Australian Government

Australian Communications and Media Authority

Replanning of the 3700–4200 MHz band

Options paper

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Contents

Contents (Continued)

Contents (Continued)

Executive summary

Spectrum in the 3700–4200 MHz band is the subject of considerable interest, both internationally and domestically, as suitable mid band spectrum for a range of applications including fixed satellite and 5G.

Current regulatory arrangements in the 3700–4200 MHz band are optimised to support the existing mixture of uses in Australia: apparatus licensed point-to-point links, coordinated fixed satellite service (FSS) earth stations, and various low power class licensed devices.[1] Increasing interest has focused on the lower and lower-adjacent parts of this band for 5G services, particularly given the large bandwidths potentially available in this range. This range includes the 3400–3575 MHz (3.4 GHz) band that the ACMA set out its policy approach regarding the band's defragmentation in the November 2019 planning decisions and preliminary views paper and the 3575–3700 (3.6 GHz) MHz band that was re-allocated for spectrum licensing in 2018.

As the current framework in the 3700–4200 MHz band does not support wireless broadband (WBB) use cases, the view of the Australian Communication and Media Authority (ACMA) is that a clear case exists for reviewing, and potentially changing, the spectrum management framework in the band. In considering any changes to use in the band, the ACMA is particularly alert to the needs of existing fixed satellite and point-to-point uses, as well as the potential for both wide-area and local area wireless broadband deployments.

This paper represents the next step in the review of planning arrangements in the 3700–4200 MHz band. We are looking at the whole band simultaneously, so there is an opportunity for a balanced planning approach that takes appropriate account of all interests. It follows the future of the 3700–4200 MHz band discussion paper (the '2019 discussion paper'), released in August 2019. It considers feedback provided on the relevant services and applications interested in accessing the 3700–4200 MHz band. It looks at international trends, domestic factors and the wider legislative policy environment informing any replanning decision.

After considering the feedback received from the 2019 discussion paper, together with recent ACMA policy decisions on the neighbouring 3400–3575 MHz and 3575–3700 MHz bands, the ACMA considers it timely to investigate future planning options by progressing the 3700–4200 MHz band to the preliminary replanning stage.

This paper identifies desirable planning outcomes for the 3700–4200 MHz band that the ACMA seeks feedback on. It proposes three options to meet these outcomes with differing emphasis for the use cases and licensing arrangements that are supported in the band. These desirable planning outcomes are:

> Introduce new WBB uses, both wide area and local area, with suitable technical frameworks.

> Support continued uses in the band for the following:

[1] While there is no radiodetermination service allocation in the band, several radiodetermination licences have been issued under section 10(7) of the Australian Radiofrequency Spectrum Plan 2017.

    - FSS use but maintaining no support for unlicensed2 FSS earth stations.
    - Point-to-point (PTP) use, focused on uses involved in the delivery of Universal Service Obligation services.
    - Radiodetermination services operated by the Department of Defence.
    - Earth station protection zones (ESPZs), as detailed in RALI MS44, to ensure there are long term options for FSS in the entire 3700–4200 MHz band in some locations.
    - Class licensing arrangements for building material analysis and ultra-wideband (UWB) devices.
- Ensure coexistence with adjacent band services, in particular radio altimeters operating above 4200 MHz and services below 3700 MHz.

Replanning options and their assessment

In the context of the domestic and international developments and informed by the desirable planning outcomes for the band, we have identified three broad replanning options for the 3700–4200 MHz band:

- Option 1
- Introduce arrangements to allow for WBB exclusively in one frequency segment, with no change to current arrangements in the remaining segment.
- Option 2
- Introduce arrangements to allow for WBB sharing with existing services in one frequency segment, with no change to current arrangements in the remaining segment.
- Option 3
- Introduce arrangements to allow for WBB both exclusively and shared with existing services in some segments, with no change to current arrangements in the remaining segment.

The ACMA preliminary view is that Option 3 is the preferred option for replanning the 3700–4200 MHz band. This option provides spectrum suitable for wide area and local area WBB uses in all areas. It reduces impact upon existing FSS and retains some spectrum for PTP uses. It consequently is likely to best achieve the desirable planning outcomes identified for the band.

Feedback on the issues presented in this paper will help inform us whether this identified option, or a variant, best meets the objective of maximising the overall public benefit from use of the 3700–4200 MHz band.

Issues for comment

The ACMA invites comments on the issues set out in this paper.

Specific questions are featured in the relevant sections of this paper and are collated below. Details on making a submission can be found in the Invitation to comment section at the end of this document.

