Witness Statement

Re: Application for merger authorisation by Telstra Corporation Limited and TPG Telecom Limited for sharing of active infrastructure and spectrum in regional Australia

Statement on behalf of Singtel Optus Pty Ltd

Statement of:	**Steve Turner**
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Occupation:	Director of Spectrum Strategy and Management
Date:	20 October 2022

I, Steve Turner, of 1 Lyonpark Road, Macquarie Park NSW 2113, say:

1. I am the Director of Spectrum Strategy and Management at Singtel Optus Pty Limited (**Optus**).

2. This statement is made in relation to the application for authorisation lodged with the Australian Competition and Consumer Commission (**ACCC**) by Telstra Corporation Limited (**Telstra**) and TPG Telecom Limited (**TPG**) on 23 May 2022 (**Application**) for sharing active infrastructure and spectrum in regional Australia (**Proposed Transaction** or **MOCN arrangement**).

3. I make this statement to the best of my knowledge and belief based on over 27 years of experience in telecommunication networks, including in relation to spectrum. Except where otherwise indicated, the matters set out in this statement are based on my own knowledge. I have also directly and indirectly made enquiries of Optus employees. Where I refer to matters on the basis of information provided to me, I believe those matters to be true and correct.

4. In this statement I cover the following topics:

   (a) First, I summarise my qualifications and experience.

   (b) Second, I define terms and concepts used in this statement.

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(c) Third, I analyse relevant spectrum holdings and mobile sites currently held by each of the three mobile network operators (**MNOs**), Optus, Telstra and TPG, and the spectrum availability and site access that would result if the Proposed Transaction were to proceed. This analysis shows that with the Proposed Transaction, Telstra will have access to significantly more spectrum than Optus in the regional area.

(d) Fourth, I address impact of the significant spectrum advantage that Telstra will achieve if the Proposed Transaction proceeds, including the reasons why Optus would not, in practice, be able to mitigate that.

(e) Fifth, I explain spectrum holdings as between Optus and TPG if the Proposed Transaction did not proceed and Optus entered into an arrangement with TPG that includes spectrum sharing.

(f) Sixth, having reviewed the Applicants' response to Optus' submission dated 28 July 2022 (**Applicants' Response**), I address claims made about the utility of mid band spectrum on Telstra's network, and the ability of Telstra to utilise its currently under-utilised mid band holdings to achieve coverage and capacity in the regional area without the Proposed Transaction.

(g) Seventh, having reviewed the expert reports provided by the Applicants, in particular the Aetha report dated 27 July 2022 (**Aetha Report**), I respond to a number of matters that I regard as significant to the analysis and which, based on my experience, I consider to contain inaccuracies or errors. In my view those inaccuracies and errors make the conclusions reached by Aetha entirely unreliable.

5. In a number of parts of this statement I refer to analysis which has been performed by my team or at my instruction. That work has been primarily led by Wilson Zheng, Director of RAN Strategy. I have reviewed all analysis that is referred to in this statement and consider it to be true and correct.

1. Qualifications and Experience

6. I hold a Bachelor of Engineering (B.Eng) degree in Electronics, Communications and Computer Engineering from the University of Bradford, England.

7. I have held my current role as Optus' Director of Spectrum Strategy and Management since April 2018. In that role I report to Kent Wu Zeyi, VP, Access Network Strategy, Planning and Quality.

8. In my current role I am responsible for the following:

   (a) managing a team of spectrum experts;

   (b) providing technical expertise and advice to Optus' Regulatory, Legal and technical teams as well as senior leadership within Optus;

   (c) assessing Optus' product, commercial and network requirements for the purposes of developing and delivering Optus' spectrum strategy;

   (d) technology coordination of, and assessment of, Optus' spectrum needs;

   (e) acquiring and trading spectrum assets in accordance with business and spectrum strategies;

   (f) leading and delivering responses to consultations, technical committees and related bodies, relating to spectrum;

   (g) delivering technical and regulatory analysis and information on behalf of Optus and in support of the Australian Mobile Telecommunications Association (**AMTA**) to the Australian Communications and Media Authority (**ACMA**), the ACCC and government departments that oversee matters concerning telecommunications;

   (h) overall spectrum governance and ensuring compliance with spectrum licence conditions and other regulatory obligations;

   (i) management of interference between Optus and neighbouring spectrum users;

   (j) management of spectrum auction activities, including business case development, consultant management, spectrum valuation, bid strategies and other associated activities;

   (k) industry-wide consultation and advocacy in support of Optus' and AMTA's requirements, including in respect of a harmonised spectrum and licencing framework to support 5G and beyond.

9. I have worked in the telecommunications industry since 1995. Prior to commencing at Optus, I have held roles in the telecommunications sector including:

(a) From 2010 to 2018 I was employed by NBN Co, performing a number of different roles in wireless, fixed line, cross-domain technical and strategy functions. As the first member of the NBN Fixed Wireless team, I was responsible for the planning, governance, design, dimensioning and initial architecture of the fixed wireless network. This involved network and site dimensioning, customer experience planning, product design, link budgets, base station and network architecture, coverage assessment, site design and multiple other radio frequency (RF) functions. In the course of my role I assessed NBN's spectrum requirements and made recommendations on price, volume and geography for the acquisition of NBN's 2.3GHz and 3.4GHz spectrum holdings. I subsequently managed the Fixed Wireless Access (**FWA**) team's planning and cross-domain teams before moving to a number of differing roles in other parts of the business, culminating in the corporate strategy office where I managed the high-level planning function for non-fixed line technologies.

(b) Prior to my role at NBN Co, from 2007 to 2009 I was employed by Hutchison 3 as a technical strategist for the radio networks team. I primarily worked on general radio strategy, network features, roadmap planning and Telstra/3GIS liaison under the Hutchison and Telstra MOCN network sharing arrangement.

10. During my years in the industry I have been involved in spectrum auctions / valuation processes including:

(a) In 2000/2001 I was involved in the spectrum valuation and bid strategy support for Vodafone Australia's acquisition of 2.1GHz spectrum.

(b) In 2011-13 I managed the specification, valuation and acquisition of 2.3GHz and 3.4GHz spectrum for NBN Co's FWA network.

(c) In 2018 I managed the team responsible for valuing and acquiring regional 3.6GHz spectrum at Optus.

(d) In 2021 I managed the team responsible for valuing and acquiring metropolitan and regional mmWave spectrum at Optus.

(e) In 2021 I also managed the team responsible for valuing and acquiring national 900MHz spectrum at Optus as part of the 850/900 MHz band spectrum auction, which is sometimes referred to as the 2021 'low band' auction.

2. Relevant concepts

11. In this section I explain a number of terms and technical concepts that are relevant to the matters that I address in my statement.

12. There are a number of key terms that I refer to in my statement, which I define below:

(a) An **apparatus licence** is a type of licence that is applied for and then issued by the ACMA, allowing the applicant to operate in the band granted and at the place or in the area that it is issued for. An apparatus licence can be issued for a period of up to 20 years, but is generally renewed annually. Apparatus licences differ from spectrum licences, which would normally be auctioned on a longer term basis (up to 20 years), allowing the licensee to register and operate devices that comply with the conditions of that spectrum licence anywhere in the bandwidth and geography for which the licence is awarded.

(b) **Band** is a description of the operating band for the equipment or the network. For example, in this statement examples of 'low band' spectrum are provided in the following 'bands': 750MHz, 850MHz and 900MHz.

(c) **Bandwidth** is the amount of spectrum that a spectrum licensee holds, and is indicative of the rate at which data can be transferred between a user's device and the mobile network (that is, the more bandwidth in MHz held by an MNO, the more data can be transferred on their network).

(d) **Contiguous spectrum** means spectrum that is immediately adjacent within the same spectrum band. An example is provided in Figure 1 below showing the before and after state of the lower part of the 3.5GHz band. This is a project I led in 2019 and 2020 in my current role. The goal of that project was to defragment Optus' and NBN Co's 3.5GHz spectrum holdings so that they moved from non-contiguous to contiguous holdings.

Figure 1

(a) **FDD** stands for Frequency Division Duplex and is also known as **'paired spectrum'**. It is a technique used to send and receive data using different frequencies within the same spectrum band. Specifically, the base station transmit (UE receive) operates in a different part of the spectrum band from the

base station receive (UE transmit). There is a spectrum gap between the base station transmit and receive in terms of the parts of the band that are utilised.

(b) **LTE** stands for Long-Term Evolution technology, which is a standard used for the 4G network.

(c) **NR** stands for New Radio and is a new radio access technology for the 5G network.

(d) **Peak downlink rates and uplink rates** are a typical measure of maximum network speed. The higher the peak data rate is, the greater the network capacity and the higher the user data speed. Downlink rates relate to download capacity and speeds, while uplink rates relate to upload capacity and speeds.

(e) **SA1** as defined by the Australian Bureau of Statistics (**ABS**) means Statistical Areas Level 1. They are geographic areas designed to maximise geographic detail for the census population and, being the smallest ABS statistical area, generally have a population of about 200 to 800 people. In my view, because of the geographic detail shown in SA1s, they are helpful in showing the vast differences in population density in a geographic area. Where I have referred to SA1s in this statement to describe the regional area more broadly, I am referring to the total or aggregate SA1s that cover that area.

(f) **Sector** means the antenna(s) oriented in one direction and the area covered by that or those antenna(s). Typically a base station has three antennas which are oriented in different compass bearings or directions to serve the areas surrounding the base station. In that scenario there would be three 'sectors'.

(g) **SIO** refers to 'services in operation', and is used as a measure of the number of customers that an MNO has at any point in time.

(h) **TDD** stands for Time Division Duplex and is also known as '**unpaired spectrum**'. Unlike FDD which uses separate frequencies for transmission and reception of data on a device, TDD is a technique that sends and receives data using different time slots within the same portion of spectrum. Specifically, base transmission and reception to and from the base station (or UE) occur on the same set of frequencies but at different times to ensure that the transmit and receive signals do not collide.

(i) **UE** stands for 'User Equipment'. UE may include a mobile phone or other compatible radio device that is used by end-users to connect to the network.

(j) **WCDMA** stands for Wideband Code Division Multiple Access technology, which is a third-generation (3G) standard.

13. I describe other key concepts under subheadings below.

A. *Network attributes needed for quality service*

14. In my experience, mobile networks typically consist of the following components:

(a) Spectrum, which I describe at paragraphs 23 – 30 below. In summary, spectrum is comprised of invisible electromagnetic radiation waves, which allow devices to communicate with mobile networks. The role of spectrum in a network is to connect users to the physical network equipment and allow for data transmission. It is a finite resource. The amount and bands of spectrum held by an MNO will impact the quality of the service they are able to provide from their network.

(b) The base station or 'mobile site', which transmits and receives wireless signals to user devices from a single physical location. A base station achieves this through several components including antennas, radio units and base band subsystems, and connects to the core network via the transmission networks. A single network will generally comprise many base stations. For example, the respective networks of Optus and Telstra each consist of several thousand base stations.

(c) Radio access networks (**RAN**) are a major component of a wireless telecommunications system. They connect individual devices to other parts of a network through a radio link.

(d) Core networks, which are a central part of the overall mobile network that allows subscribers to get access to the services that they are entitled to use. The core network is responsible for critical functions such as subscriber profile information, location, service authentication and necessary switching tasks. The RAN will connect into and through the core network via the transmission network.

(e) Transmission networks (also referred to as backhaul networks) which generally connect the RAN to the core network, transport user data and control information.

15. From a technical perspective, I consider there to be three key elements required in order to deliver a quality service over a mobile network.

16. The first element is **'coverage'**, being the geographic area over which a network is capable of delivering a service. I have read the Application and understand that the Proposed Transaction primarily relates to a zone referred to as the 17.4% population zone.

17. For the purposes of considering the Application, the Applicants' Response and the Aetha Report, and preparing my statement, I consider that mobile coverage across Australia can be divided into the following 'zones':

(a) **Metropolitan zone** covering metropolitan and major suburban areas. Around 81% of the population is serviced by MNOs in this area. Optus has coverage across this zone.

(b) **Regional coverage zone** or **'RCZ'** covering regional and fringe urban areas. 17.4% of the population is serviced by MNOs in this area. Optus has coverage across the majority, but not all of this zone. I understand based on the Application that the Proposed Transaction relates primarily to this zone. Where I refer to the RCZ in this statement it is based on my estimate of what that area covers, as I am not privy to the precise geographic boundaries of the Proposed Transaction. I also refer to the RCZ in parts of this statement as the 'regional area'.

(c) **Rural and remote zone** covering rural and remote areas. I understand that Telstra has exclusive coverage in this zone. Less than 1% of the population is covered by this zone. Optus has no coverage in this zone.

18. The second element is **'capacity'**, being the total amount of data (or 'network traffic') that can be transmitted over the network at any point in time. A lack of capacity can lead to what is commonly referred to as 'network congestion' and can impact both the ability of a user to connect to the network and the speeds achievable on a network once a connection is established.

19. The third element is '**capability**' or '**speed**', being the speeds that can be achieved on the network. The speeds achievable on a network are, in part, dependent on the ability of the network to deliver capacity and coverage where customers need it. The network capability or 'speed' is typically measured by the peak data rate of a sector aggregated across the network. The peak sector data rate is calculated by multiplying the spectrum bandwidth available to an MNO (MHz) at a site, by the peak spectral efficiency (bps/Hz) for each spectrum band available, and aggregating that across all the spectrum bands to the specific sector per site level. The result shows the peak data rate of a single sector on the base station. The peak data rate for multiple sectors can then be aggregated to show the peak data rate for an entire base station or region on that network.

20. The higher the sector peak data rate, the greater the network capacity and therefore the speeds achievable for customers in the area served by that sector.

21. The ability of an MNO to deliver on each of the above three elements will impact the quality of service that can be provided to customers across that MNO's mobile network.

22. The coverage, capacity and capability achievable by a mobile network is dependent on a mix of the number and location of mobile sites (including the types of equipment used on

those sites), the technologies deployed and the amount of spectrum, at varying ranges, that an MNO has access to. I expand on these factors below.

B. Spectrum and how it impacts service quality

23. Spectrum is comprised of invisible electromagnetic radiation waves. These waves allow mobile phones and other devices to communicate with mobile networks. Without spectrum, mobile phones and other devices cannot connect to mobile networks.

24. There is not an infinite amount of spectrum. Spectrum is a limited and valuable resource. As a result, the right to transmit signals over particular spectrum bands is licensed by government pursuant to telecommunications and radiocommunications regulatory frameworks. The ability to use spectrum can be obtained through:

    (a) An auction process that is overseen by the ACMA. Depending on the particular regulatory arrangements and rules concerning a particular auction, MNOs typically bid for spectrum at the national, metropolitan and regional levels.

    (b) Applying to the ACMA for an apparatus licence (defined at paragraph 12(a) above).

    (c) Offers on the secondary market where MNOs may on-sell rather than deploy spectrum they hold on their own network.

    (d) Third party authorisations, where one licensee grants another permission to use all or part of their spectrum to provide services. An example of this is the existing arrangement between Telstra and TPG in the 3.5GHz band, where TPG has authorised Telstra to use some of its spectrum in several capital cities (based on publicly available information in ACMA's Register of Radio Locations (RRL) database).

25. Typically, large amounts of spectrum are acquired through the auction process described at 24(a) above, although it is not uncommon for spectrum to be acquired by apparatus licence or for licensees to exchange and loan smaller amounts of spectrum, often in geographically constrained areas, using the other mechanisms I described above.

26. Spectrum and apparatus licences are subject to geographical licence boundaries. This means that spectrum can only be used in the geographical areas stipulated in the licence. In some instances that geographical area is Australia-wide. Typically, however, it is limited to a particular region. Regardless of the way in which any spectrum is acquired, all conditions associated with a licence for a portion of the spectrum (including licence boundaries) remain in force.

27. At a general level, the potential capacity and speed of a mobile network may be increased by acquiring more spectrum. Where everything else is equal, more spectrum will enable a network to have greater capability and capacity. However, the spectrum layering that each MNO chooses to apply at mobile sites will impact the variability in capacity and speed that customers experience in the areas serviced by those sites.

28. The reason for this is because spectrum exists in a number of megahertz (**MHz**) ranges. Those ranges are commonly categorised as 'low band', 'mid band' or 'high band', with each category having different attributes:

(a) **Low Band** is generally used to describe spectrum bands below 1GHz (i.e. 700MHz, 850MHz, 900MHz). Low band spectrum can carry signals over larger distances than mid band or high band spectrum, making it particularly useful in sparsely populated regional areas where signals may be required to travel further between mobile networks and devices. By using lower band spectrum, fewer sites are required to provide coverage over an area relative to the number of sites required when using mid or high band spectrum. Low band spectrum generally also provides better in-building penetration compared with mid or high band.

However, while having more low band spectrum can better an MNO's 'worst possible performance' in terms of capacity and speeds, it does not enable the same speeds and capacity as higher bands that do not travel as far. That is because there is generally more spectrum available for use at higher frequencies and, in my experience, MNOs tend to build sites using that higher frequency spectrum closer to population centres where there is a demand for capacity.

(b) **Mid Band** is generally used to describe spectrum above 1GHz and below 6 GHz (1,800MHz, 2,100MHz, 2,300MHz, 2,600MHz, 3.5GHz, 3.6GHz). While mid band spectrum does not carry signals as far as low band spectrum, it does carry signals further than high band spectrum. Mid band achieves higher capacity and speeds than low band but less than high band spectrum.

Mid band spectrum is an important ingredient when seeking to increase network capacity in regional areas in circumstances where mobile sites are close enough to populated areas for the mid band spectrum to carry or travel to those areas.

For example, Optus' live network statistics in regional Australia show that mid band spectrum in the 1,800MHz and 2,100MHz bands can serve customers in a range of up to 6.6km-14.5km from network sites, and spectrum in the 2,600MHz band can provide network capacity for customers in a range of 3.5km-6.6km from relevant sites in regional areas. Approximately [redacted] of Optus' regional mobile regional customers are within 6.6km of relevant sites. This is illustrated in Figure 2

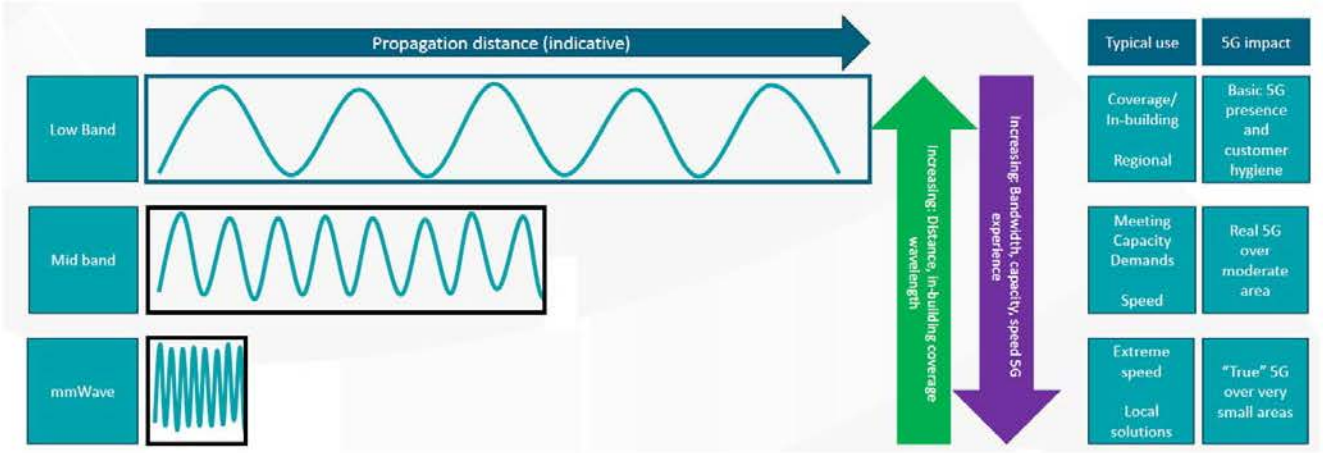
below, which I instructed my team to prepare using Optus' live network statistics and 3GPP timing advance measurements. 3GPP timing is a measure of the time taken for a signal to travel from a mobile site to a mobile device. This can be used to calculate the distance from the mobile site to that device.

