of an AFC system – either 30 or 36 dBm, again with lower power for client devices.

The ACMA's preliminary view for LPI devices is to allow an EIRP of 24 dBm (250 mW) per occupied channel coupled with a maximum Power Spectral Density (PSD) of 11 dBm/MHz, and that LPI devices are only to be used indoors. The concern we have with this approach is that the PSD of 11 dBm/MHz can only be achieved on a 20 MHz channel and as the channel size increases, the PSD will drop.

Thus, for LPI devices we propose an alternate approach of 30 dBm EIRP coupled with an 11 dBm/MHz PSD limit. This has the benefit of at least maintaining 11 dBm/MHz PSD on channel sizes up to 80 MHz which is important for in-home coverage as described in section 5.1, while ensuring incumbent services such as P2P links are not subject to PSD levels above 11 dBm/MHz on smaller channel sizes. The table below shows how this approach would work for channel sizes between 20 MHz and 320 MHz, with the attribute that limits the power in red.

Channel	EIRP	PSD
20 MHz	24 dBm	11 dBm/MHz
40 MHz	27 dBm	11 dBm/MHz
80 MHz	30 dBm	11 dBm/MHz
160 MHz	30 dBm	8 dBm/MHz
320 MHz	30 dBm	5 dBm/MHz

5.3. Power limits for 'standard' devices

The ACMA's preliminary view is not to allow so-called 'standard' devices (operating at power levels of 30 dBm to 36 dBm) in Australia. As we noted in section 2.5, demand exists for higher-powered outdoor devices for a range of use cases, and we consider it important to be able to service this demand. At the same time, incumbent service types (existing deployment and future deployment) must be protected from class licensed RLAN devices.

We recommend standard RLAN devices operating at power levels of 30 dBm to 36 dBm should be permitted in the LIPD class licence in the lower sub-band (5925-6425 MHz), with the condition that Automatic Frequency Coordination (AFC) is mandated for these devices regardless of whether the device is intended for indoor or outdoor deployment. Further, allowing standard devices that are expressly designed for outdoor deployment is a better approach than completely banning outdoor devices, as the latter simply creates an incentive for people to weather-proof LPI devices (capable of operating at 30 dBm EIRP) and deploy them outdoors with no guidance on their deployment, and no AFC mechanism. We consider the better approach is to consciously accommodate outdoor devices, and to mandate appropriate mechanisms (such as AFC) to manage interference to incumbent service types.

Please refer to section 3.3 for our views on AFC and deployment guidelines that we consider essential for any devices operating above 30 dBm, regardless of indoor or outdoor deployment.

06 Attributes for the 5 GHz RLAN for Australia

The final chapter of our submission offers our views on increasing the power limit in the 5150-5250 MHz segment, as well as opening the 5600-5650 MHz segment of the 5 GHz band for RLAN use.

6.1. Power limits in the 5150-5250 MHz band should be increased

The current 200 mW EIRP (23 dBm) coupled with a 10 dBm/MHz PSD limit for indoor use for the 5150-5350 MHz segment of the 5 GHz band is too low for good quality indoor coverage, limiting the number of usable channels in the 5 GHz band (see section 5.1 for details). However, WRC-19 Resolution 229 only provides latitude for administrations to increase the power on the lower half of this segment, i.e., 5150-5250 MHz. Resolution 229 does also propose to lift the restriction on indoor use, such that it can be used for outdoor devices (with elevation restrictions), although this is potentially of less importance than increasing the power for indoor use. We also acknowledge that the 5150-5250 MHz segment includes aeronautical radionavigation as a coprimary service and the 5250-5350 MHz segment includes Earth Exploration Satellite Service (EESS) as a coprimary service. Nevertheless, we consider the case exists to slightly lift the power levels for indoor use in the 5150-5250 MHz segment to resolve indoor coverage problems in accordance with WRC-19 Resolution 229, Resolve 3.

We propose a similar approach to our proposal for the 6 GHz band could be adopted for the 5150-5250 MHz segment of the band, namely allowing up to 30 dBm EIRP but with only a slight increase in the PSD from 10 dBm/MHz to 11 dBm/MHz. This would make wider channels (40 MHz and 80 MHz) capable of achieving the same coverage as a 20 MHz channel, as the PSD would be the limiting factor, not the total power. Under this proposal, there would be only a minimal rise in the overall PSD, as for example, one 40 MHz channel operating at 27 dBm EIRP produces the same PSD as two 20 MHz channels each operating at 24 dBm EIRP (i.e., both produce 11 dBm/MHz), and so the rise in the noise floor should be very minimal (hence no noticeable increase in interference), but the benefit to indoor coverage would be substantial, as wider channels could be used.