[redacted]

(c) **High Band** is generally used to describe spectrum bands above about 13GHz (e.g. 26Ghz spectrum) and is otherwise known as mmWave spectrum. High band spectrum does not travel as far as mid band spectrum, but has more capacity and can deliver faster speeds due to the very high bandwidths available.

29. To summarise, as the frequency of spectrum in use increases, it achieves less geographical coverage but can sustain greater volumes of user traffic (capacity) and achieve greater speeds (capability) due to the availability of larger bandwidths at those higher frequencies. Figure 3 below shows the benefits of the various spectrum bands as described above.

Figure 3



30. As a result of the attributes of particular spectrum bands, in my experience, a 4G and 5G network in regional areas currently benefits from a mixed holding of low and mid band spectrum. Low band spectrum assists in resolving coverage problems, as well as capacity issues at the edge of the network (ie for customers who are connected to the network exclusively on low band spectrum). In areas of extreme demand, there may be instances in the regional area where the deployment of mmWave spectrum is necessary to meet customer expectations, but this has not yet been observed by Optus. Based on my experience and understanding, the main spectrum for achieving capacity and capability for the provision of 5G in regional areas is expected to be mid band 3.5GHz spectrum due to its combination of relatively high bandwidth and adequate propagation characteristics. I address the ability of mid band spectrum to service densely populated regional areas later in this statement.

C. Contiguous spectrum and carrier aggregation

31. Capability and capacity can be improved by access to more spectrum, particularly at higher bandwidths. That is particularly the case where an MNO holds contiguous spectrum in a single band, because the spectrum can 'bind' together and achieve a greater overall bandwidth to be deployed in the relevant area. If spectrum is not contiguous then the acquisition of more spectrum may increase capacity but not necessarily capability.

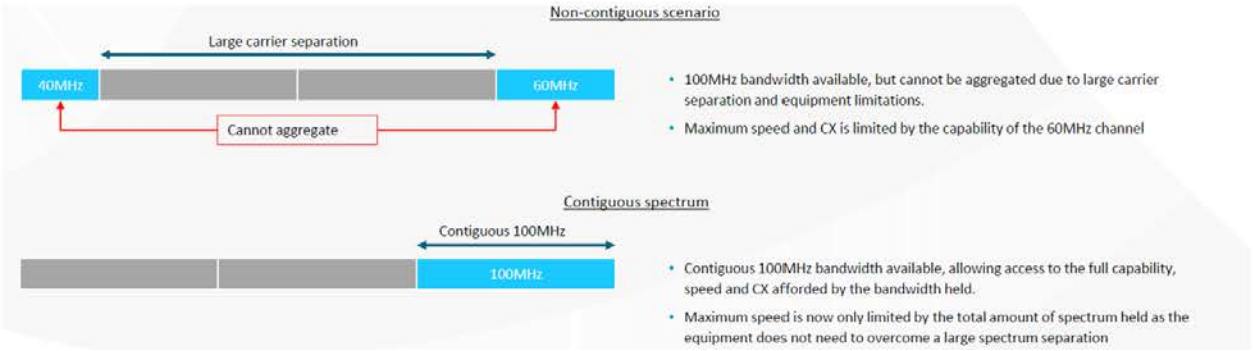
32. Where an MNO does not hold contiguous spectrum in a band and, if the separation between the holdings is large enough, more equipment may be needed on its base stations to aggregate the spectrum and achieve similar speed and capacity outcomes. For some bands it is not possible to aggregate spectrum at all where the separation between holdings is large

33. The process by which spectrum is bound together is referred to as '**carrier aggregation**'. Carrier aggregation is a technique that combines and simultaneously makes available to a user, different frequency bands within the same sector on a base station to increase the total spectrum bandwidth to serve a mobile user.

34. Carrier aggregation is easier to achieve with 4G technology (where the maximum carrier bandwidth is 20MHz) than it is with 5G (which is delivered on carrier bandwidths of 100MHz and above) due to the breadth of frequency ranges within a band, and limitations of the equipment involved in 5G technology. It is very difficult to achieve carrier aggregation on 5G if the bandwidth channels are far apart, which is why

contiguous bandwidth in 5G is, in my view, crucial in order to maximise speed and customer experience. This is illustrated in Figure 4 below.

Figure 4



35. Further, the effectiveness of carrier aggregation depends on the capability of both the network and the end user devices, as not all mobile devices can support aggregated spectrum. That means having contiguous spectrum also improves the likelihood of any given user being able to take advantage of the additional speed that the extra spectrum enables (when compared to the delivery of a service that relies on carrier aggregation).

36. One further disadvantage of carrier aggregation over access to contiguous spectrum is that carrier aggregation involves additional system overheads in terms of computational power. The process of aggregating also marginally reduces the spectral efficiency. For that reason, holding contiguous bandwidths of spectrum creates cost efficiencies.

3. Spectrum holdings and site access with and without the Proposed Transaction

37. Below I set out the spectrum holdings of each MNO with and without the Proposed Transaction. As the Proposed Transaction does not involve high band spectrum sharing, in this section I focus on spectrum holdings in the low band and mid band ranges.

38. In the course of reviewing the Application, the Applicants' Response and the Aetha Report, and though my involvement in preparing and verifying certain parts of Optus' submission to the ACCC dated 27 June 2022 (**Optus' Submission**), I have identified that parties have, at different times, referred to differing spectrum holdings.

39. There are a number of reasons for these differences, some of which I point out below. However, I consider that these differences are minor and do not have any material impact on the matters that I refer to in this statement, including deficiencies that I refer to in the Aetha Report. I consider that if the Proposed Transaction proceeds, it will increase the spectrum that is accessible to Telstra. The effect will be to place Telstra in a dominant position to service customers in the RCZ that, in my view, Optus will be unable to match.

40. For completeness, some of the minor differences in spectrum holdings which have been referred to include the following:

    (a) Optus' 900MHz (national licence), in particular:

        (i) 2 x 25MHz is what Optus will hold from 1 July 2024 and be able to use (almost) all of from 18 June 2028.

        (ii) 2 x 20MHz is the realistically useable amount for a full NR carrier up to 18 June 2028 unless Optus agrees on an early downshift arrangement with Telstra and TPG.

    (b) Telstra 2,100MHz in regional and remote areas, in particular:

        (i) 2 x 10MHz spectrum licenced holdings, which Aetha has referred to.

        (ii) An additional 2 x 10MHz accessible to Telstra under an apparatus licence which Aetha omitted, but which Optus has included in its calculations.

41. I also note at this point that the Applicants' Response at [69] suggests that the calculation presented at paragraph [5.47] of Optus' Submission treated TPG's 1,800MHz spectrum as forming part of the Proposed Transaction. I was involved in preparing that analysis and verify that it did *not* consider TPG's 1,800MHz as part of the MOCN arrangement.

42. As I describe below, in my experience the true advantage that can be achieved by competing MNOs through spectrum access depends not only on total spectrum holdings, but also the areas in which that spectrum can be used and on access to mobile sites. Overall spectrum holdings are, however, an important measure of an MNO's ability to provide service quality because:

(a) the greater the amount of spectrum held, the greater the capacity and speed achievable by each mobile site in the area where that spectrum is licensed for use; and

(b) spectrum is a finite resource, and so, unlike mobile sites, which subject to capital expenditure constraints can be built or upgraded at any time, there are fixed limits on how much spectrum can be accessed by any one MNO at a particular time.

For these reasons, MNOs view spectrum as a key strategic asset. In my experience, Optus uses overall spectrum holdings as a key indicator of how competitive it can be.

43. This section shows the spectrum advantage that Telstra already enjoys, and which will increase should the Proposed Transaction proceed. While the Applicants' Response provides that Telstra does not have the rights of use and control over TPG spectrum through the Proposed Transaction (at [58]), in my view, Telstra stands to gain more out of the spectrum pooling. That is because, according to their own SIO figures, Telstra services approximately 70% of the regional area, whereas TPG only serves approximately 6%. In my view that means the additional spectrum under the MOCN arrangement will largely be to Telstra's benefit.

A. Low band spectrum

44. Table 1 shows the amount of low band spectrum currently held by each of Optus, Telstra and TPG in regional areas (noting some of it is not accessible until a later point in time which is identified in the note below). I have sourced this data from the ACMA.

Table 1

MNO	700MHz	850MHz	900MHz	Total
Optus	2 x 10MHz		2 x 25MHz*^	2 x 30MHz
Telstra	2 x 20MHz	2 x 25MHz*		2 x 45MHz
TPG	2 x 15MHz	2 x 5MHz		2 x 20MHz

* Optus' 900MHz and 2x10MHz of Telstra's 850MHz spectrum is available post June 2024. The lower 5MHz block in the 900 MHz band cannot be fully utilised until downshift occurs, which is currently mandated for 2028.

^ Only 2 x 20MHz of this 900MHz Optus spectrum can be fully utilised prior to downshift occurring (currently mandated for 2028). Until that point the lower 5 MHz of this 900MHz spectrum cannot be fully utilised.

45. Table 2 shows useable low band spectrum access in regional areas if the Proposed Transaction proceeds. The pooled spectrum indicates spectrum available to both TPG and Telstra, and the spectrum listed separately against TPG and Telstra shows spectrum that each MNO will retain after the Proposed Transaction for their exclusive use. I have prepared this table using information sourced from the ACMA and the Application.

Table 2

MNO	700MHz	850MHz	900MHz	Total
Optus	2 x 10MHz		2 x 20MHz**	2 x 30MHz
Telstra		2 x 10MHz*		2 x 10MHz
TPG	2 x 5MHz^*			2 x 5MHz
Pooled	2 x 30MHz	2 x 20 MHz		2 x 50MHz

^cannot be used for public mobile services.

* Spectrum that is retained for exclusive use by Telstra / TPG post MOCN.

** The lower 5MHz block in the 900 MHz band cannot be fully utilised until downshift occurs, which is currently mandated for 2028.

46. The access that Telstra will have to low band spectrum in regional areas with the Proposed Transaction will mean that Telstra's low band spectrum access will:

    (a) represent 66% of all available low band regional spectrum - Optus will have 33%, and TPG will have access to 55%;

    (b) increase from 1.3 to 1.7 times Optus' spectrum holdings.

47. Telstra's access to a significant pool of additional low band spectrum will provide additional capacity and capability for LTE, meaning that it can service higher speeds with the Proposed Transaction as a result of access to contiguous 2 x 30MHz spectrum in both the 700MHz and 850MHz bands (see Figure 8 below which addresses TPG / Telstra contiguous spectrum). This is compared to Optus' 2 x 10MHz at 700MHz as well as 2 x 20MHz at 900MHz which is accessible after July 2024 and increasing to 2 x 25MHz in 2028.

B. Mid band spectrum

48. Table 3 shows the amount of mid band spectrum currently held by each of Optus, Telstra and TPG in regional areas

Table 3

MNO	1800MHz*	2100MHz	2.6Ghz	3.5GHz**	Total
Optus	2 x 20-25MHz	2 x 15MHz^	2 x 20MHz	30-35MHz***	140-155MHz
Telstra	2 x 40MHz	2 x 20MHz	2 x 40MHz	50-80MHz	250-280MHz
TPG	2 x 10-15MHz	2 x 15MHz		20-40MHz	80-100MHz

* Varies by regional area

** 3.5 GHz refers to the 3400 – 3700 MHz range.

*** excluding Regional WA due to restrictions of use.

^ The spectrum holdings for each of Telstra and Optus in the 2,100MHz band include the 2 x 10 MHz apparatus licences held by each MNO that are acquired on a year-by-year payment arrangement

49. Table 4 shows useable mid band spectrum access in regional areas if the Proposed Transaction proceeds. The pooled spectrum indicates spectrum available to both TPG and Telstra, and the spectrum listed separately against TPG and Telstra shows spectrum that each MNO will retain after the Proposed Transaction for their exclusive use. This table was prepared using information sourced from the ACMA and the Application.

Table 4

MNO	1800MHz*	2100MHz	2.6Ghz	3.5GHz**	Total
Optus	2 x 20-25MHz	2 x 15MHz^	2 x 20MHz	30MHz***	140-155MHz
Telstra	2 x 40MHz				80MHz
TPG	2 x 10-15MHz				20-30MHz
Pooled		2 x 35MHz	2 x 40MHz	90-120MHz***#	240-270MHz

* Varies by regional area

** 3.5 GHz refers to the 3400 – 3700 MHz range.

*** excluding Regional WA due to restrictions of use.

^ The spectrum holdings for each of Telstra and Optus in the 2,100MHz band include the 2 x 10 MHz apparatus licences held by each MNO that are acquired on a year-by-year payment arrangement.

The areas where Telstra hold 50MHz of 3.5GHz spectrum are geographically different from where TPG holds 20MHz spectrum, making the minimum of this range 90MHz.

50. The access that Telstra will obtain to mid band spectrum in regional areas if the Proposed Transaction proceeds will mean that Telstra's mid band spectrum holdings will increase from 1.9 to 2.3 times Optus' spectrum holdings.

51. As set out above, spectrum holdings are subject to licence boundaries that determine where the spectrum can be used. Table 5 below outlines the position of the MNOs in relation to 3.5GHz spectrum by region with and without the Proposed Transaction. It demonstrates the extent of the difference between the Applicants and Optus that would result if the Proposed Transaction proceeds in relation to 3.5GHz spectrum.

Table 5

Region	Optus	Telstra	TPG	MOCN Pooled	% difference with Optus
Launceston	35	82.5	40	122.5	250%
Regional NSW	30	65	30	95	216%
Regional VIC	35	50	40	90	157%
Regional SE QLD	35	50	40	90	157%
Regional QLD	30	50	40	90	200%
Regional SA	30	75	20	95	116%
Regional TAS	35	50	40	90	157%
Regional WA – West	65	80	45	125	92%
Regional WA – East	65	80	45	125	92%
Regional WA - Moora	0	80	45	125	92%

52. The impact of Telstra's access to significant amounts of mid band spectrum with the Proposed Transaction was described at paragraph [5.27] of Optus' Submission. I have reviewed paragraph [5.27] and consider it to be accurate. It provides that:

'...access to a disproportionate amount of mid band spectrum means that Telstra is able to outperform any competition on a capacity basis without the need to invest in expensive spectral

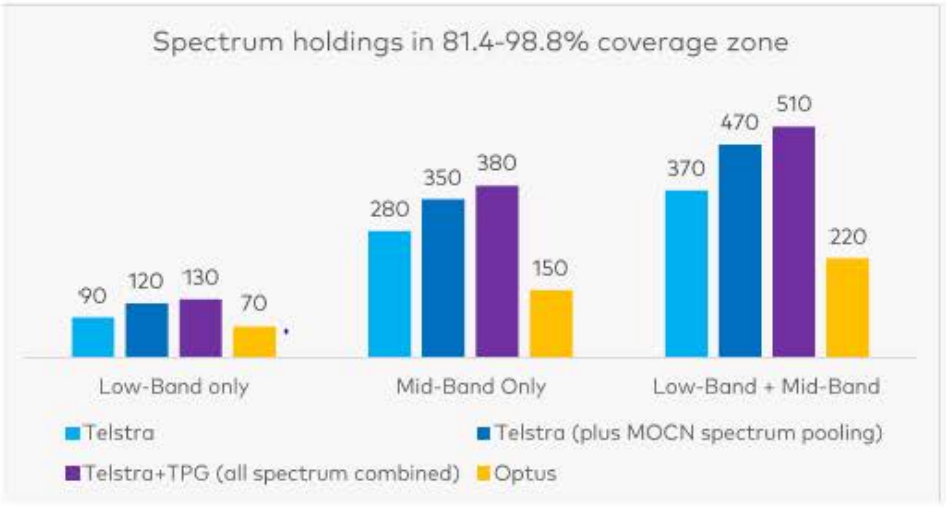
efficiency equipment. Even if Optus or other new entrants had the will and ability to invest in new mobile infrastructure to challenge Telstra's position, they would not be able to deliver the same network quality (nor achieve similar unit cost levels) as spectrum is not available.'

53. Access to a disproportionate amount of 3.5GHz spectrum in particular, provides an advantage in respect of regional 5G roll out because the superior bandwidths will mean that Telstra will enjoy a very significant speed advantage on 5G in this band. That advantage will make it impossible for Optus to compete in regional areas in relation to 5G speeds.

C. *Total low band and mid band spectrum holdings*

54. I instructed my team to prepare Figure 5. It shows the total low and mid band MNO spectrum holdings in the RCZ, including spectrum holdings accessible to Telstra if the Proposed Transaction proceeds. It is expressed in MHz held by each MNO within the bands of spectrum noted.

Figure 5



55. As set out in Table 6 below, Telstra currently holds 1.7 times the combined low and mid band spectrum holdings of Optus in regional areas (1.3 times in low band spectrum and 1.9 times in mid band spectrum). If the Proposed Transaction proceeds, using the spectrum figures in Tables 1 to 4 above, I calculate that this will increase to 2.1 times Optus' low and mid band spectrum holdings. In circumstances where Telstra already holds a considerable spectrum advantage, access to this additional spectrum would further strengthen Telstra's dominant spectrum holdings in the RCZ.

Table 6

Comparative spectrum bandwidth ratio

Spectrum Bands	Telstra vs Optus	Telstra (MOCN spectrum pooling) vs Optus	Telstra & TPG (all spectrum combined) vs Optus
Low Band only	1.3	1.7	1.9
Mid Band Only	1.9	2.3	2.5
Low Band + Mid Band	1.7	2.1	2.3

56. Based on the holdings and pooled spectrum identified in Tables 1 to 4 above, if the Proposed Transaction proceeds, Telstra will have access to combined spectrum totalling around 65% of the regional spectrum available in Australia (across all spectrum bands). Telstra's current spectrum holding accounts for around 46% of all the regional spectrum available in Australia (across all spectrum bands).

57. As I set out above, spectrum is a key strategic asset which drives significant advantages to its holder. All else being equal, the MNO with the largest quantity of spectrum will be able to offer the best network quality to its users. Accordingly, where spectrum holdings are significantly skewed, in my experience, this impacts the ability of MNOs to compete effectively.

D. How Telstra and Optus currently use their low and mid band spectrum holdings

58. Table 7 below illustrates Optus' spectrum usage as at April 2022. As Optus has now largely completed a 3G spectrum re-farm, Optus currently uses its regional low and mid band spectrum as follows:

(a) 700MHz, used exclusively for 4G.

(b) 900MHz, currently used for 3G (and some 4G) under PTS licences enabling 2 x 8.4MHz nationally and planned to be used for 5G in areas where early access can be obtained.

(c) 1,800MHz, used for 4G technology only.

(d) 2,100MHz, used predominantly for 4G, with some limited 5G use.

(e) 2,600MHz, used for 4G.

(f) 3.5GHz, used for 5G only.

Table 7

Optus's Spectrum Bands	Spectrum Available (unit: MHz)	# of Macro Sites Spectrum Available [1]	# of Macro Sites Spectrum Installed by Optus (April 2022)			
			WCDMA	LTE	NR	Total (% to available sites)
700MHz (FDD, paired)	20	2274		2239		2239(98.5%)
900MHz (FDD, paired)	16.8(Current)/ 50(Y2024)	2274	2244			2244(98.7%)
1800MHz (FDD, paired)	50	2029		766		766(37.8%)
2100MHz(FDD, paired)	30	2090	698	390	46	842(40.3%)
2600MHz (FDD, paired)	40	2274		1011		1011(44.5%)
3500MHz(TDD, unpaired)	30	2119			2	2(0.1%)

Note: 2100MHz may have multiple technologies deployed on a same site, so the total site count is less than the sum of all technology units

59. Table 8 below shows that Telstra, to the best of my knowledge, currently uses its regional low and mid band spectrum as follows:

(a) 700MHz, used exclusively for 4G.

(b) 850MHz, used primarily for 3G.

(c) 1,800MHz, used for 4G only.

(d) 2,100MHz, used predominantly for 4G with some limited 3G use.

(e) 2,600MHz, used for 4G and 5G.

(f) 3.5GHz, used for 5G only.

Table 8

Telstra's Spectrum Bands	Spectrum Available (unit: MHz)	# of Macro Sites Spectrum Available [1]	# of Macro Sites Spectrum Installed by Telstra [2]			
			WCDMA	LTE	NR	Total (% to available sites)
700MHz (FDD, paired)	40	3752		3369		3369 (89.8%)
850MHz (FDD, paired)	50 [3]	3752	3248		425	3673 (97.9%)
1800MHz (FDD, paired)	70-80	3065		1013		1013 (33.1%)
2100MHz(FDD, paired)	40 [4]	3752	38	327		365 (9.7%)
2600MHz (FDD, paired)	80	3752		364	30	394 (10.5%)
3500MHz(TDD, unpaired)	50-82.5	3250			442	442 (13.6%)

Note 1: Macro site count is calculated by Optus based on RFNSA site data information (April 2022), public ACMA spectrum boundaries and Telstra wholesale coverage map: https://www.telstrawholesale.com.au/products/mobiles/coverage.html
Note 2: Spectrum installed is based on RFNSA site data information (April 2022). Telstra does not install the full spectrum bandwidth in some mid-bands based on Optus drive testing report
Note 3: This includes Telstra's Extended 850 MHz Band (804-814MHz/849-859MHz) which Telstra won at the auction in 2021 and will be available from July 2024
Note 4: 2100MHz apparatus licenses are included

E. Regional site access with and without the Proposed Transaction

60. As I have identified above, the quality of a network depends not only on spectrum holdings, but also how those spectrum assets interact with the number and location of mobile sites that an MNO has access to, and the technology installed at those sites.

61. Typically, there are three types of mobile sites:

(a) Macro sites, which are the first sites MNOs generally build in a new area. They provide base line coverage and capacity, with additional macro sites added when needed for capacity purposes (ie neighbouring macro sites are located at or near congestion where upgrade paths on existing macro sites have been exhausted).

(b) Small cells (also known as micro cells) which are closer to the ground than macro sites and are generally designed to relieve pressure on macro sites by soaking up capacity.

(c) In-building cells (**IBC**), which assist with solving coverage problems deep inside buildings.

62. Telstra has the most sites in the RCZ of all the MNOs. Table 9 shows the mobile sites that each MNO has access to with and without the Proposed Transaction. These figures are drawn from Optus' own data and information provided in the Application.

Table 9

MNO	Without Proposed Transaction	With Proposed Transaction
Optus sites	2,374 (comprised of 2,274 macro sites and 100 IBC / small cells)	2,374
Telstra sites	3,930 (comprised of 3,752 macro sites and 178 IBC / small cells)	4,099 (access to around 169 TPG sites primarily inside the RCZ)
TPG sites	737 (comprised of 727 macro sites and 10 IBC / small cells)	4,099 (access to 3,930 Telstra sites and transfer 169 sites to Telstra in the RCZ as a result of the Proposed Transaction)

63. Telstra has a number of cost and time-based advantages in terms of its total number of mobile sites and their location in regional areas. My understanding, based on publicly available information, is that those advantages include:

(a) Telstra's history as a former state-owned enterprise which was the first to roll out telecommunications infrastructure.

(b) Significant government funding it has received for regional mobile sites.

(c) Unlike Optus, Telstra does not have Huawei equipment on base stations. As a result of the government's decision to ban Huawei RAN equipment, Telstra has obtained a time and cost advantage over Optus in not having to replace Huawei equipment to provide 5G services. This is because Telstra did not use Huawei equipment in its 4G roll out. For completeness, TPG faces the same issue in terms of Huawei RAN equipment.

64. These advantages have contributed to Telstra having more sites and in more optimal locations than Optus, to serve the RCZ. Combined with Telstra's spectrum dominance, including if the Proposed Transaction proceeds, Telstra's regional network will be able to achieve greater coverage, capability and capacity in the RCZ than any other MNO. I consider that the spectrum advantage that Telstra will achieve if the Proposed Transaction proceeds will make it near impossible for Optus to compete effectively.

4. Telstra's spectrum advantage from the Proposed Transaction

65. I have described above that Telstra is already in a dominant position in regional areas, both in terms of the number of sites and the amount of low and mid band spectrum it holds. In combination, the impact of the Proposed Transaction will be to significantly enhance Telstra's ability to provide better capacity and speeds to customers in regional areas.

66. The additional low band spectrum available as part of the Proposed Transaction will provide Telstra with larger baseline capacity and capability (or capacity and capability at the edge of the network). That is due to the 2 x 50MHz combined 700MHz and 850MHz spectrum that Telstra will have access to with the Proposed Transaction. That has the potential to increase to 2 x 60MHz should the Proposed Transaction be modified to include the additional 2 x 10MHz of 850MHz spectrum acquired by Telstra in 2021. By contrast, Optus will have access to a combined 2 x 30MHz useful low band spectrum until 2028 and 2 x 35MHz thereafter (using 700MHz and 900MHz bands).

67. Until 2028, this means that Telstra customers could, if attached to low band spectrum only, enjoy a capacity and speed advantage of 100% over Optus'. After 2028 that advantage could still be 71%. These percentages assume that Telstra gains access to its 850MHz extension spectrum at or before 1 July 2024 and Optus makes full use of its lower 5MHz block of 900MHz spectrum only after 2028.

68. My team was involved in preparing analysis to consider the impact of the Proposed Transaction on Telstra's ability to deliver better capacity and speeds in regional areas. My team prepared Figures 6 and 7 below which show the downlink and uplink sector peak data rates of each MNO in the regional area calculated based on industry practice. In particular, those calculations were arrived at in accordance with the following:

    (a) With respect to 4G, Chris Johnson, *Long Term Evolution In Bullets* (2nd Ed), 2012.

    (b) With respect to 5G, Harri Holma, Antti Toskala, Takehiro Nakamura, *5G Technology 3GPP New Radio, 2020*.

69. The following assumptions were also made in preparing Figures 6 and 7, which I regard as reasonable:

    (a) In 5 to 10 years, all MNO mid band holdings will be utilised to deliver 5G services. The low band holdings on which 4G services are currently being delivered (ie, Telstra and Optus 700MHz and TPG 850MHz) will not be re-farmed.

    (b) MNO spectrum holdings post-July 2024 are used in these figures, including spectrum acquired in the course of the 850/900MHz low band spectrum auction.

70. The analysis shows that with access to additional spectrum through the Proposed Transaction, Telstra has the potential to increase its:

(a) downlink peak sector data rates on low and mid band spectrum combined in the regional area from 1.8 times that of Optus' currently, to 2.4 times that of Optus; and

(b) uplink sector peak data rates on low and mid band spectrum combined in the regional area from 1.6 times Optus' currently, to 2 times that of Optus.

Figure 6

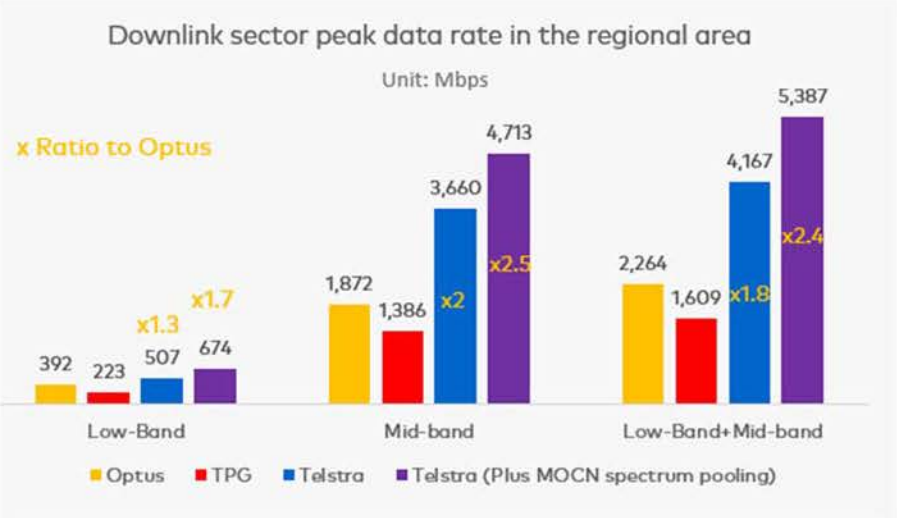
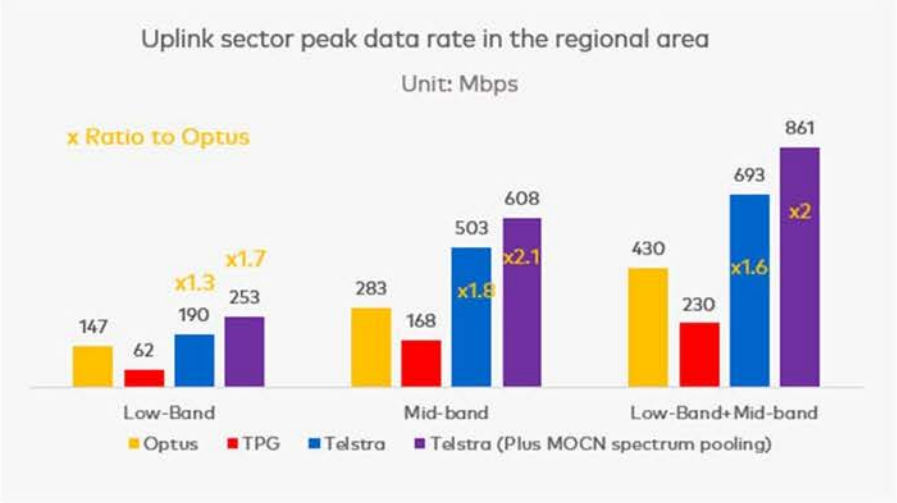


Figure 7

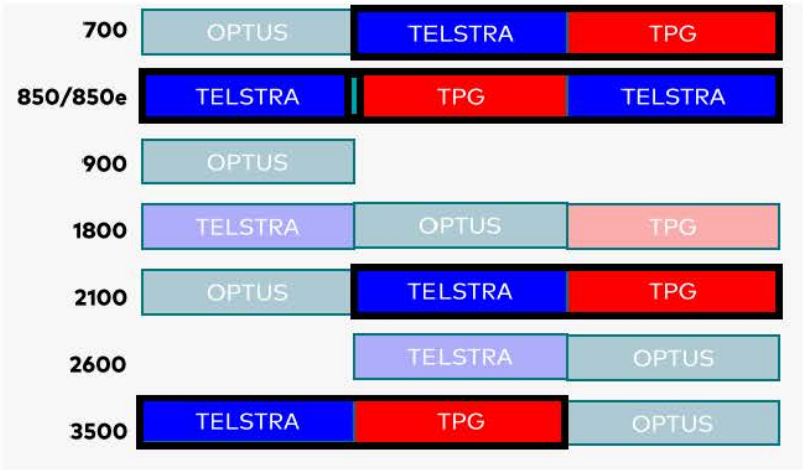


71. The in-band adjacency of the pooled MOCN spectrum assets is a factor that further impacts what can be achieved with those assets. As I set out at paragraph 36, it is more cost effective to combine contiguous than non-contiguous spectrum. Combining in-band adjacent spectrum holdings enhances the potential capacity and speed benefits that

Telstra would gain from the Proposed Transaction for reasons I have already described above.

72. TPG and Telstra have several contiguous regional spectrum bands. This is reflected in the high level illustration in Figure 8 below.

Figure 8



73. The contiguous spectrum of Telstra and TPG in the 3.5GHz spectrum band will be particularly useful for the delivery of 5G services in regional areas if the Proposed Transaction proceeds. This is because the 3.5GHz spectrum band provides the necessary channel bandwidth to deliver the high speeds and low latency necessary for 5G technology, as per my earlier explanation of capability and customer experience. As the table at paragraph 48 illustrates, Telstra already has a significant share of the 3.5GHz spectrum band in regional areas (40%-52%), and the magnitude of Telstra's share of 3.5GHz will only increase through pooling under the Proposed Transaction (to 72%-78%). I also describe later in my statement, the utility of mid bands such as 3.5GHz in the regional area.

74. As a result of such substantial spectrum holdings, especially when those holdings are contiguous and in the absence of further 'native' 5G bands (i.e. 3.5GHz, which was structured for 5G compatibility), no competitor will be able to provide equivalent 5G capacity (due to total available bandwidth) or speed (due to total contiguous bandwidth). This will substantially impact the ability of other MNOs to compete with Telstra because capacity and speed are almost linear functions of the spectrum bandwidth (they improve as the bandwidth increases).

75. Assuming full deployment of spectrum holdings, a competing MNO would, in my view be unable to meaningfully compete with a TPG-Telstra pooled network on capacity and speed due to the sheer imbalance in the holdings. In the absence of sufficient spectrum holdings (which as I have described is a finite resource), the only way to compete would

be to build additional infrastructure which is time consuming, costly, and based on my experience and understanding, difficult for Optus to justify in regional areas where Telstra is already at a significant advantage.

76. To illustrate this, I instructed my team to prepare a similar comparison to those above, but in respect of 5G 3.5GHz and 3.6GHz peak data rates only. Specifically Figures 9 and 10 below compare the downlink and uplink sector peak data rates of those bands between Optus, Telstra and the proposed MOCN arrangement, using the same industry references noted at paragraph 68. The results show that Telstra already has a 2.6 times speed advantage over Optus in the regional area on 3.5GHZ/3.6GHz spectrum. With the Proposed Transaction, that will increase, with Telstra gaining the potential to achieve approximately 4 times the peak data rate of Optus in terms of downlink and uplink peak sector data rates in the regional area.

Figure 9

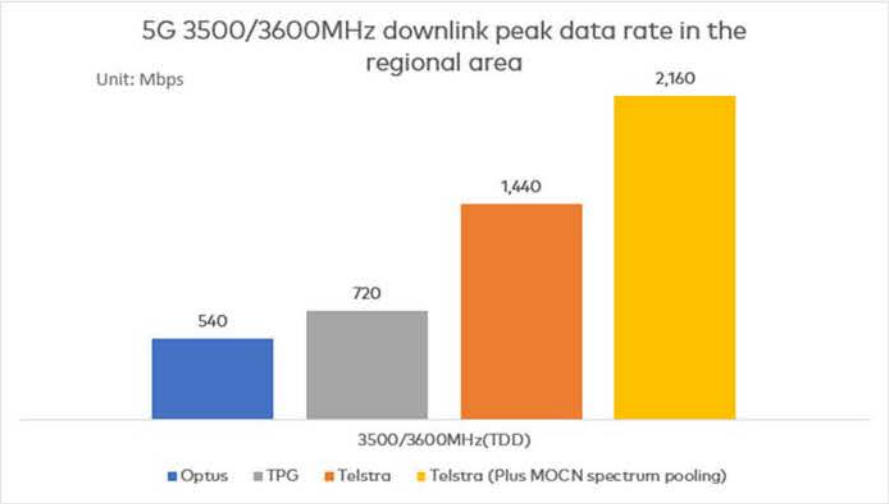
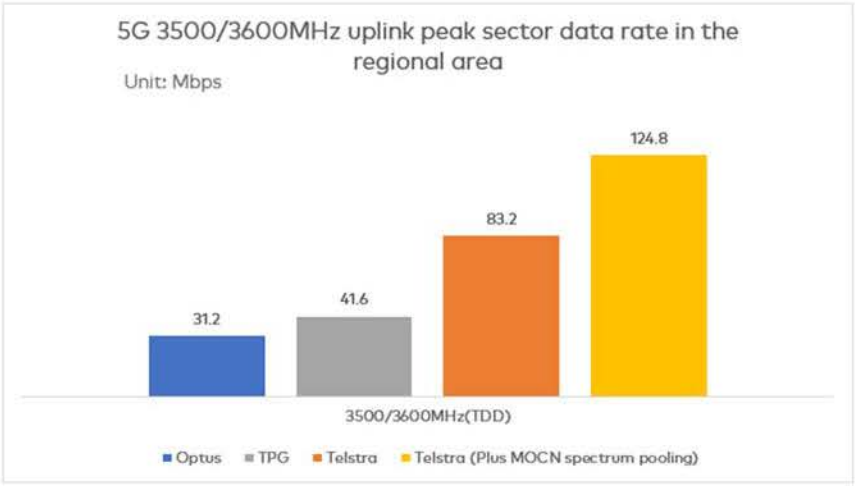


Figure 10



5. Potential use of TPG's spectrum by Optus

77. I consider that in the absence of the Proposed Transaction there would be a number of alternate use cases for TPG's spectrum in circumstances where TPG does not itself use its existing spectrum holdings.

78. While I expect that there may be other commercial use cases for TPG's spectrum, I have focused on the benefits to Optus and TPG if their respective spectrum holdings were shared in regional areas.

79. Pooling Optus' and TPG's spectrum in regional areas would result in spectrum holdings set out in Tables 10 and 11 below. Specifically, Table 10 shows that pooling Optus' and TPG's regional spectrum would bring the parties closer to Telstra's current spectrum holdings. In particular:

(a) Telstra currently holds approximately 1.3 times Optus' low band spectrum holdings. An Optus and TPG spectrum pooling arrangement would reduce Telstra's advantage to 0.9 times Optus' low band spectrum holdings.

(b) Telstra currently holds approximately 1.9 times Optus' mid band spectrum holdings. An Optus and TPG spectrum pooling arrangement would reduce Telstra's advantage to 1.1 times Optus' low band spectrum holdings.

Table 10

Comparative spectrum bandwidth ratio

Spectrum Bands	Telstra vs Optus	Telstra vs TPG	Telstra vs Optus &TPG (Spectrum pooling[3])
Low Band only	1.3	2.3	0.9
Mid Band Only	1.9	2.8	1.1
Low Band + Mid Band	1.7	2.6	1.1

80. Table 11 shows the current spectrum holdings of each MNO in the RCZ. Table 11 also shows the holdings that a future Optus-TPG pooling arrangement has the potential to generate. In respect of the last column in this table, I have assumed that TPG's 2 x 5MHz holdings in the 700MHz band would remain set aside by TPG for private networks.