Our views on how the ACMA can proceed with the increase in power in the context of Resolution 229 are contained in our answer to Question 6 in Appendix 1.

6.2. Make the 5600-5650 MHz segment of the 5 GHz band available for RLAN

As per our previous submissions[25] [26] [27], we remain supportive of the ACMA's decision to offer incumbent 3.6 GHz band point-to-multipoint licensees a possible alternative in the 5.6 GHz band. To date, only 54 point-to-multipoint licences have been issued in this segment, with almost half (22) of them issued to mining operations in regional and remote locations. We remain of the view that there is an opportunity to open the 5600-5650 MHz for indoor and outdoor class-licensed Wi-Fi equipment in Australia, commensurate with the surrounding 5470-5725 MHz segment of the 5 GHz band. We consider the risk of interference from Wi-Fi devices into regional FWA services in the 5610-5650 MHz range would be small considering that the Wi-Fi services are low power, often located indoors, are likely to be more dispersed in regional areas, and (in accordance with FCC-14-30A3) are required to employ techniques such as dynamic frequency selection to avoid interfering with channels used by incumbent services.

Importantly, blocking this 50 MHz in the middle of the 5 GHz Wi-Fi band disables three of 25 x 20 MHz channels, two of 12 x 40 MHz channels, one of 6 x 80 MHz and one of only 2 x 160 MHz channels.

We request the ACMA consider making the 5600-5650 MHz segment of the 5 GHz band available for class licensed RLANs in Australia. However we recognise that technical studies would need to be undertaken to ensure incumbent 5.6 GHz band users are adequately protected.

[25] Telstra submission to ACMA consultation on "Proposed variation to the Radiocommunications Class Licence for Low Interference Potential Devices", 26 February, 2016, Item B, p.2.

[26] Telstra submission to the ACMA's consultation on "Future approach to the 3.6 GHz band", 11 August 2017, p.4

[27] Telstra submission to the ACMA's consultation on "Five year spectrum outlook 2020-2024", 24 June 2020, p12.

Appendix 1: Response to consultation questions

This appendix contains our responses to the six questions contained in the consultation paper.

1. **What is the demand for spectrum for RLAN use in the 6 GHz band (5925–7125 MHz)?**

We consider there is substantial demand for additional spectrum for RLAN use in the 6 GHz band. COVID-19 has set a 'new normal' for society including increased levels of working from home and social connection with family and friends using video calling. At the same time, increased use of higher resolution video streaming and adoption of devices such as AR/VR headsets is driving higher data rates in the home. Industrial and municipal applications such as public spaces (coverage in factories and warehouses, train stations, industrial plants, mines, etc) is also creating demand for more spectrum.

We believe there is a compelling case for the whole of the 5925-7125 MHz band to be made available for LPI and VLP RLAN devices in the LIPD class license, and the lower sub-band (5925-6425 MHz) for standard power devices where an AFC scheme is employed. We set out the evidence in support of this position in section 02 of this submission. In particular, we outline in section 2.2 how increasing the available spectrum (and hence, the number of available channels) can resolve quality of service issues in a residential setting by overcoming the "Catalyst Effect".

2. **Should the ACMA proceed, as proposed, to consult on a formal variation to the LIPD class licence that adds the frequency range 5925–6425 MHz for RLAN use, bounded by the parameters described in the ACMA's preliminary view section of this paper?**

We consider the ACMA should proceed with consulting on the formal variation of the LIPD class licence for the lower 6 GHz band as proposed. We also consider the upper 6 GHz sub-band should also be included for indoor (LPI) and very low power (VLP) RLAN use (see also our answer to question 4), such that the total range for LPI and VLP RLAN devices in the 6 GHz band in Australia would be 5925-7125 MHz. We consider there is sufficient evidence pointing to future demand for the full 1,200 MHz to be made available for RLAN use as outlined in section 02 of this submission. We also consider that incumbent service types (fixed links and FSS) as well as future possible future IMT allocation in the top 100 MHz of the band (7025-7125 MHz) can be accommodated and protected, as outlined in sections 03 and 04 of this submission respectively.

3. **If class licensing arrangements are to be made in the lower 6 GHz band (by variation to the LIPD class licence), should alternative/additional power limits and/or other conditions be considered?**

We recommend the following power limits can be introduced for RLAN devices operating in the 6 GHz band:

- **VLP devices**: We agree with and support the ACMA's proposal of 14 dBm per occupied channel with the commensurate PSD limit of 1 dBm/MHz.
- **LPI devices**: We recommend a higher EIRP than the ACMA's preliminary view can be accommodated. We recommend an EIRP of 30 dBm per occupied channel can not only be tolerated in terms of interference management, but will also be helpful in resolving indoor coverage issues currently experience by RLAN devices in the 5 GHz band (see section 5.1 for details). However, the ACMA's preliminary view of a PSD limit of 11 dBm/MHz must remain in order to

ensure protection of incumbent service types (both currently deployed and future deployment). See our answer to Question 5 and section 3.3 in the body of our submission for further details.