Table 11

Band	Band Type	Telstra	TPG	Optus	Optus & TPG (Spectrum pooling[3])
700MHz (FDD[1])	Low Band	2 x 20MHz	2 x 15MHz	2 x 10Mz	2 x 20Mz
850MHz (FDD)	Low Band	2 x 25MHz	2 x 5MHz		2 x 5MHz
900MHz (FDD)	Low Band			2 x 25MHz	2 x 25MHz
1800MHz (FDD)	Mid Band	2 x 40MHz	2 x 15MHz	2 x 25MHz	2 x 40MHz
2100MHz (FDD)[2]	Mid Band	2 x 20MHz	2 x 15MHz	2 x 15MHz	2 x 30MHz
2600MHz (FDD)	Mid Band	2 x 40MHz		2 x 20MHz	2 x 20MHz
3500/3600MHz (TDD[1])	Mid Band	80MHz	40MHz	30 MHz	70 MHz

Note 1: FDD - Frequency Division Duplex, typically with paired downlink and uplink spectrum. TDD - Time Division Duplex, typically downlink and uplink shared the same unpaired spectrum
Note 2: 2100MHz apparatus licenses are included
Note 3: All spectrum pooled except 2x5MHz 700MHz band, which will likely be retained by TPG to provide managed private networks to enterprises in the regional area

81. My team has, in the context of considering the Proposed Transaction (and alternatives should it not proceed), also considered the speeds that Optus and TPG would be able to achieve in the RCZ if their spectrum were to be pooled, as compared to Telstra operating without the MOCN arrangement. The same industry references referred to at paragraph 68 were used to determine the peak sector data rates shown in Figure 11 and 12 below.

82. Figures 11 and 12 show that an Optus and TPG spectrum pooling arrangement of the nature set out in Table 11 above would result in Optus and TPG:

(a) just surpassing Telstra in low band sector peak data rates; and

(b) almost matching Telstra in mid band sector peak data rates and combined low and mid band sector peak data rates,

in the regional area for both downlink and uplink sector peak data rates.

Figure 11

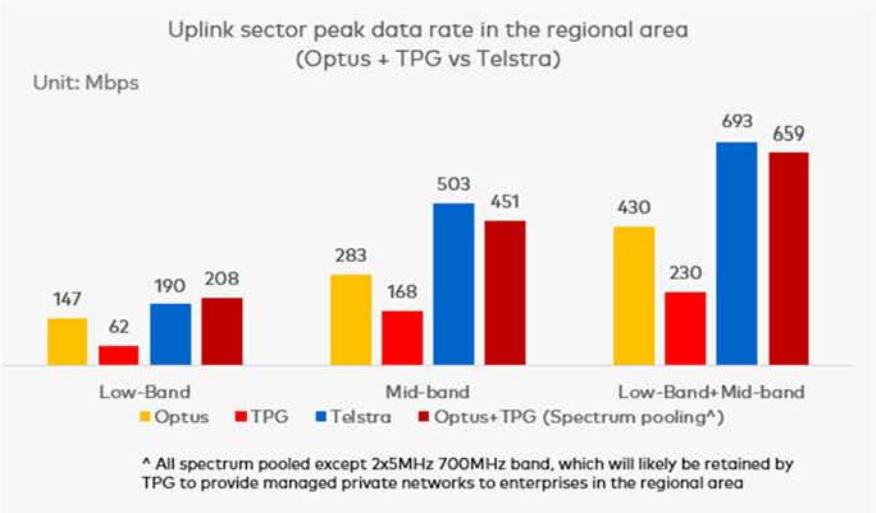
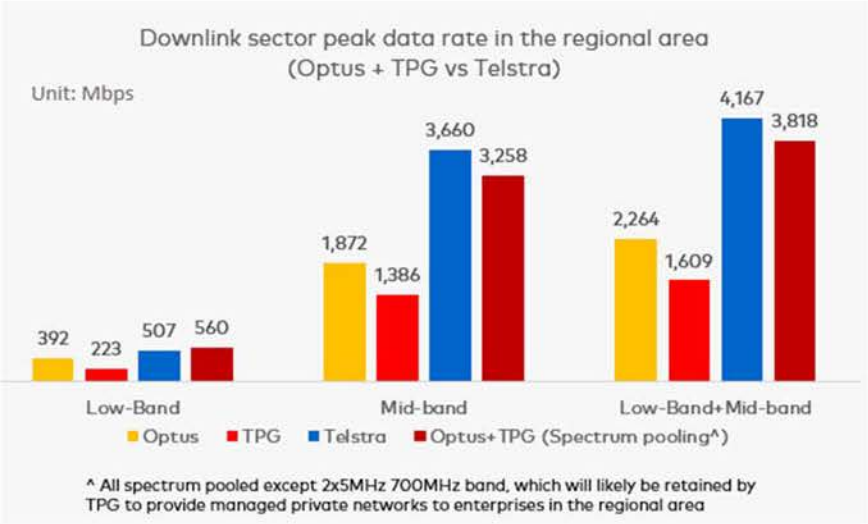


Figure 12



83. A combined Optus and TPG spectrum sharing arrangement in the RCZ would also benefit from in-band contiguous spectrum in the 1,800MHz and 3.5Ghz bands. As I have already set out in further detail above, spectrum assets which are contiguous are more valuable as they bring efficiencies in network deployment and enable MNOs to achieve greater speeds and capacity. I consider that the pooling of these spectrum bands would be of particular value for Optus.

84. Access to an additional 40MHz of TPG's 3.5GHz spectrum would enable the gap on Telstra to be closed in this spectrum band which, as set out at paragraph 73 above, would be valuable in the rollout of 5G technology in regional areas. In the following section, I address the particular uses and benefits of mid band spectrum in the context of network deployment in regional areas.

85. While Optus would require additional radio equipment on its base stations to make use of additional TPG spectrum, I understand Telstra would also need additional radio units to use TPG spectrum on its mobile sites.

6. Utility of mid band spectrum

86. In this section I address aspects of the Applicants' Response which suggest that Optus has overstated the role of mid band spectrum in regional and rural networks deployment.

87. In summary, I consider that mid band can be utilised to achieve coverage and capacity in regional networks and that Telstra is not fully utilising its current mid band spectrum holdings in the RCZ. In my view, this is particularly relevant in considering the Applicants' claim that addressing congestion issues, as well as achieving higher quality services in more locations are key commercial drivers for Telstra in pursuing the Proposed Transaction: Application at [22]-[23], [257]-[272]. For the reasons I set out below, I consider that these commercial objectives can be readily achieved by Telstra without the Proposed Transaction were Telstra to fully deploy its existing mid band spectrum holdings.

A. The utility of mid band spectrum in regional network deployment

88. The Applicants' Response suggests that Optus has overstated the role of mid band in regional and rural networks deployment. I explain below the reasons why I do not agree with that assessment and why I consider mid band to be important in this context.

89. First, the Applicants' Response at paragraph [86(a)] suggests that Optus *'would appear to accept that it is not useful to deploy mid band spectrum on towers outside of population centres'*. In making this statement the Applicants appear to rely on the assertion that Optus has only deployed 3.5GHz spectrum at around 20 sites in the RCZ.

90. I consider that it is incorrect to address Optus' deployment in the RCZ by referring to only one mid band spectrum range (3.5GHz). As at April 2022, Optus had deployed mid band spectrum at over 1,000 sites in the RCZ. Tables 12 and 13 below compare the spectrum bands deployed on macro sites by Telstra, and by Optus in the RCZ. By way of example, these tables show that Optus has deployed 2,600MHz spectrum on 1,011 regional sites, while Telstra only deployed 2,600MHz spectrum at 394 sites.

Table 12

Telstra's Spectrum Bands	Spectrum Available (unit: MHz)	# of Macro Sites Spectrum Available [1]	# of Macro Sites Spectrum Installed by Telstra [2]			
			WCDMA	LTE	NR	Total (% to available sites)
700MHz (FDD, paired)	40	3752		3369		3369 (89.8%)
850MHz (FDD, paired)	50 [3]	3752	3248		425	3673 (97.9%)
1800MHz (FDD, paired)	70-80	3065		1013		1013 (33.1%)
2100MHz(FDD, paired)	40 [4]	3752	38	327		365 (9.7%)
2600MHz (FDD, paired)	80	3752		364	30	394 (10.5%)
3500MHz(TDD, unpaired)	50-82.5	3250			442	442 (13.6%)

Note 1: Macro site count is calculated by Optus based on RFNSA site data information (April 2022), public ACMA spectrum boundaries and Telstra wholesale coverage map: https://www.telstrawholesale.com.au/products/mobiles/coverage.html
Note 2: Spectrum installed is based on RFNSA site data information (April 2022). Telstra does not install the full spectrum bandwidth in some mid-bands based on Optus drive testing report
Note 3: This includes Telstra's Extended 850 MHz Band (804-814MHz/849-859MHz) which Telstra won at the auction in 2021 and will be available from July 2024
Note 4: 2100MHz apparatus licenses are included

Table 13

Optus's Spectrum Bands	Spectrum Available (unit: MHz)	# of Macro Sites Spectrum Available[1]	# of Macro Sites Spectrum Installed by Optus (April 2022)			
			WCDMA	LTE	NR	Total (% to available sites)
700MHz (FDD, paired)	20	2274		2239		2239(98.5%)
900MHz (FDD, paired)	16.8(Current)/ 50(Y2024)	2274	2244			2244(98.7%)
1800MHz (FDD, paired)	50	2029		766		766(37.8%)
2100MHz(FDD, paired)	30	2090	698	390	46	842(40.3%)
2600MHz (FDD, paired)	40	2274		1011		1011(44.5%)
3500MHz(TDD, unpaired)	30	2119			2	2(0.1%)

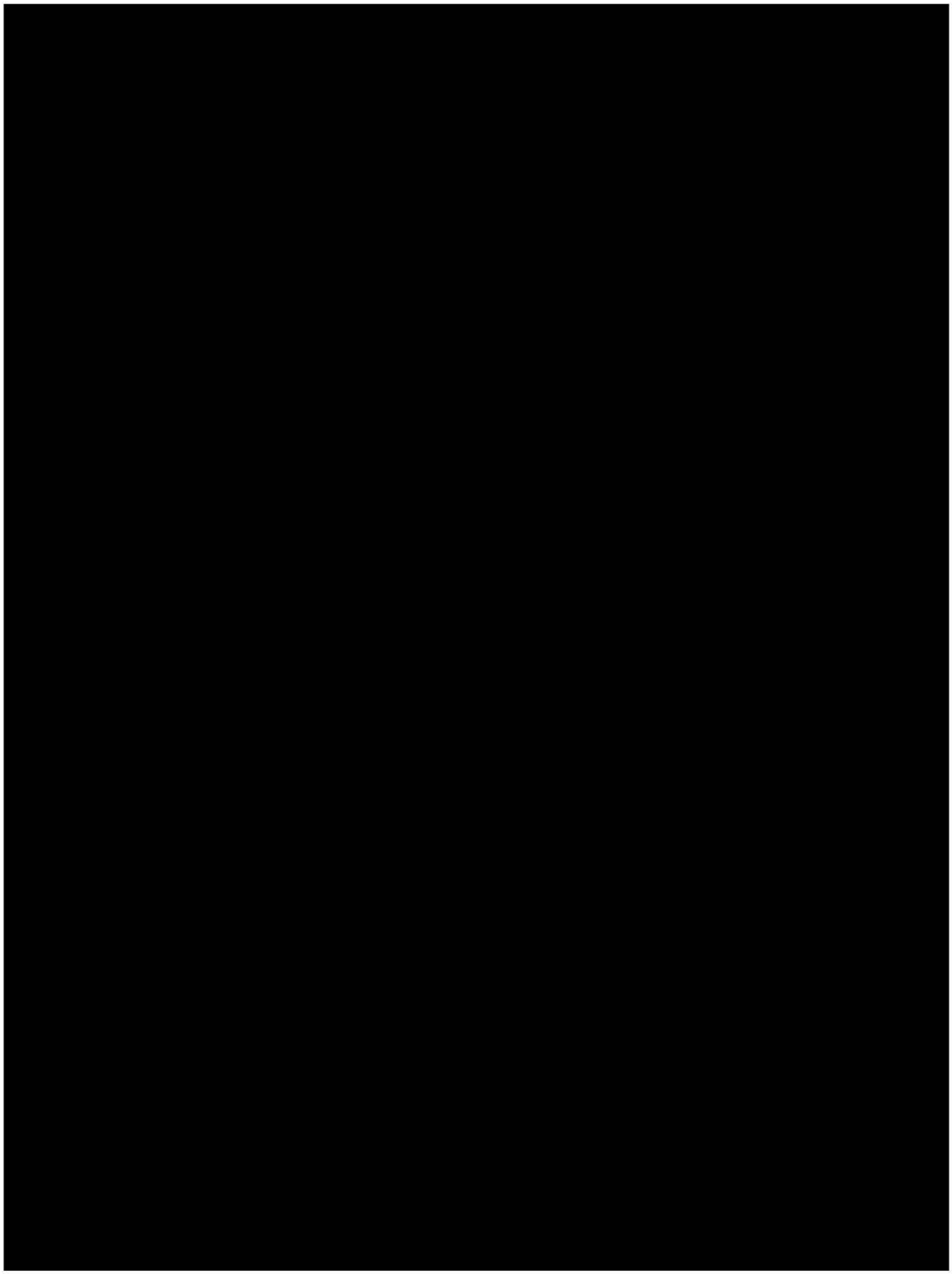
Note: 2100MHz may have multiple technologies deployed on a same site, so the total site count is less than the sum of all technology units

91. Second, the Applicants' Response at paragraph [82] provides that mid band spectrum is largely ineffective in providing reliable outdoor coverage at 6.6km (or down to 2km) from a tower, and that any in-building coverage from that distance will be rare. Further, the Applicants' Response states that at 14.5kms from a tower, mid band spectrum is completely ineffective for delivering reliable outdoor and indoor service.

92. I do not agree with the Applicant's position regarding the coverage propagation of mid band spectrum outlined in the Applicants' Response. In particular:

(a) Optus' live network statistics and 3GPP timing advance measurements (which I explain above at paragraph 28(b)), show that 1,800MHz and 2,100MHz bands can serve customers in a range of 6.6km-14.5km from mobile sites, and that spectrum in the 2,600MHz band can provide network capacity for customers in a range of 3.5km-6.6km from mobile sites in the RCZ. Optus' statistics also show that [redacted] of Optus' regional mobile customers are within 6.6km and 14.5km respectively of an Optus base station, with mid band spectrum playing a key role in the capacity offloading in Optus' regional network. This is shown in Figures 13 and 14 below.

(b) At paragraphs 95 to 106 below I use various case studies to show the ability of mid band spectrum to cover populated regional towns, including Optus' drive testing results in the city of Dubbo at paragraph [98].



93. Thirdly, at paragraph [83] of the Applicants' Response, the Applicants use a map of Dubbo to, as I understand it, illustrate the assertion that Optus has overestimated the role and capabilities of mid band spectrum in regional areas. I provide further detailed information below as to why I consider this to be incorrect. However, in summary:

    (a) Australia's regional population is largely centralised to town areas. For example, according to Australian Bureau of Statistics (**ABS**) 2016 census data, approximately 70% of the population in the RCZ is located within 0.32% of the total RCZ area. That is represented by Table 14 and Figure 15 below.

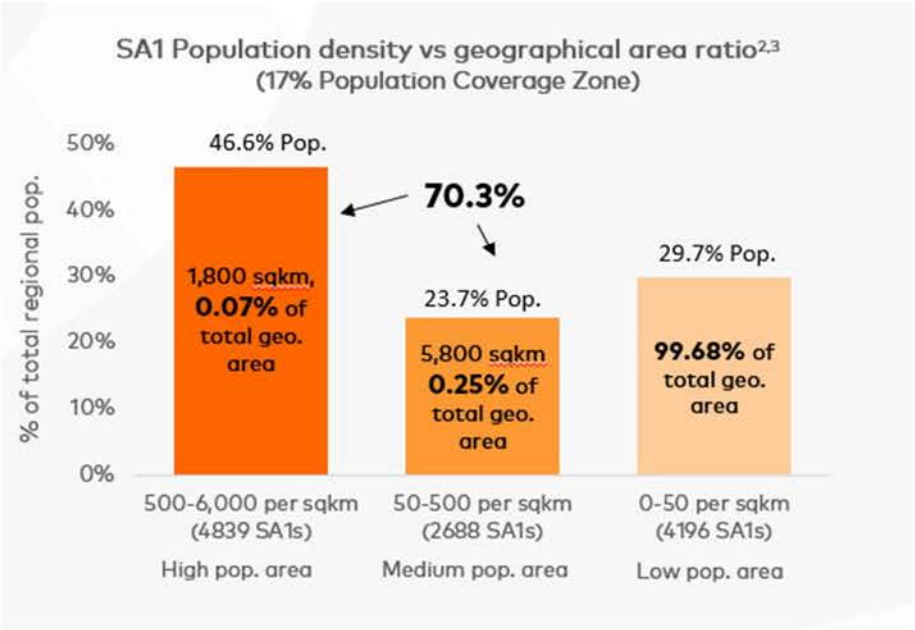
Table 14

SA1 distribution in the 17% Population Coverage Zone[2,3]

	# of SA1		Geographical Area		Population Size	
SA1 Population Density	#	% of total	sqkm	% of total	#	% of total
4000+ per sqkm	4	0.03%	0.42	0.00%	1,919	0.05%
3000-4000 per sqkm	28	0.24%	4.48	0.00%	14,257	0.35%
2000-3000 per sqkm	768	6.55%	138.81	0.01%	315,382	7.66%
1000-2000 per sqkm	2,300	19.62%	648.67	0.03%	916,803	22.26%
500-1000 per sqkm	1,739	14.83%	955.40	0.04%	671,086	16.29%
200-500 per sqkm	1,494	12.74%	1,780.48	0.07%	558,867	13.57%
50-200 per sqkm	1,194	10.19%	4,045.46	0.17%	416,667	10.12%
0-50 per sqkm	4,196	35.79%	2,368,172.81	99.68%	1,223,604	29.71%
Grand Total	11,723	100.00%	2,375,746.52	100.00%	4,118,585	100.00%

Note 1: Significant Urban Area (SUA) defined by ABS 2016 census:
https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1270.0.55.004~July%202016~Main%20Features~Significant%20Urban%20Area%20(SUA)~5
Note 2: Statistical Area Level 1 (SA1), Statistical Area Level 2 (SA2), ABS 2016 census data.
Note 3The number of SA1 is determined by whether or not its centroid is located within the 17% Population Coverage Zone polygon produced by Optus based on the publicly available coverage maps from Telstra. The total SA1 count may include low-population SA1s outside the 17% Coverage Zone. The number of SA1 is very close to Telstra-TPG's 11,615 due to the slight difference between Optus' estimated 17% Population Coverage Zone polygon and the proposed MOCN polygon. The population difference to Telstra-TPG's 4,471,800 should be mainly from the population growth since 2016 AUST. However, it is not statistically significant to this analysis

Figure 15



Note 2: Statistical Area Level 1 (SA1), Statistical Area Level 2 (SA2), ABS 2016 census data.
Note 3The number of SA1 is determined by whether or not its centroid is located within the 17% Population Coverage Zone polygon produced by Optus based on the publicly available coverage maps from Telstra. The total SA1 count may include low-population SA1s outside the 17% Coverage Zone. The number of SA1 is very close to Telstra-TPG's 11,615 due to the slight difference between Optus' estimated 17% Population Coverage Zone polygon and the proposed MOCN polygon. The population difference to Telstra-TPG's 4,471,800 should be mainly from the population growth since 2016 AUST. However, it is not statistically significant to this analysis

(b) In my experience, MNOs tend to serve these densely populated regional areas through multiple mobile towers. A query of the ACMA RRL database will show that MNO mobile sites in densely populated regional areas in Australia are on average between 1.5km and 2.5km apart from each other. The examples I use below demonstrate that Telstra's sites in regional areas, and the mid band spectrum which is available to it, would allow Telstra to serve the majority of the regional population on mid band spectrum.

94. In assessing this issue, I have considered the coverage map of Dubbo at paragraph [83] of the Applicants' Response. I consider that this mapping does not accurately or fully

represent coverage achieved by Telstra using mid band spectrum in Dubbo. That is because it only contemplates coverage achieved through one particular mobile site. The fact there are other sites is acknowledged at footnote 92 of the Applicants' Response.

95. Telstra has nine macro sites in Dubbo. In my experience, these nine sites should be considered together in determining the coverage that can be achieved by Telstra in Dubbo using mid band spectrum. The nine sites are illustrated in Figures 16 and 17 below. All nine of Telstra's macro sites in Dubbo have installed 1,800MHz and 3.5GHz mid band spectrum, and eight of those sites also have installed 2,600MHz spectrum.

Figure 16

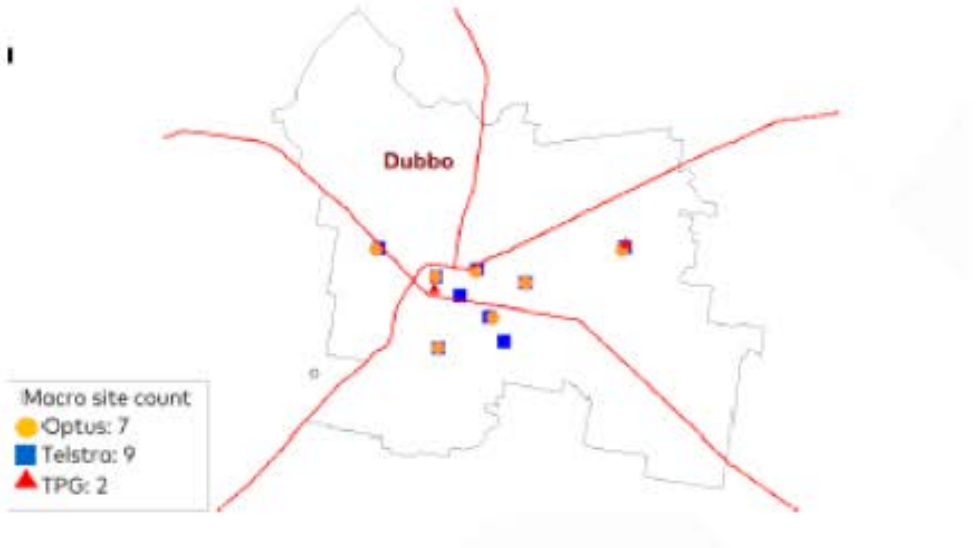


Figure 17

Telstra site list in Dubbo (April 2022)

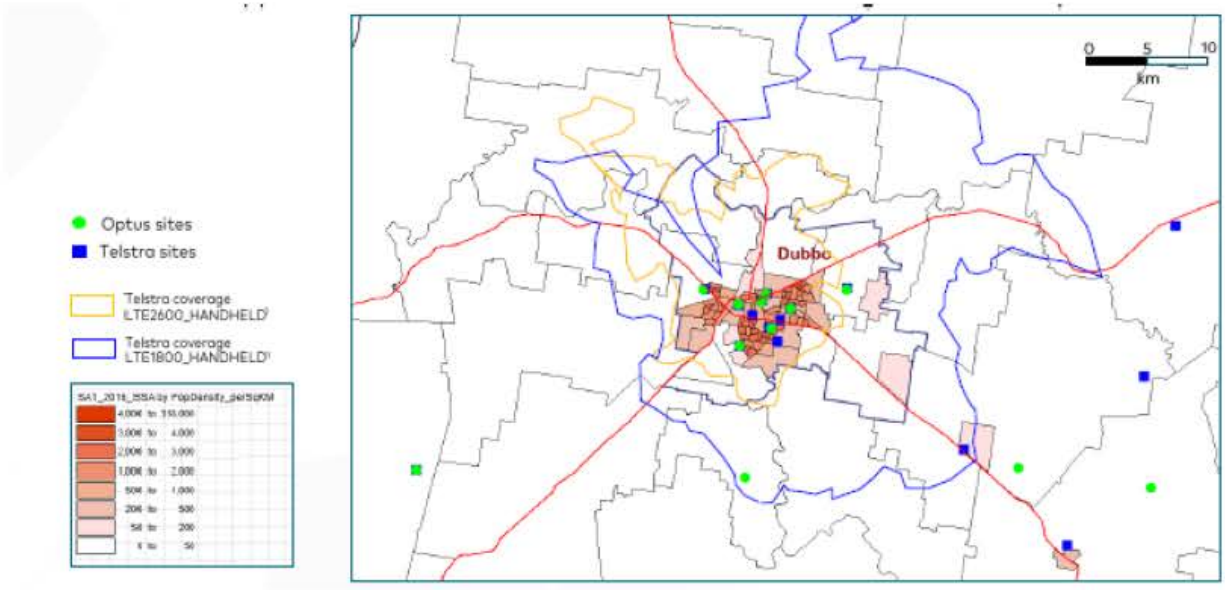
NSA_ID	Site_Type	Status	State	SUA	Existing Technology Units
2830001	Macro	Existing	NSW	Dubbo	U08-L07L18L26-N08N35
2830005	Macro	Existing	NSW	Dubbo	U08-L07L18L21L26-N08N35
2830006	Macro	Existing	NSW	Dubbo	U08-L07L18L21L26-N08N35
2830007	Macro	Existing	NSW	Dubbo	U08-L07L18L21L26-N08N35
2830009	Macro	Existing	NSW	Dubbo	U08-L07L18-N08N35
2830019	IBC	Existing	NSW	Dubbo	U08-L18L26-N35
2830020	Macro	Existing	NSW	Dubbo	U08-L07L18L21L26-N08N35
2830021	Macro	Existing	NSW	Dubbo	U08-L07L18L21L26-N08N35
2830033	Macro	Existing	NSW	Dubbo	U08-L07L18L21L26-N08N35
2830043	IBC	Existing	NSW	Dubbo	U08-L18-
2830044	Macro	Existing	NSW	Dubbo	-L07L18L21L26-N08N35

Source: Macro site information is illustrated by Optus based on RFNSA site data information (April 2022)

96. Further, the conclusions drawn from the coverage map at paragraph [83] of the Applicants' Response reflects an assumption of uniform population distribution. As can be seen in Figure 18 below which has been prepared by my team based on RFNSA data (April 2022) and ABS 2016 census data, population density across Dubbo is not uniformly distributed. Regional customers are generally centralised to a town area.

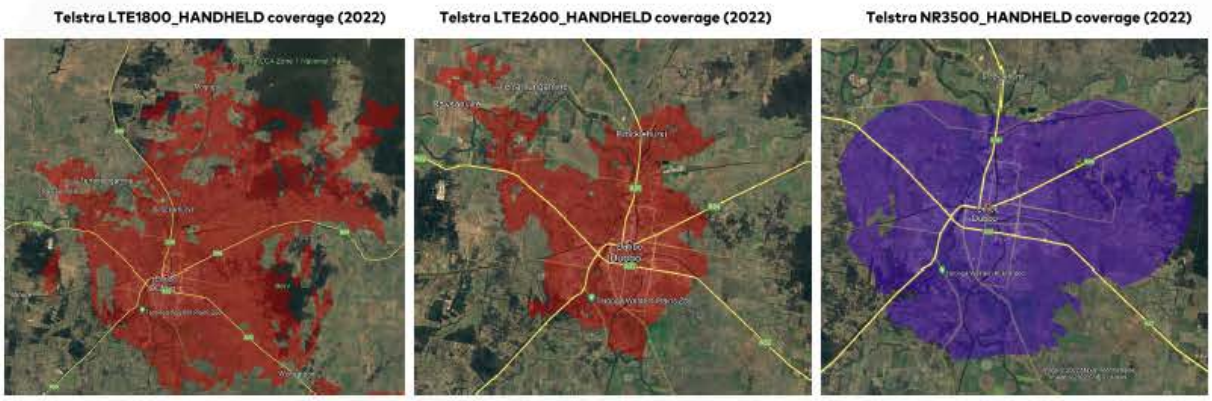
Based on my knowledge and experience, it is common practice for MNOs to build mobile sites close to populated areas.

Figure 18



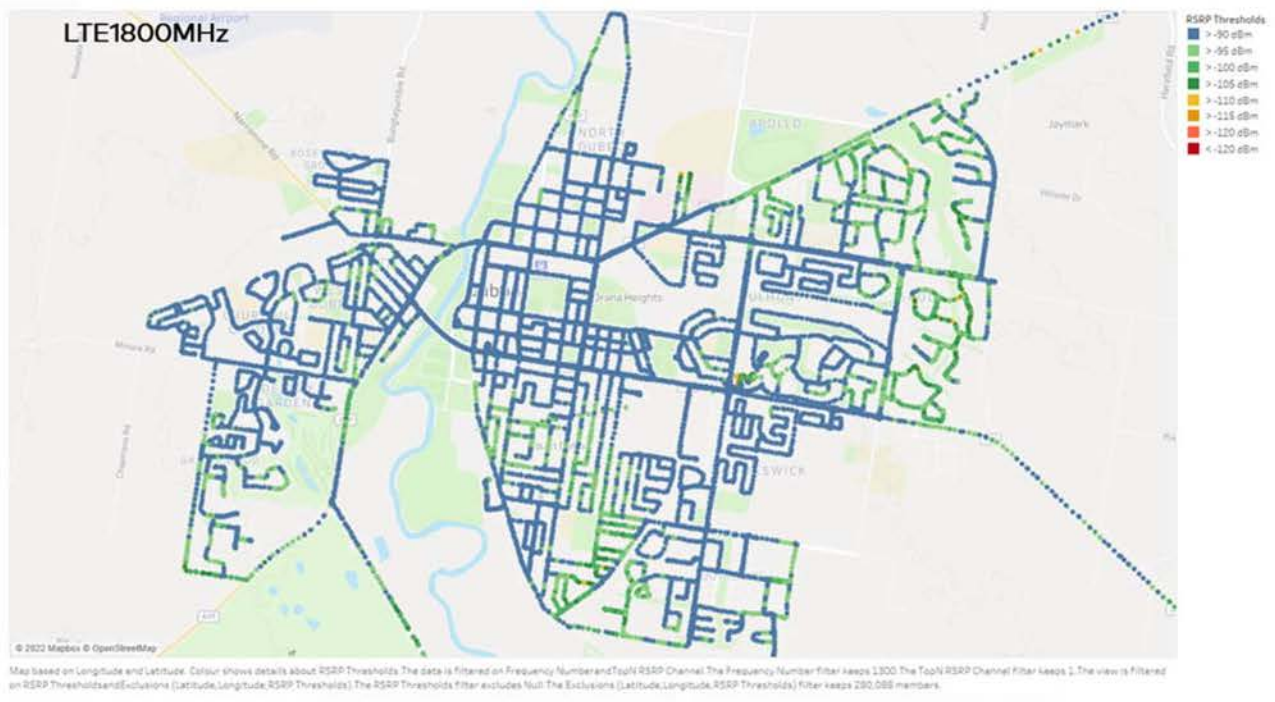
97. Telstra's official coverage map per frequency band (derived from the ACCC's 2021 Mobile Infrastructure Report) and reflected in Figure 19 below, illustrates that Telstra's LTE1800/2600 and NR3600, using all nine Telstra macro sites, are capable of fully covering the Dubbo population centre.

Figure 19



98. Optus' own data shows a similar outcome but provides further detail which is instructive. Specifically, Optus conducted drive testing in the Dubbo area from 14 to 22 September 2022. Drive testing is common industry practice in which data is derived from vehicles with antennae and appropriately configured calibrated and operated testing equipment attached to measure signal strength around a particular region. The results of Optus drive testing shows that Telstra has coverage over the entire population centre of Dubbo with its 1,800MHz band spectrum. That drive testing data is depicted in Figure 20 below.

Figure 20

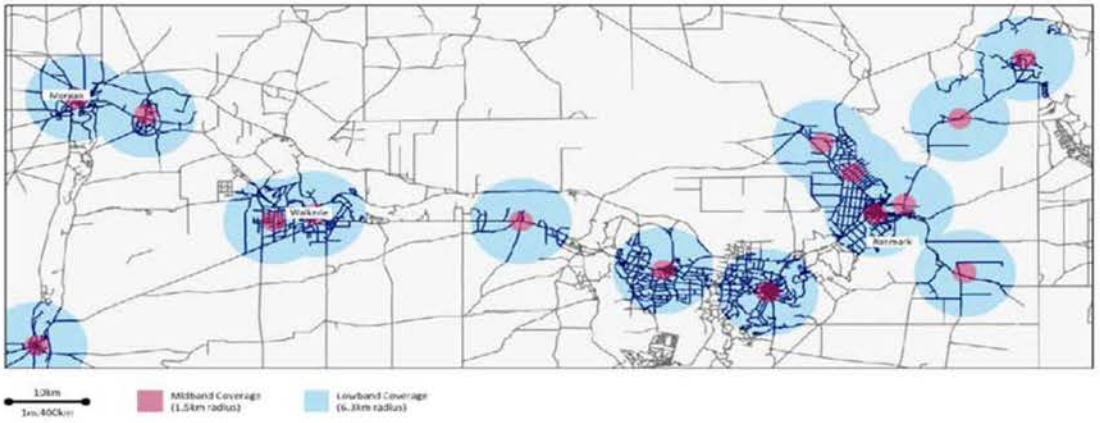


99. The Reference Signal Received Power or 'RSRP' thresholds described in the key to Figure 20 identify the level of outdoor and indoor coverage that a customer will receive in a particular area. Based on Optus' live network statistics, the typical 4G serviceable signal strength, as measured by RSRP in dBm units, is considered to be [redacted] or higher for outdoor signal. To serve indoor customers, based on my experience, a penetration loss from outdoor to indoor must be accounted for, which is generally around [redacted]. In my view, this means the necessary signal strength to achieve typical 4G serviceable signal strength indoors [redacted] or above.

100. Optus' drive testing as set out in Figure 20 shows that Telstra's network achieves at least >-105dBm throughout Dubbo (with some very small exceptions), with the majority of Dubbo achieving >-90dBM from Telstra's network. On that basis, I consider that Telstra's network achieves 4G serviceability on 1,800MHz mid band spectrum throughout the entire city of Dubbo (both indoors and outdoors).

101. The Applicants' Response at paragraph [84] also includes mapping of the relative coverage achieved between low and mid bands across a range of existing Telstra towers in regional and rural areas. An example of the Murray Bridge area is in Figure 5 of the Applicants' Response which I extract below for ease. It notes assumptions that low band spectrum has a cell radius of 6.3km and that mid band has a cell radius of 1.5km.

Figure 5. Murray Bridge low-band and mid-band relative coverage map illustration



102. Together with my team I have considered Figure 5 and the analysis is at odds with the conclusions reached by the Applicants. Again, using drive testing to measure the Telstra signal in the Murray Bridge area from 19 to 21 September 2022, the results show that Telstra's LTE 1,800MHz spectrum reaches well beyond what is shown in Figure 5 of the Applicants' Response. In particular, the results of the drive testing indicate a reach of over 15km from Telstra's sites, 10 times the Applicants' claim of a 1.5km cell radius. In addition, Telstra's 3500MHz spectrum reaches up to 4km from its sites (again higher than the suggested 1.5km mid band cell radius). This is captured in Figures 21 and 22.

Figure 21

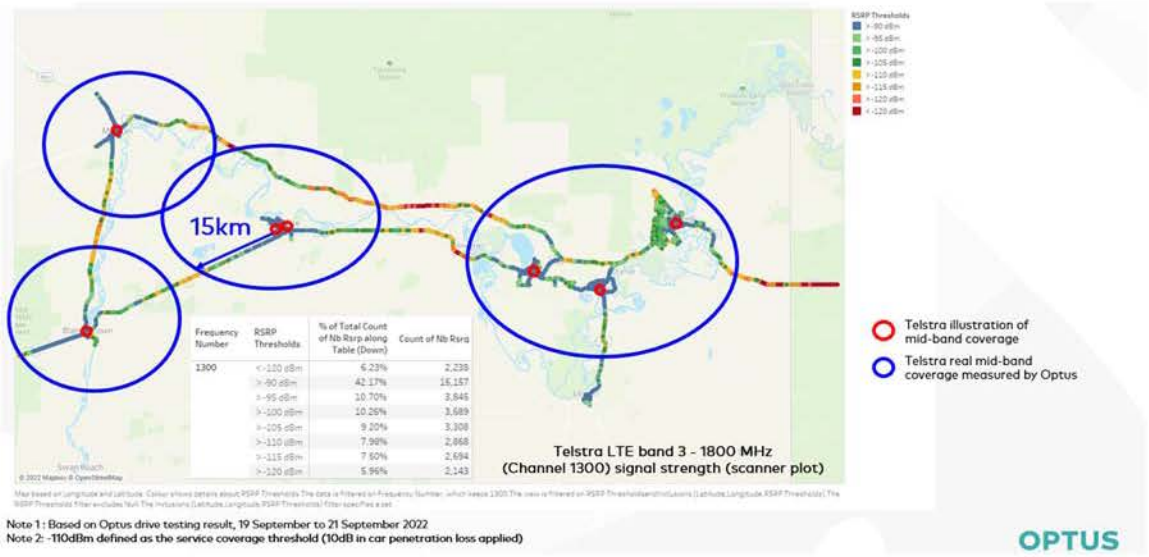
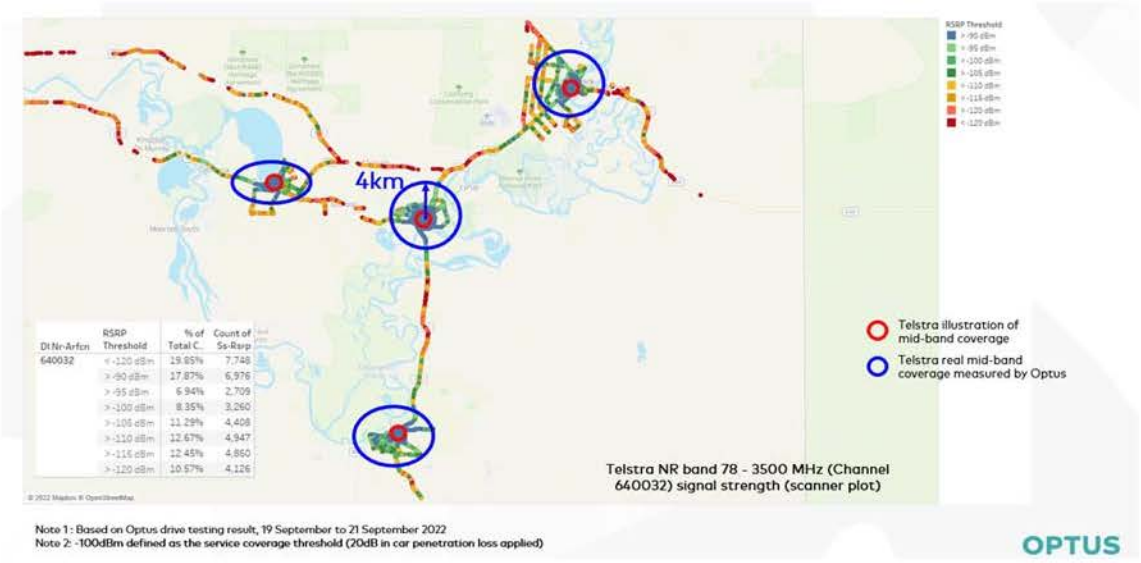


Figure 22



103. This demonstrates the value of mid band spectrum in regional areas.

104. Table 15 and Figures 23 to 27 below further illustrate that mid band is appropriate for achieving coverage and capacity in regional areas. Table 15 shows the population of the top 10 populated towns in the RCZ based on 2016 ABS data and the estimated portion of the RCZ that this constitutes in terms of geographic area. Based on this data the top 10 towns account for 13.36% of the total population in the RCZ but only 0.07% of the RCZ's geographical area.