- **Standard Devices**: We also recommend that standard devices capable of operating up to an EIRP of 36 dBm per occupied channel should be introduced in the lower sub-band (5925-6425 MHz). We consider demand exists for this deployment scenario (see section 2.5). However, Automatic Frequency Coordination (AFC) is required on all standard devices (regardless of whether they're intended for indoor or outdoor use), and guidelines should be developed to assist with outdoor deployment to minimise the risk of interference to incumbent services. See section 3.3 for further details.

4. **Is it appropriate to consider inclusion of the upper 6 GHz band (6425–7125 MHz) in the LIPD class licence or should this be deferred to monitor future developments (for example, in the wide-area International Mobile Telecommunications (IMT) space) as outlined in the ACMA's preliminary view?**
   We invite comments from submitters on the utility of the band for IMT use.

We consider it is appropriate to introduce the upper 6 GHz band (6425-7125 MHz) for indoor (LPI) and very-low power (VLP) RLAN use now, ahead of international developments for area-wide IMT services at the top of the band (7025-7125 MHz).

We consider the band to have very good utility for IMT use. The 6 GHz band is "mid-band" spectrum, which strikes a good balance between propagation distance / building penetration (the key feature of "low-band" spectrum) and data carrying capacity (the key feature of "high-band" spectrum). As it is below 10 GHz, it is also largely immune to many atmospheric effects (e.g., rain-fade).

See also our answer to Question 2.

5. **Should standard power (that is, higher power devices, including for outdoor use) operating under a dynamic spectrum access system such as the automatic frequency coordination (AFC) system adopted in the USA, be adopted in Australia for some or all of the 6 GHz band? Is there an appetite and capability for industry to provide the necessary systems to enable such use? We welcome views and evidence on the commercial and technical feasibility of introducing AFC systems in the band.**

We consider that should standard devices be permitted under the LIPD class licence in Australia it should be mandatory that some form of dynamic spectrum access system is incorporated. We have not yet completed sufficient analysis to form a view as to whether it is the exact same system as the AFC system adopted in the USA, although recognising that it would be preferable to leverage a device ecosystem developed for a market the size of the USA, superficially we see merit in adopting the USA's AFC system to avoid the need for creating bespoke devices for the Australian market. Further consideration, however, is required, including as to whether industry should provide the system.

While the ACMA is clear in its comment that it does not propose to develop and manage a DSA/AFC system, we consider that the ACMA nevertheless needs to play a role in regulating (mandating) the use of such as system. If standard devices are to be used in an outdoor setting, we consider it is essential that an

AFC system is used, and this will require the ACMA to mandate its use. See section 3.3 in the body of our submission for further details.

6. **Should the higher power regulatory arrangements and associated interference mitigation measures added to the International Telecommunication Union (ITU) Radio Regulations at WRC-19 (see *Resolution 229 (Rev WRC-19)*) in the 5 GHz band be included in any amendment to the LIPD class licence?**

Yes, the regulatory arrangements in Resolution 229 (Rev. WRC-19) should be included in any amendment to the 5 GHz band in the LIPD class licence. Resolve 3 and Resolve 5 of Resolution 229 provide latitude for administrations to increase the power level in the 5150-5250 MHz and 5250-5350 MHz segments of the band above the levels prescribed in Resolve 2[28]. Of particular note is that Resolve 3 for 5150-5250 MHz allows administrations to allow an EIRP up to 30 dBm for indoor use, or for controlled[29] outdoor use, although Resolve 5 for 5250-5350 MHz does not make any allowance for an increase above the levels currently permitted in the LIPD class licence.

Our submission advocates for both higher powered LPI devices as well as outdoor deployment of standard devices, both up to an EIRP of 30 dBm, and we welcome the ACMA's consideration of our proposal in light of this version of Resolution 229. We do note that Resolves 3 and 5 specifically require elevation pointing restrictions to be imposed for *outdoor* deployment, and we consider this can be accommodated through deployment guidelines for outdoor deployment. We discuss possible guidelines and our willingness to assist in their development in section 3.4 in the body of our submission.

Our views on increasing the power limits in the 5150-5250 MHz segment of the band are contained in section 6.1 of our submission.

[28] Resolve 2 requires RLAN devices to be capped at a maximum mean EIRP of 200 mW (23 dBm) with a maximum density of 10 mW (10 dBm) in any 1 MHz.

[29] "controlled" requires elevation pointing restrictions to avoid the main lobe of the device pointing toward satellites.