105. Figures 23 to 27 then show the mobile site locations on SA1 population density maps (using 2016 ABS data and RFNSA data as of April 2022) in the top 5 populated towns within the RCZ, against Telstra's own coverage prediction on mid band spectrum in those areas. Putting aside the results of Optus' drive testing noted above, these Figures show that Telstra's own mid band coverage predictions provided for in Figure 5 of the Applicants' Response would entirely cover the population centres of the relevant towns.

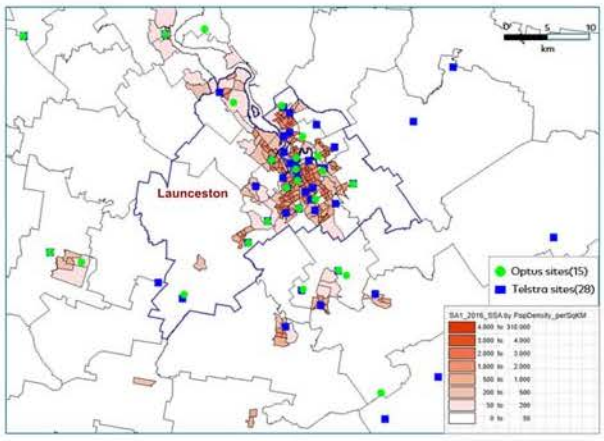
Table 15

No.	SUA_NAME_2016	STATE	Population size	% of total pop. in 17% MOCN zone	AREA_ALBERS_SQKM	% of total 17% MOCN zone area
1	Launceston	TAS	84,204	2.01%	435.4	0.0105%
2	Bundaberg	QLD	69,021	1.65%	305.1	0.0073%
3	Coffs Harbour	NSW	68,538	1.64%	505.5	0.0122%
4	Wagga Wagga	NSW	54,457	1.30%	192.1	0.0046%
5	Hervey Bay	QLD	52,064	1.25%	93.2	0.0022%
6	Mildura - Wentworth	NSW	50,227	1.20%	588.9	0.0142%
7	Shepparton - Mooroopna	VIC	49,698	1.19%	248.9	0.0060%
8	Port Macquarie	NSW	45,397	1.09%	96.3	0.0023%
9	Gladstone - Tannum Sands	QLD	43,893	1.05%	246.1	0.0059%
10	Tamworth	NSW	41,007	0.98%	240.7	0.0058%
		Total	558,506	13.36%	2,952	0.07%

Figure 23

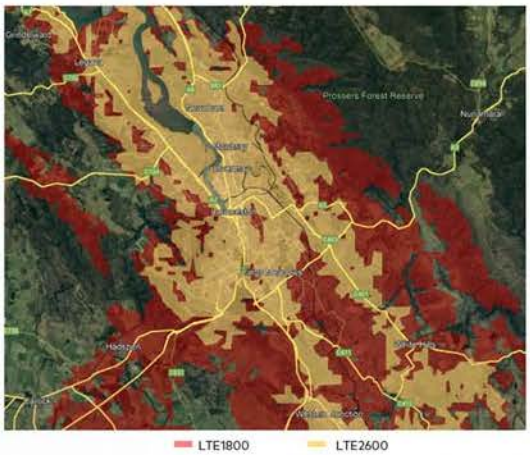
Telstra's sites and mid-band coverage in Launceston, TAS

Mobile Site vs SA1 Map



Source: RFNSA, April 2022

Telstra's coverage prediction on LTE1800/2600 (2022)

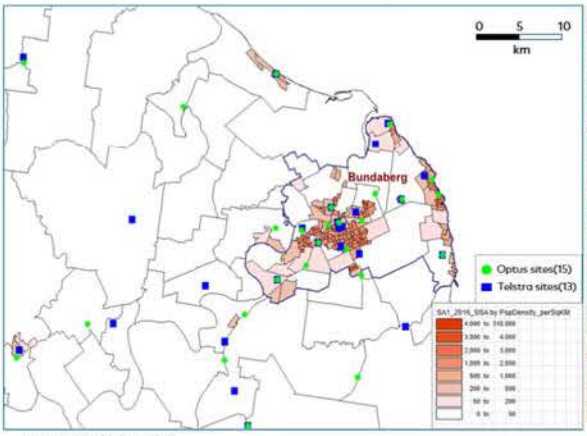


Source: ACCC Mobile infrastructure report, available at https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC

Figure 24

Telstra's sites and mid-band coverage in Bundaberg, QLD

Mobile Site vs SA1 Map



Source: RFNSA, April 2022

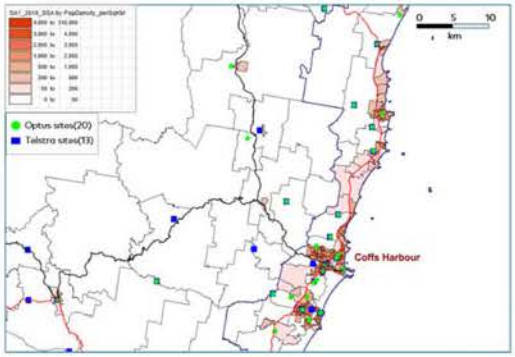
Telstra's coverage prediction on LTE1800/2600 (2022)

Source: ACCC RKR Mobile infrastructure report, available at https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC

Figure 25

Telstra's sites and mid-band coverage in Coffs Harbour, NSW

Mobile Site vs SA1 Map



Source: RFNSA, April 2022

Telstra's coverage prediction on LTE1800/2600 (2022)

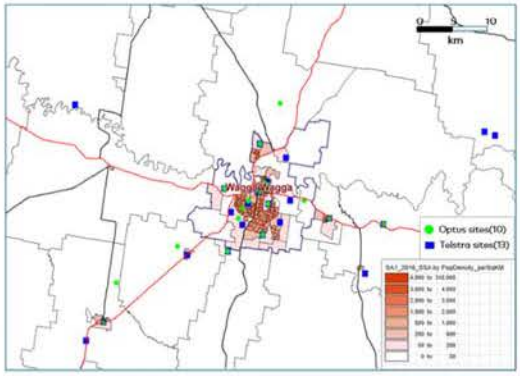
LTE1800 LTE2600

Source: ACCC RKR Mobile infrastructure report, available at https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC

Figure 26

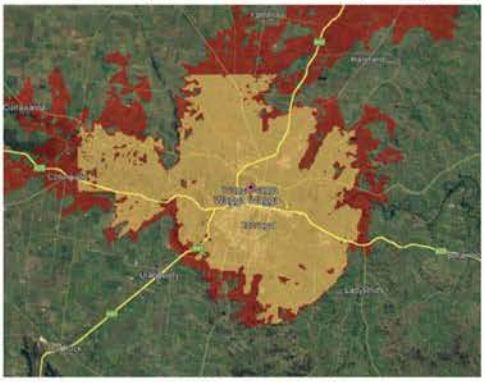
Telstra's sites and mid-band coverage in Wagga Wagga, NSW

Mobile Site vs SA1 Map



Source: RFNSA, April 2022

Telstra's coverage prediction on LTE1800/2600 (2022)



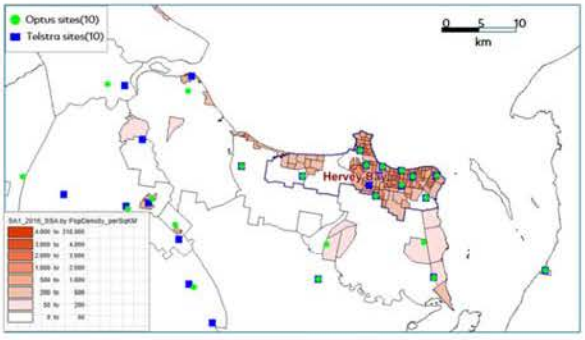
LTE1800 LTE2600

Source: ACCC RKR Mobile infrastructure report, available at https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC

Figure 27

Telstra's sites and mid-band coverage in – Hervey Bay, QLD

Mobile Site vs SA1 Map



Source: RFNSA, April 2022

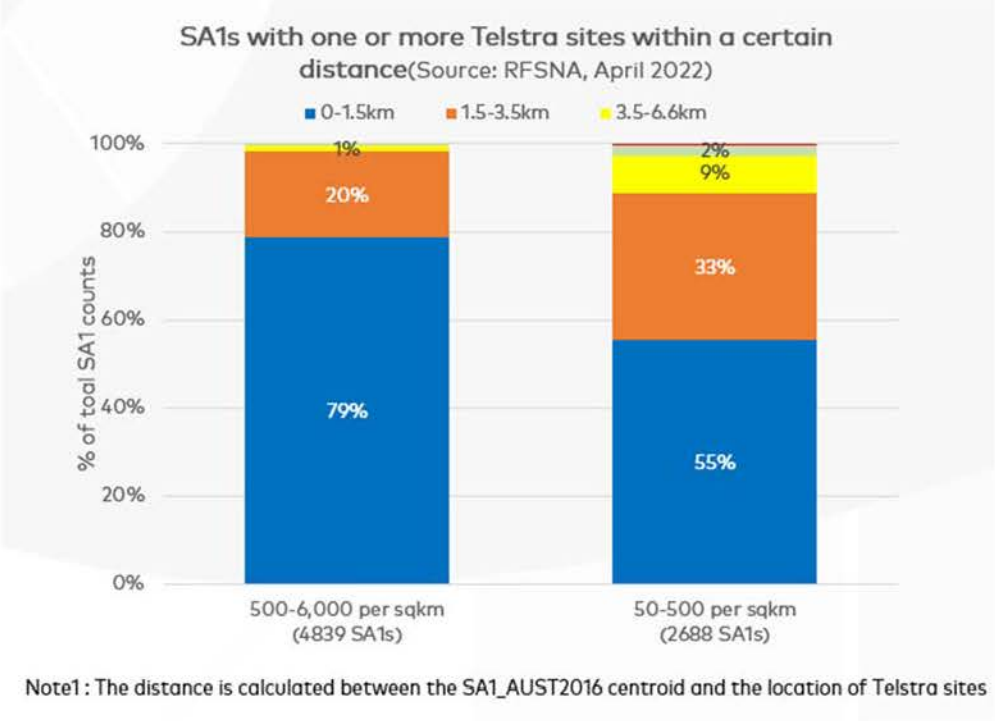
Telstra's coverage prediction on LTE1800/2600 (2022)

LTE1800 LTE2600

Source: ACCC RKR Mobile infrastructure report, available at https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC

106. Finally, to further demonstrate that the examples provided above are not anomalies, I instructed my team to assess RFNSA data from April 2022 regarding Telstra's mobile site locations in regional Australia. In particular, data shows that 100% of the high population SA1 locations and 97% of the medium population SA1 locations in the RCZ have one or more Telstra sites built within a 6.6km distance of the population centre (ie within reach of the 1,800 / 2,100MHz cell radius on Optus' estimates). Further 99% of the high population SA1s have Telstra sites with 3.5km reach (ie within reach of 3.5GHz cell radius). Taken together, I consider this to show that the majority of regional populations can be served by mid band spectrum from Telstra sites. Figure 28 below illustrates this.

Figure 28



Note1 : The distance is calculated between the SA1_AUST2016 centroid and the location of Telstra sites

B. The significance of mid band spectrum in regional network deployment

107. The analysis above illustrates the ability for MNOs to use mid band spectrum to provide coverage and capacity in regional areas. Telstra could achieve greater capacity and coverage by deploying its heavily underutilised mid band holdings in the regional area.

108. To explain this further, I assisted in preparing paragraphs [5.52], [5.55] and [5.58] of Optus' Submission, which I consider to be accurate. In particular, those paragraphs provide:

> *'Telstra does not lack spectrum to support the capacity demand for its customers in the regional areas'*,

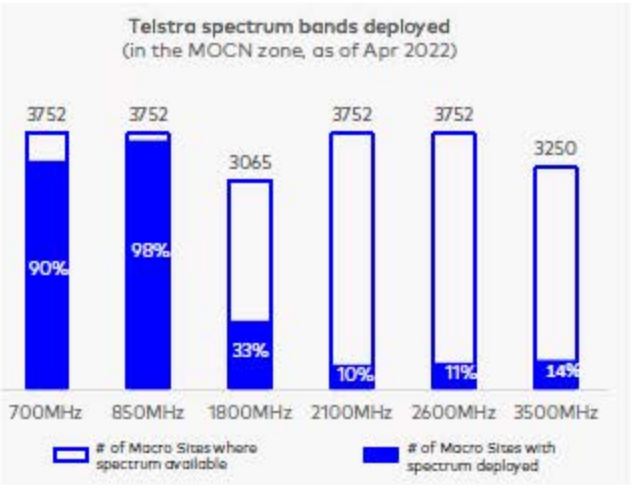
'Mid bands such as 1800 MHz and 2100 MHz provide greater coverage in regional areas due to less propagation loss than in the metropolitan areas. Mid bands are the key spectrum to offer network capacity. Telstra currently holds 1.7 times more mid band spectrum than Optus in the regional areas. Telstra may claim that even though mid band can travel further in regional areas, the population remains too fragmented for efficient use of this spectrum. Optus' analysis finds that any such claim is false',

'It is clear from Optus' analysis that Telstra could, if it chose to, deploy its extensive mid band holdings to alleviate congestion on its regional network. The fact that it chooses not to demonstrates the inefficiency of Telstra's spectral use.'

109. Telstra currently has access to mid band spectrum in regional areas that it does not fully utilise. To demonstrate this, I instructed my team to prepare Figures 29 to 31 below to demonstrate overall regional mid band spectrum deployment, and the location of Telstra's non-government funded sites, and use of mid band spectrum on those sites (again using RFNSA data from April 2022, public ACMA spectrum boundary information and Telstra's wholesale coverage map).

110. Figure 29 shows Telstra's current mid band spectrum is deployed on just 10 – 33% of its regional mobile sites.

Figure 29



111. Figures 30 and 31 below break that down further by distance from SA1 locations. Specifically, that data shows that 57% and 70% of Telstra non-government funded sites are located within 3.3km (2600/3500MHz cell radius) and 6.6km (1800/2100MHz cell radius) of their nearby SA1 locations respectively. Despite this, Telstra has not deployed mid bands on the vast majority of these regional sites, including within 1.5km distance of

the nearby SA1 locations. While I do not have access to information regarding Telstra's network deployment strategy, in my experience and based on the analysis I have set out above, mid band spectrum could provide exceptionally good coverage and capacity in such areas.

Figure 30

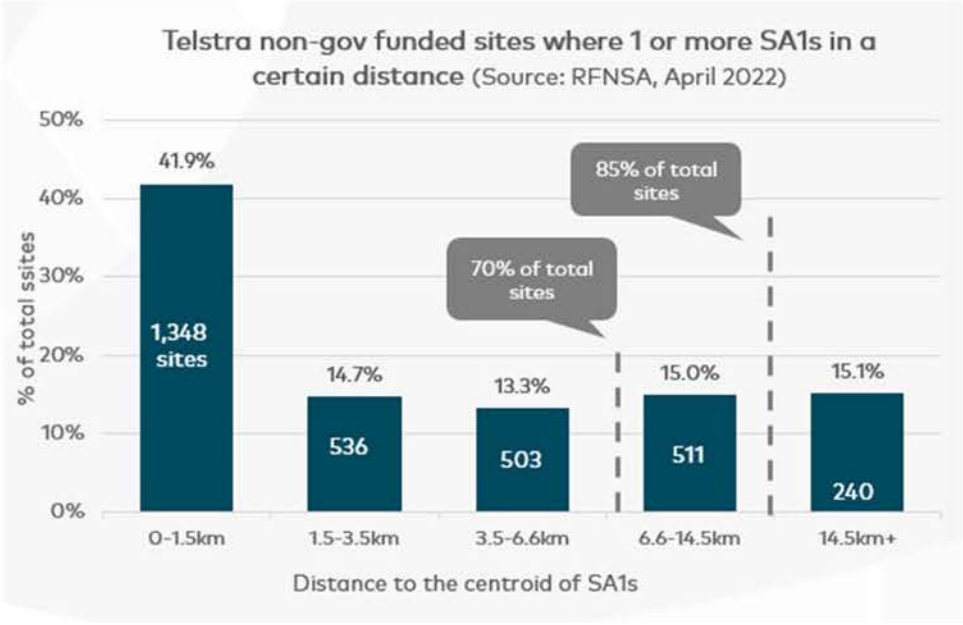
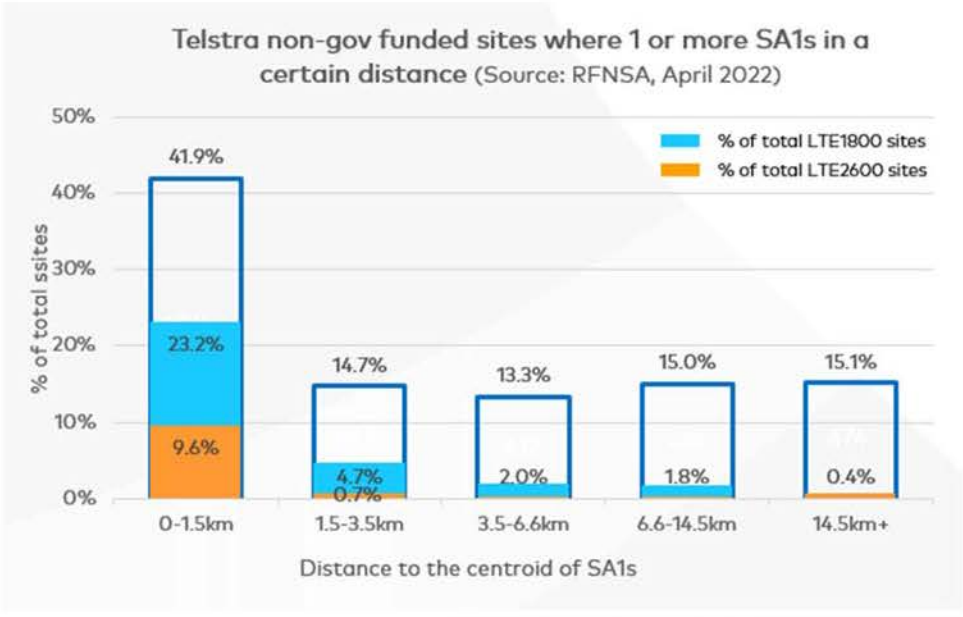


Figure 31



Note 1: Telstra site count is obtained based on the proposed MOCN coverage polygon developed by Optus from the publicly available Telstra's coverage maps and Optus-TPG eJV sharing boundary. It may involve minor error but is very insignificant. This site count is proximate to Telstra's public announcement of ~3,700 sites
Note 2: ACCC mobile infrastructure report 2022, https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC
Note 3: Optus estimated 3,752 Telstra macro sites1 within the proposed MOCN coverage zone. 613 sites have been co-funded by the government's mobile black spot program since 2015 in the remote areas. Hence only non-gov funded 3,139 sites are included in this analysis

112. Further, I understand that there are additional technologies and approaches that Telstra could deploy to expand capacity on its existing mobile sites and the speeds achievable by its regional networks without the Proposed Transaction. For example Massive

Multiple-Input Multiple-Output (**m-MIMO**) and multi-sector twin-beam antenna technology could enhance Telstra's use of mid band spectrum. I understand that Telstra has not introduced these technologies or methods in regional areas, which would enhance network capacity and capability if mid band spectrum were being fully deployed by Telstra.

7. Network capacity and the Aetha Report

113. I have carefully reviewed and considered the public version of the Aetha Report. In my view and based on my experience, I consider there to be a number of significant deficiencies with the underlying assumptions, methodology and conclusions in the Aetha Report.

114. In this section, I have addressed what I regard as the most significant issues that I have identified with the Aetha Report. However, that does not mean that I otherwise agree with or endorse the balance of the Aetha Report. For the reasons that I outline in further detail below, I consider that there are significant shortcomings with it. It sets out modelling that I consider to be incorrect and I would not rely upon it in the course of my role as Director of Spectrum Strategy and Management.

115. In particular, I explain below that the Aetha Report compares MNOs in two distinct ways:

(a) First, comparing MNO spectrum holdings using a method Aetha refers to as the 'site-weighted average effective downlink' (**SWAED**), and applying that method to various different metrics. This is not a method I have encountered in my 27 years of experience working in the telecommunications sector, nor is it a method I would consider to be a reliable means by which to assess spectrum availability and network capacity. I explain this issue further at paragraphs 117 to 139 below.

(b) Second, by developing a network dimensioning model to forecast network capacity over a five year period. There are a number of errors in the assumptions underlying Aetha's network dimensioning model which I regard as significant. I explain this in further detail from paragraphs 140 onwards.

116. As a result of these deficiencies in the Aetha Report, I consider the conclusions reached in it to be incorrect and unreliable.

A. *The SWAED method and its application in the Aetha Report*

117. The Aetha Report uses a number of metrics to compare the aggregation of Telstra and TPG spectrum as a result of the Proposed Transaction against Optus' spectrum. This includes SWAED spectrum per SIO and 'SWAED spectrum per SIO per site'. I consider both of these metrics further below.

118. Before I consider those metrics, I first assess the methodology that Aetha employs for averaging spectrum. Specifically, Aetha applies an averaging method that it refers to as SWAED spectrum. Based on Aetha's explanation, I understand that SWAED spectrum is calculated by summing the total effective downlink spectrum available at each site, and dividing that by the number of sites that the MNO has access to in the whole RCZ: Aetha

Report, pg 17. Aetha concludes that TPG / Telstra combined has an average of 218.3 of sub 6GHz SWAED MHz while Optus has 106.1, Telstra alone has 170.9, and TPG alone has 68. I understand this is a measure of MHz per site.

119. In my 27 years of experience in the industry, including in respect of spectrum valuations, analysing network dimensioning and spectrum planning, I have not encountered Aetha's SWAED approach. I consider that it does not provide meaningful insight into the comparative spectrum position of MNOs for the following reasons:

(a) Aetha uses the SWAED method to average the spectrum from all sites available to an MNO across the RCZ. This is a large geographical area across which MNOs have varied spectrum holdings across multiple spectrum licences and licence boundaries, meaning that those holdings cannot be used across the entire RCZ. This means the SWAED method does not account for the fact that the spectrum held by an MNO can only be deployed in certain parts of the RCZ.

(b) The SWAED method also does not account for the spread of traffic across the RCZ. By simply summing all spectrum available in the RCZ and dividing it by the number of sites in the RCZ, it incorrectly assumes the average spectrum that results will be capable of servicing all customers equally across the regional area. That assumes uniform customer distribution across the entire regional area: Aetha Report, p21. However, according to Australian Bureau of Statistics (**ABS**) 2016 census data, approximately 70% of the population in the RCZ is located within 0.32% of the total RCZ area (see Table 14 at paragraph 93 and examples of population distribution in regional towns at paragraphs 104 to 106).

(c) In calculating SWAED, Aetha has omitted remote apparatus licenced spectrum available to Telstra and TPG in the 2.1GHz band. If the SWAED method is accepted, including these apparatus licences it will increase the combined SWAED of TPG / Telstra by around 4%, Telstra's standalone SWAED by around 3%, and TPG's by around 6%. My calculations are presented in Table 16 below:

Table 16

Operator	Optus						Telstra						TPG						MOCN					
Analysis	Aetha			+ remote apparatus			Aetha			+ remote apparatus			Aetha			+ remote apparatus			Aetha			+ remote apparatus		
Band	Min	Max	SWAED	Min	Max	SWAED	Min	Max	SWAED	Min	Max	SWAED	Min	Max	SWAED	Min	Max	SWAED	Min	Max	SWAED	Min	Max	SWAED
700	10	10	10	10	10	10	20	20	20	20	20	20	15	15	15	15	15	15	30	30	30	30	30	30
850	0	0	0	0	0	0	20	25	24.7	20	25	24.7	5	10	5.5	5	10	5.5	30	30	30	30	30	30
900	20	20	20	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1800	15	25	22	15	25	22	15	40	33.8	15	40	33.8	0	30	13.3	0	30	13.3	15	40	33.8	15	40	33.8
2100	5	20	6.9	10	20	11.3	10	30	10.8	15	30	15.6	5	25	7.4	10	25	11.8	15	40	17.7	25	40	26.6
2300	0	73.5	3.6	0	73.5	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2600	20	20	20	20	20	20	40	40	40	40	40	40	0	0	0	0	0	0	40	40	40	40	40	40
3400	0	54	2.6	0	54	2.6	0	24.4	2.5	0	24.4	2.5	0	0	0	0	0	0	0	24.4	2.5	0	24.4	2.5
3600	0	26.3	20.9	0	26.3	20.9	0	60	39.1	0	60	39.1	0	71.3	26.9	0	71.3	26.9	0	93.8	64.2	0	93.8	64.2
Total SWAED			106.0			110.4			170.9			175.7			68.1			72.5			218.2			227.12

120. For these reasons, I do not consider the SWAED method to be an accurate indicator of what an MNO can achieve with the spectrum available to it. It does not account for several practical realities, including in respect of how spectrum can be deployed. On that basis I do not consider it an appropriate way to compare spectrum holdings of MNOs.

121. The SWAED method is, however, further relied on by Aetha to compare the spectrum holdings of the MNOs using different metrics. I consider this in further detail below.

SWAED spectrum per SIO

122. One of the metrics that Aetha uses to compare spectrum is SWAED bandwidth (or spectrum) per subscriber (SIO): Aetha Report, pg 21 Figure 3-7. I understand that Aetha refers to this metric on the basis that it is important to consider spectrum bandwidth per SIO as *'demand for capacity scales with the number of SIOs'*: p 27. I take that to mean that Aetha has used the bandwidth per SIO metric to show the capacity of MNO networks to service their existing customer base.

123. I do not, however, consider that this metric accurately achieves that result. In any event, I do not consider that SWAED bandwidth per SIO to be an appropriate means by which to compare the competitiveness of MNOs because:

(a) The SWAED method averages spectrum across sites in the RCZ, without considering the license boundaries to which that spectrum applies, and the spread of traffic across those regions, as I have described above. Without properly accounting for the spread of traffic across the regions, I do not consider that Aetha has achieved the outcome of determining whether MNOs can meet the capacity of their existing customer base with the spectrum that is already available to them. A more accurate approach by which to measure the capacity of MNOs to service their existing customer base using their existing spectrum holdings would be to compare MNOs on a region by region basis having regard to the boundaries applicable to their spectrum licences and the mobile sites that they have access to within those particular boundaries.

(b) Calculating bandwidth on an SIO basis is of limited utility when comparing the spectrum advantage that an MNO may have in terms of capacity. In my experience, considering a bandwidth per population count more accurately shows the ability of MNOs to compete when considering spectrum alone because:

(i) Comparing spectrum holdings on an SIO basis assumes a static market and only indicates the ability of a network to meet current demand. In order to accurately show the impact of an MNO's spectrum holdings on its ability to compete with other MNOs on capacity, it is important to consider

an MNO's ability to provide services beyond its existing customer base (ie an MNO's ability to service new customers with the spectrum available).

(ii) By way of contrast, bandwidth per population count acknowledges that MNOs have the ability to build (or lose) their customer base and allows for a comparison across MNOs using a common denominator. Spectrum auctions in Australia determine the value of spectrum based on population count. For example, I am aware of the ACCC's allocation limits advice in the context of the recent 850/900MHz auction, where the ACCC noted:

> '*…determining the spectrum requirements of an operator based on its existing customer base at any given point risks entrenching existing market structure, and restricts the ability of operators to improve their services in order to gain market shares over time.*' ('ACCC, 'Allocation limits advice for the 850/900 MHz spectrum allocation', ACCC March 2021, p 15)

I agree with the ACCC's observation and consider that Aetha's SWAED method focuses on existing market structure and, as a result, fails to account for the possibility of MNOs gaining market share over time.

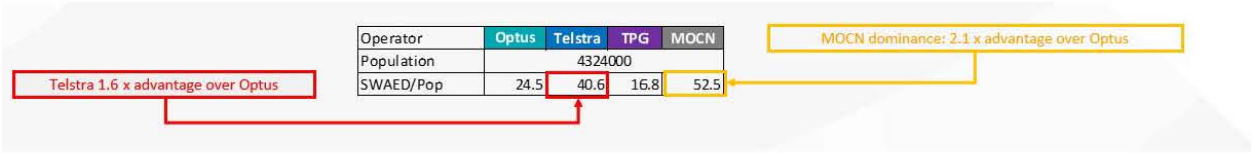
124. In applying the SWAED Bandwidth per SIO methodology, the Aetha Report concludes that '*the MOCN remains inferior to Optus on this measure when considering total mobile spectrum below 6GHz, and when considering only spectrum below 3GHz and only spectrum below 1GHz'* (pg 21). I do not agree with Aetha's conclusion.

125. The limited utility of the 'SWAED Bandwidth per SIO' approach is further demonstrated by the fact that Aetha's results (p 21) show that TPG without the Proposed Transaction enjoys a spectrum advantage over Optus, Telstra and the proposed Telstra / TPG MOCN. That is because 'SIO' forms the denominator in Aetha's calculation, and TPG has fewer SIOs than Optus and Telstra. I consider, however, that it is inaccurate to suggest TPG is at an advantage in providing customers in the RCZ with a superior network experience compared to Optus and Telstra (with or without the Proposed Transaction) as a result of its spectrum holdings. This is because TPG's spectrum is not necessarily deployed on all of its sites; nor are the site counts for each respective MNO considered in this metric.

126. Despite the criticisms I have set out above, I have applied the SWAED method below for the purposes of showing the alternate outcome if a 'per population count' approach was applied by Aetha (as opposed to a 'per SIO' approach). Using the SWAED MHz attributed to each MNO across Figures 3-2 to 3-5 of the Aetha Report and applying the SWAED method on a regional population count basis results in: (1) Telstra having

access to 1.6 times as much effective spectrum as Optus in regional areas and (2) the proposed TPG / Telstra arrangement benefiting from a 2.1 times advantage when compared to Optus in regional areas. That is illustrated in Table 17 below using the same regional population count referenced by Aetha (4,324,000). I have assumed this was divided by a customer penetration count to arrive at the SIO figures that is used in the Aetha calculations (Aetha Report, p 16).

Table 17



127. In addition to the approach taken by Aetha above, I have read the Applicants' Response and understand the Applicants have sought to illustrate the 'SWAED bandwidth per SIO' regional advantage which the Aetha Report suggests that Optus enjoys. In particular, at paragraph [65] of the Applicants' Response the Applicants refer to speed comparisons using third party network speed data provided by Ookla. The Applicants use that data to suggest that Optus' average download speed on low band spectrum in the RCZ is 33.5Mbps, while Telstra's is only 28.9Mbps.

128. I do not consider the Ookla data used to be an appropriate indicator of Optus having a speed advantage as a result of a claimed spectrum per SIO advantage. This is because:

(a) The Applicants' Response refers only to Ookla data comparing low band spectrum. Based on my experience, an accurate assessment of user speeds should address all users, not just those on a particular set of spectrum bands. Most customers in the RCZ will typically experience multi band deployment (not just low band spectrum), as regional customers are concentrated in populated areas that are proximate to mobile sites. As a result, most regional customers are able to be reached by various spectrum bands (not just low bands), and as a consequence will receive better speeds through multi band deployment. Almost all mobile phones in the market support aggregation of multiple bands deployed.

(b) Telstra's low band only assessment is further limited as the samples used were only from Android devices. iPhone users were not included in that comparison.

129. I instructed my team to analyse the same Ookla data source for all users, using all available spectrum, testing within the RCZ which, for the reasons noted above, I regard as a more accurate approach. On that approach it is clear Telstra is significantly ahead of Optus in average download speed (by [redacted] since November 2021. That analysis is set out in Figure 32.

SWAED spectrum per site per SIO

130. I understand the Aetha Report then proceeds to take the analysis one step further by multiplying SWAED spectrum per SIO by MNO site count. That is, Aetha applies the following calculation: [(SWAED x site count) / (SIO)]. I have already set out the shortcomings of the SWAED spectrum per SIO approach. As a result, in the following paragraphs I focus on the new factor introduced to the calculation, being the site count.

131. I have considered the site count provided per MNO at Figure 3-8 of the Aetha Report and the conclusions reached in Figure 3-9 regarding Sub-6GHz spectrum. By applying the equation above I arrive at different results to Aetha in relation to both Telstra and the proposed TPG / Telstra arrangement. My analysis is summarised in Table 18 below.

Table 18

	RRL sites	SWAED	Sites x SWAED	SIO (m)	(Sites x SWAED)/SIO(m)	
					Aetha report	Calculated
Optus	2743	106	290758	1.40	0.21	0.21
Telstra	3855	170.9	658820	3.71	0.14	0.18
TPG	834	68	56712	0.35	0.16	0.16
MOCN	3964	218.2	864944.8	4.05	0.16	0.21

Directly calculated from Aetha site numbers

Require modified site counts to achieve

132. Table 18 above shows that by using the same data and calculations as those presented in Figure 3-9 of the Aetha Report, I arrived at a different figure for both Telstra and the proposed Telstra / TPG arrangement (represented in the last column of Table 18 above) compared to Figure 3-9 of the Aetha Report (shown in the second last column of Table 18).

133. In order to determine the reason for this difference, I considered and then derived the site numbers that I expect Aetha will have used to arrive at the figures in Figure 3-9 for Telstra alone and the MOCN arrangement. In determining those figures, I assumed there had been a discounting of Telstra sites only (as I achieved the same results for TPG as those in Figure 3-9 of the Aetha Report using the site count in Figure 3-8 of the Report).

134. Taking that approach it appears that in order to achieve the results for Telstra and the MOCN arrangement set out in Figure 3-9 of the Aetha Report, Telstra's site counts have been discounted by between 18% and 23% from those presented in Figure 3-8 of the Aetha Report. The details of my analysis are presented in Table 19 below.

Table 19

	Solve for Telstra 0.14			Solve for MOCN 0.16		
	Sites	Reduction	% down	Sites	Reduction	% down
Telstra	3145	710	18.4%	2955	900	23.3%
MOCN	3254	710	17.9%	3064	900	22.7%

Site count reductions required to achieve numbers from Figure 3-9 of the latest Aetha report

135. In any event, the site count provided in respect of Optus by Aetha at Figure 3-8 (2743 sites) is overstated by a measure of approximately 500 sites. While I do not know why it is that Aetha came to apply that particular site count for Optus, I expect that it may be because Aetha included sites within the Optus-TPG passive sharing zone. That area covers the metropolitan zone rather than the RCZ as is suggested by Aetha. Whatever the reason for this site input, it is a material error which impacts Aetha's conclusions.

136. In light of that significant error, and the discounting that appears to have been applied by Aetha to Telstra's site count which I referred to above, I have attempted to replicate Aetha's approach by resorting to an accurate public source of site counts. Specifically, in Table 20 below, I have:

(a) used site information provided by each MNO in their 2020 Internet Activity Record Keeping Rule (RKR) submissions to the ACCC; and

(b) I have then re-applied Aetha's calculation.

137. This analysis shows that absent the Proposed Transaction Telstra is, at worst, equivalent to Optus. If the Proposed Transaction proceeds, Telstra and TPG would then enjoy an advantage over Optus.

Table 20

RKR	ACCC sites	SWAED	Sites x SWAED	SIO (m)	(Sites x SWAED)/SIO(m)	710 site discount	900 site discount
Optus	2458	106	260548	1.40	0.19		
Telstra	4760	170.9	813484	3.71	0.22	0.19	
TPG	834	68	56712	0.35	0.16		
MOCN	4869	218.2	1062416	4.05	0.26		0.21

Equivalent

Telstra advantage

MOCN advantage

138. If I apply a further step to this analysis, to correct some of the other issues I have described in above, namely to:

(a) apply the Aetha calculation on the basis of population count as opposed to SIO; and

(b) correct the amount of spectrum contemplated per SIO to include the 2.1GHz apparatus licences,

the disparity becomes even greater compared to the conclusion reached at Figure 3-9 of the Aetha Report. That further correction is provided in my analysis in Table 21 below.

Table 21

RKR	ACCC sites	SWAED	Sites x SWAED	Pop (m)	(Sites x SWAED)/pop(m)	710 site discount	900 site discount
Optus	2458	110.4	271363	4.324	0.06		
Telstra	4760	175.7	836332		0.19	0.16	
TPG	834	72.5	60465		0.01		
MOCN	4869	227.1	1105750		0.26		0.21

Telstra advantage

MOCN advantage

139. Together with my team, I have considered Aetha's reconstruction of the calculation presented in Optus' Submission which Aetha sets out at 3-10 of their Report. I understand that the errors in underlying facts I have noted above (notably in respect of Optus' regional site count and the 2.1GHz apparatus licence), carry over into Aetha's recalculation at Figure 3-10.

B. Aetha's network dimensioning methodology

140. Aetha also presents a model, which I understand is intended to assess the impact of the Proposed Transaction on the ability of each MNO to deliver services in the context of sustained growth in network traffic over a five year period commencing 1 July 2023 and

ending 30 June 2028. That modelling is set out at pages 25 to 45 of the Aetha Report and is summarised at paragraphs [71] to [76] of the Applicants' Response.

141. I understand that the results of the modelling are summarised at page 40 of the Aetha Report. Relevantly, Aetha finds that '*Optus has a slight superiority to the MOCN in the rate of growth in usage per SIO that it can sustain…based on a constant market share for each of the network operators.*'

142. I have considered Aetha's model and the underlying assumptions on which it is based. In my view, there are a number of errors in the underlying assumptions that undermine the conclusions reached by Aetha. I consider that Aetha's spectral efficiency calculations, and the 'frequency zone method' to be particularly significant. Specifically:

(a) Aetha uses a 'frequency zone method' which attributes a percentage to each mid band to show the proportion of low band coverage and capacity that the particular mid band can achieve on a single sector. Compared to low band, Aetha claims 1,800 / 2,100 MHz spectrum achieves the highest and 3,600MHz spectrum achieving the lowest proportion of coverage and capacity.

(b) Those proportions are then applied to the spectral efficiency of each band by Aetha resulting in spectral efficiency that is in my view discounted. This has an impact on Aetha's claim about the capacity of each mid band in its modelling. The greatest discount is applied to the 3,600MHz spectrum band.

(c) Based on calculations conducted by my team which I have verified, applying the data used for Aetha's frequency zone method and the spectral efficiency calculations, would require an average distance between mobile sites of 9.5km. However, on average, MNOs have a distance of 1.5 – 2.5km distance between cell sites in the RCZ. That discrepancy is significant because it has an impact on the purported ability of mid bands to provide coverage and capacity in the RCZ and the overall ability of MNOs to sustain capacity over the five year period considered by Aetha.

143. In my view these errors lead to Aetha forecasting Telstra's network congestion over a five year period in a way that is disproportionately inflated compared to other MNOs by Aetha. While the frequency zone method and spectral efficiency calculations are applied to each MNO, they disproportionately affect Telstra because of the significant discounting applied to the 3,600Mhz band (of which Telstra holds significantly more than Optus and TPG).

144. My detailed analysis of Aetha's frequency zone method and spectral efficiency calculations are set out below.

Frequency zone method

145. Aetha describes the sector traffic coverage (reach of each sector on a base station) in respect of each mid band spectrum frequency (expressed as a percentage of low band spectrum and referred to by Aetha as 'frequency zones') as an important input into the model: pg 26. I understand that the frequency zones are an input used in Aetha's network dimensioning model to determine the capacity at different distances that can be handled by a sector (and as aggregated, by the network in the RCZ).

146. The Aetha Report at page 50 assumes that low band spectrum covers '*the entire area and traffic served by a sector and each of the other bands as covering a proportion of the area and traffic served by the sector*'. That is reflected in Figure A-5 of the Aetha Report, which, for ease of reference, I have extracted below.

Figure A-5: Site category 54 characterising parameters

	700 / 850 / 900MHz	1800/2100MHz	2600MHz	3600MHz	BH-BS traffic (%)
Site 1	100.0%	69.8%	60.4%	29.2%	0.38%
Site 2	100.0%	75.0%	65.0%	31.4%	0.33%
Site 3	100.0%	86.5%	75.4%	35.9%	0.67%
Site 4	100.0%	76.1%	65.9%	31.9%	0.43%
Site 5	100.0%	70.2%	60.8%	29.4%	0.33%
Category 54	100.0%	75.5%	65.5%	31.5%	2.14%

147. I understand that 'category 54' in Figure A-5, is a site archetype used to demonstrate coverage, and sites 1 to 5 are examples of sites within that archetype. On that basis the row labelled 'category 54' below is showing the average coverage achieved on mid bands for that site archetype. That is an input into the modelling for all regional sites in Aetha's modelling.

148. For example, Aetha suggests that the 1,800/2,100MHz bands achieve 75.5% capacity and coverage from a single sector compared to low band spectrum (700 / 850 / 900 MHz) and that the 3,600MHz band achieves only 31.5% capacity and coverage from a single sector compared to low band spectrum. These percentages are then applied to Aetha's valuations of spectral efficiency to determine the capacity achievable by the entire regional network.

Spectral efficiency

149. The spectral efficiency (expressed in bps/Hz) that can be achieved by combinations of spectrum bands and technology, is also described by Aetha as an important input into its network dimensioning model: pg 26. I understand that spectral efficiency is used in the model to determine the amount of data that can be transmitted over a specific bandwidth.

The higher the spectral efficiency, the more data that can be transmitted and the more capacity that becomes available for any given bandwidth of spectrum.

150. Page 50 of the Aetha Report (Figure A-4), sets out the spectral efficiencies for each technology type and relevant spectrum band used in the model. For example, I understand that Aetha has assumed a spectral efficiency of 5bps / Hz for 3,500 / 3,600MHz spectrum using 64T64R technology. That is reflected in Table 22 under the heading 'Aetha SE assumptions'. It is unclear what the source of this spectral efficiency rate is. Whatever the source, it is at odds with:

(a) the industry recommended value for that technology of around 10bps / Hz (Chapter 10.4, 5G Technology 3GPP New Radio, 2020, Harri Holma, Antti Toskala, Takehiro Nakamura); and

(b) Optus' own estimation for that technology of [redacted] / Hz based on modelling in live regional networks.

151. Aetha has then applied the frequency zone ratios identified in Figure A-5 above, to its spectral efficiency estimates, further discounting them from the industry standards and Optus' own estimates.

152. I instructed my team to prepare Table 22 below to show the other difference between Optus' spectral efficiency data and that presented in Figure A-4 of the Aetha Report and the way in which the frequency zone ratios have been applied to further discount spectral efficiency in the Aetha model.

Table 22

5G Spectral Efficiency(SE)		Optus SE estimation[1,2]	Aetha SE assumptions			SE ratio to Optus
Bands (MHz)	MIMO	[redacted]	bps/Hz (non-FZ[3,4])	Band coverage ratio (FZ)	bps/Hz (FZ)	[redacted]
700/800/900	2T2R		1.50	100.0%	1.50	
1800/2100	4T4R		2.25	75.5%	1.70	
2600	4T4R		2.25	65.5%	1.47	
3500/3600	64T64R		5.00	31.5%	1.58	

Note 1: Industry reference: chapter 10.4, 5G Technology 3GPP New Radio, 2020, Harri Holma, Antti Toskala, Takehiro Nakamura
Note 2: Optus spectral efficiency estimation in regional populated areas, based on Optus' modelling in live regional 4G network and industry references
Note 3: Mobile traffic ratios that the mid-bands could serve from one Aetha's example, page 50-51, [Applicants (Expert report of Aetha) - 27.07.22 - PR VERSION - MA1000021 Telstra TPG.pdf]. Optus understands the values used in other areas of regional Australia are very similar based on Figure 4-11, page 37, [Applicants (Expert report of Aetha) - 27.07.22 - PR VERSION - MA1000021 Telstra TPG.pdf]
Note 4: FZ-Frequency zone applied by Aetha to define the traffic ratio for each band type according to its coverage ratio to the low-band coverage footprint. The spectral efficiency with band ratio applied is calculated as spectral efficiency times the band ratio, which is used by Aetha to calculate the offered spectrum capacity

153. Using Optus' more conservative estimates compared to the industry recommended value by Holma (5G Technology 3GPP New Radio, 2020), the table above still shows that Aetha has adopted what I consider to be discounted spectral efficiency values. For example, using the 3.5Ghz spectrum and 64T64R MIMO technology, Aetha estimates a 'non-frequency zone' or standard spectral efficiency of 5bps / Hz for 64T64R technology. Aetha then appears to multiply that spectral efficiency rate by the coverage ratios

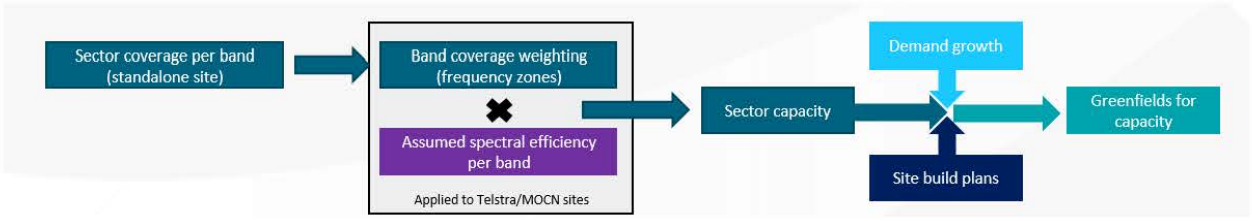
presented in Figure A-5 and set out above for the 3,500 / 3,600 MHz spectrum. This leads Aetha to conclude that 3,500 / 3,600 MHz spectrum using 64T64R technology and applying the relevant 'frequency zone' ratio has a spectral efficiency of 1.58bps/Hz. That is just [redacted] of Optus' estimate of [redacted]/Hz, which was derived using live regional network statistics.

154. The Aetha model multiplies the discounted spectral efficiency (as reflected in the column 'bps / HZ (FZ)' in Table 22 above) for each spectrum band by the available spectrum in each band, to determine the overall capacity per Telstra site in the RCZ.

Overall impact of deficiencies on Aetha's network dimensioning model

155. I prepared Figure 33 to summarise a simplified view of how the frequency zone coverage ratios and Aetha's discounted spectral efficiency drive Aetha's modelling of capacity. It shows that the coverage per band per sector set out in the frequency zone method is applied on a per sector basis in the model in order to determine the need for capacity greenfield site builds across the whole regional network of an MNO – that is, new sites that must be built across the regional network to manage capacity related constraints.

Figure 33



156. The error in this approach can be seen when Aetha's 'frequency zone' and spectral efficiency data is applied to determine the inter-site distance required to achieve those data points. Specifically, that shows a required average distance between mobile sites of 9.5km. However, based on RFNSA site location data, on average there is a distance of 1.5km–2.5km between cell sites for both Telstra and Optus in densely populated regional centres where 70% of the regional population resides. That error has an impact on how much coverage and capacity can be provided by an MNO on mid band spectrum in regional areas.

157. To illustrate this, I instructed my team to prepare:

(a) Table 23 below which shows the difference between Telstra's and Optus' estimates of the maximum distance from a base station where a user can expect service from the network for each spectrum band (I refer to this from hereon as the '**serving distance**'). Telstra's estimate of serving distance was determined using:

(i) the 6.3km serving distance of low band that is depicted in the Applicants' Response (at page 35, Figure 5); and

(ii) applying to that the formula of a standard three-sector hexagon cell radius, which is, in my experience standard industry practice when assessing site and spectrum requirements.

Optus' estimates of serving distances were derived from Optus' own live network statistics in regional Australia (as described at paragraph 28(b)). For the purposes of this Table and further calculations derived from it, a conservative approach was adopted by applying the lower end of the range which is noted at paragraph 28(b).

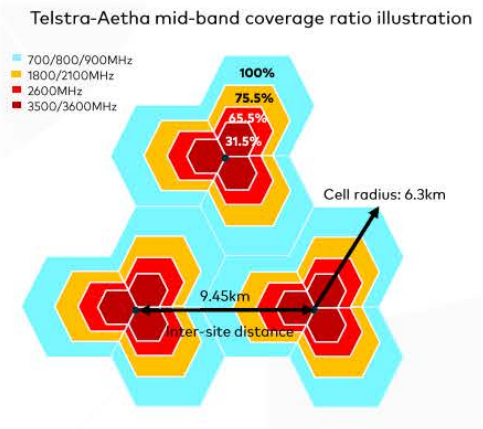
(b) Figure 34 which depicts the inter-site cell distance that would result if Aetha's frequency zoning and spectral efficiency data, and Telstra's serving distances in Table 23 were applied. Figure 34 was developed by calculating the relative serving distances per band that would be required to deliver the 'frequency zone' multipliers that Aetha presented in Figure A-5. If 6.3km represents 100% of the cell radius of Telstra's low band, then the inter-site distance needs to be at least 9.45km to ensure that other bands satisfy the coverage percentage ratios proposed by Aetha.

Table 23

	Telstra estimations		Optus estimations
Bands (MHz)	Band coverage ratio (FZ[1])	Serving distance derived (km)[2]	Serving distance (km)
700/800/900	100%	6.3km	14.5km+
1800/2100	75.5%	5.5km	6.6km
2600	65.5%	5.1km	3.5km
3500/3600	31.5%	3.5km	3.5km

Note 1: Mobile traffic ratios that the mid-bands could serve from one Aetha's example, page 50-51, [Applicants (Expert report of Aetha) - 27.07.22 - PR VERSION - MA1000021 Telstra TPG.pdf]. Optus understands the values used in other areas of regional Australia are very similar. based on Figure 4-11, page 37, [Applicants (Expert report of Aetha) - 27.07.22 - PR VERSION - MA1000021 Telstra TPG.pdf] . FZ-Frequency Zone
Note 2: page 35, figure 5, para 84, Applicants (Tranche 2 response to Optus' interested party submission and ors) - 28.07.22 - PR VERSION - MA1000021 Telstra TPG.pdf. The low band cell radius is used for this calculation. Telstra's mid-band cell radius of 1.5km is an apparent mistake as it is inconsistent with its mid-band coverage ratios

Figure 34



158. Taking the typical inter-site distance of 1.5km-2.5km in populated regional areas, the coverage from 3,500 / 3,600MHz mid bands with an average cell radius of 3.5km, can still overlap between sites to cover those areas. That is demonstrated in the examples of regional mid band coverage I provided above, including at paragraphs 103 to 106 above.

159. By applying the frequency zone coverage ratios and discounting spectral efficiency in this way, Aetha reaches a conclusion of lower traffic carrying capacity on mid band spectrum in accordance with their proposed 'frequency zones'. Notably, the band most affected by discounted coverage (in the frequency zone method) and discounted spectral efficiency is the 3,500 / 3,600Mhz band, where Telstra has the greatest spectrum holding advantage over Optus in regional areas.

160. As a result, the errors in the frequency zone method and spectral efficiency calculations in Aetha's Report have a disproportionate impact on Telstra's forecast network capacity compared to other MNOs.

161. To illustrate this, I instructed my team to develop a similar dimensioning method based on spectral efficiency (**Optus SE method**) to Aetha's which was applied to account for FY24 to FY28 network traffic growth. My team, however, used Optus' own spectral efficiency values (set out in Table 23 above) and did not apply the frequency zoning method. I have described above the various flaws that I consider that method to suffer.

162. This analysis tests the impact of Aetha's methodology on the:

    (a) Typical average sector spectrum capacity (Mbps), calculated by multiplying, for each band present on that sector, the spectrum bandwidth available at a typical regional sector (MHz) by the spectral efficiency associated with that band (bps / Hz) then summing the results for each band present on that sector. Typical bandwidths per band are set out in Table 24 below.

    (b) Total RCZ network capacity achievable (Tbps) by aggregating the multiplication set out in (a) for all of an MNO's sectors in the RCZ.

163. This analysis assumes 3 sectors per Telstra site, which was the approach taken in the Aetha Report.

164. The difference in the results between this approach and that taken in the Aetha Report is set out in Figure 35 below. The results show that the conclusions in the Aetha Report regarding sector and overall network capacity were effectively downplayed for each of Optus, Telstra and the MOCN arrangement (ie inflating forecast network congestion). There was, however, a particular impact in relation to Telstra and the MOCN arrangement. Specifically, the difference between these calculations and the Aetha Report shows:

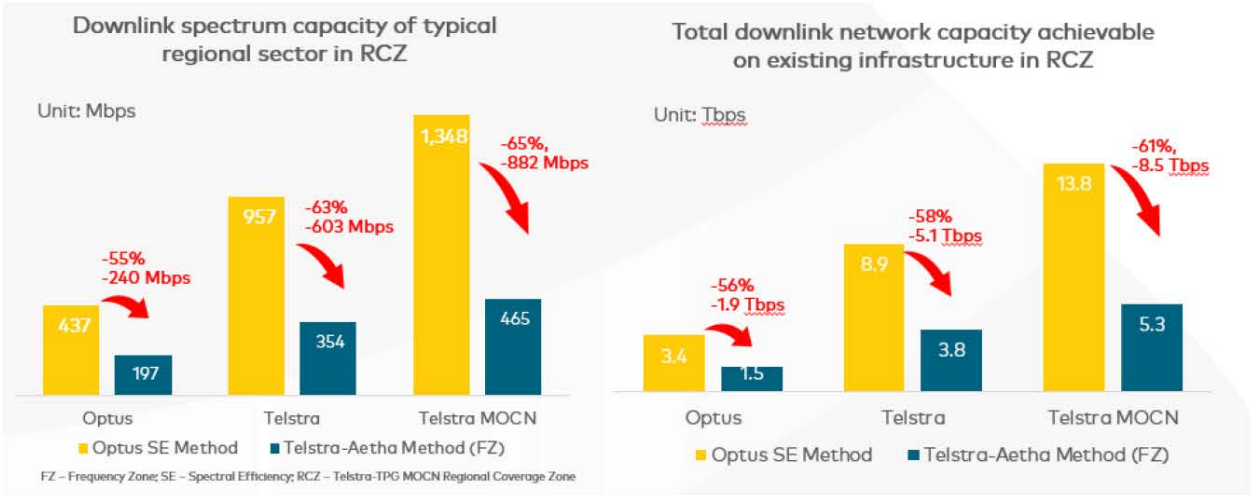
(a) Aetha discounted Optus' future average sector capacity in the RCZ by 55%, but Telstra's by 63% and the MOCN arrangement by 65%;

(b) Aetha discounted Optus' future total network capacity in the RCZ by 56%, but Telstra's by 58% and the MOCN arrangement by 61%.

Table 24

Typical regional sector downlink bandwidth in RCZ (MHz)			
Spectrum bands	Telstra	Optus	Telstra MOCN
700MHz	20	10	30
850MHz	25		30
900MHz		25	
1800MHz	40	25	40
2100MHz	20	15	35
2600MHz	40	20	40
3500/3600MHz	80	30	120
Total	225	125	295

Figure 35



Note 1: The average sector spectrum capacity, is calculated by aggregating the bandwidth (MHz) x band spectral capacity (bps/Hz) for all the available bands on sector level
Note 2: Total RCZ network capacity achievable is the sum of the average sector spectrum capacity of all existing sectors within the RCZ by activating all the available spectrum bands. Optus assumed 3-sector across all Telstra sites for this dimensioning, which is a common industry practice. Aetha also used this approach in their dimensioning

165. The Aetha Report then applies the results depicted above on an SIO basis and assumes a constant market share for each network operator in order to conclude that *'Optus has a slight superiority to the MOCN in the rate of growth in usage per SIO that it can sustain…based on a constant market share for each of the network operators.'*

166. I have already described the limitations of a bandwidth or capacity per 'SIO' approach to comparing MNOs above.

167. To test the validity of my understanding of the behaviour of Aetha's capacity and growth modelling and demonstrate my concerns with it, I asked the team to compare Optus' 5-year capacity greenfield build program using:

(a) Optus' internal (RANCAP) model;

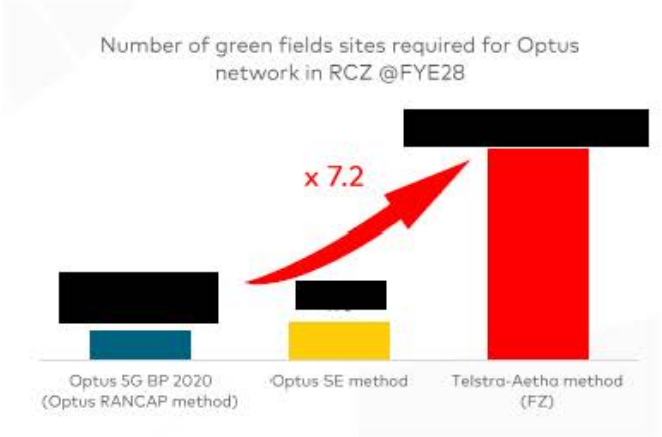
(b) a standard unweighted spectral efficiency and sector spectrum capacity model (**Optus SE method**); and

(c) the methods employed by Aetha in their report, including "frequency zones", their proposed spectral efficiencies and the resultant capacity reductions

168. As can be seen in Figure 36, the standard, unweighted spectral efficiency method delivers an outcome that is within 30% of Optus' actual plans. I consider this to be a satisfactory outcome as the Optus RANCAP model has been developed and optimised over more than 20 years. An "off the shelf" method with this level of accuracy is, in my view, perfectly acceptable.

169. The Aetha method, in contrast, produces a result that requires Optus to increase its capacity greenfield rollout by a factor of 7.2 over the projected period. In my professional view, this output indicates an unreliable model whose results should not be accepted. The compounding nature of the low starting spectral efficiency for a band with a high proportion of the spectrum on a cell and the use of the "frequency zone" concept to heavily reduce the capacity of a cell are the reasons for this significant over-statement of the need to build capacity greenfield sites.

Figure 36



170. On the basis of this result and my assessment of the inputs assumptions and techniques I have presented in this statement, I do not consider Aetha's modelling to be reliable.

Signature of witness

Steve Turner