[2] As per the ACMA website FSS receivers generally require a fixed earth receive apparatus licence. See also the Radiocommunications (Specified Radiocommunications Receivers and Types of Transmitter Licences and Receiver Licences) Determination 2014,

1. Comment is sought on the case for action and desirable planning outcomes for the 3700–4200 MHz band, including the supporting information at Appendices A, B and C.
2. Comment is sought on the proposed options, including appropriate values for frequency segment breakpoints as well as any alternative options.
3. Comment is sought on possible variations to the proposed options and implementation considerations.
4. Comment is sought on the discussion and outcomes of the assessment of options, including the cost benefit analysis and its assumptions. This includes any evidence for the value placed on the band for WBB and FSS use.
5. The ACMA invites comment on its preliminary preferred option.

Introduction

Purpose of this paper

In August 2019, the ACMA released a discussion paper identifying domestic and international considerations for the future of the 3700–4200 MHz band and inviting comment on possible changes in planning arrangements for the band. The consultation closed on 13 September 2019, with 23 submissions received.

An outcome of the 2019 discussion paper is that the ACMA is progressing its consideration of arrangements in the 3700–4200 MHz band from the initial investigation stage to the preliminary replanning stage of its planning process.

Comment is invited on the options and their development, including preferred options, presented in this paper to inform possible progression of the 3700–4200 MHz band to the replanning stage.

Legislative and policy environment

Managing spectrum efficiently and effectively for the benefit of all Australians is a key priority for the ACMA.[3]

Guiding legislation and policy

The ACMA's decisions are guided by the objects of the *Radiocommunications Act 1992* (the Act) to provide for management of the radiofrequency spectrum, in order to (among other goals):

> maximise—by ensuring the efficient allocation and use of the spectrum—the overall public benefit derived from using the radiofrequency spectrum

> make adequate provisions of the spectrum:

(i) for use by agencies involved in the defence or national security of Australia, law enforcement or the provision of emergency services

(ii) for use by other public or community services

> provide a responsive and flexible approach to meeting the needs of spectrum users

> encourage the use of efficient radiocommunication technologies so that a wide range of services of an adequate quality can be provided

> support the communications policy objectives of the Commonwealth Government.

Several communications policy objectives relevant to the replanning considerations in this band have been identified.

The 5G–Enabling the future economy strategy, released in 2017 committed to government actions to support the timely rollout of 5G in Australia, including making spectrum available in a timely manner.

Civil space policy is guided federally by the Australian Space Agency, which is part of the Department of Industry, Science, Energy and Resources. The Australian Civil Space Strategy outlines the Australian Government's plan to transform and grow the space industry over the next 10 years and contains a number of priority areas that the

[3] ACMA *Corporate plan 2019–20*

Australian Space Agency is giving focus to. Additionally, the Queensland and New South Wales state governments have developed space industry strategies that highlight the importance of ground stations for the space sector, echoing that of the Australian Space Agency. These strategies may influence industry's priorities and in turn some of the future uses for the fixed satellite service in the 3700–4200 MHz band.

In 2018 there was a Regional Telecommunications Review. The government responded to the review, including the recommendations around the Universal Service Obligation (USO), and is in the process of assessing the future of the USO, including potential USO voice service alternatives that may affect the need for some of the Telstra PTP links in the 3700–4200 MHz band.

Further context

While the government has not yet responded, the ACMA notes the parliamentary report Next Gen Future: Inquiry into the deployment, adoption and application of 5G in Australia was finalised in March 2020. Recommendation 1 of this report recommended that the ACMA finalise spectrum allocations expeditiously and investigate how future spectrum auctions can promote improved market competition for the benefit of consumers.

Licensing arrangements

There are three licensing approaches available to authorise access to spectrum—spectrum, apparatus and class licences. These approaches influence how options can be developed and implemented.

A spectrum licence authorises the operation of devices within a defined frequency range and geographic area, with a high degree of exclusivity. The geographic area can vary in size and can comprise the entire country. Spectrum licences are usually allocated by an auction and have historically been utilised for most bands used to deploy commercial mobile broadband networks. Spectrum licences may be allocated for up to 15 years.

An inherent feature of spectrum licensing is technological flexibility—that is, the licence conditions and associated technical framework, while usually optimised for an expected technology, specify generic technical conditions[4] and do not usually expressly mandate or limit specific technologies or services. This allows a licensee to deploy any technology that complies with the conditions of the licence. It is up to the licensee to manage interference between their devices (note that the adoption of international standards within the technical framework mitigates the potential for interference between devices). Spectrum licences are more conducive to secondary trading than apparatus licences, due to design features such as their longer tenure and their ability to be sub-divided.

An apparatus licence authorises the use of a radiocommunications device (or group of devices) operating under a specific radiocommunications service type, in a specific frequency range, and traditionally at one or more specific geographic locations for a period of up to five years. They are typically issued 'over-the-counter' in accordance with coordination rules developed by the ACMA. The ACMA charges fees and taxes for apparatus licences, which cover our costs and give people incentive to use spectrum efficiently.

The ACMA has now determined a new apparatus licence type called the area-wide licence (AWL). An AWL authorises the operation of one or more radiocommunications

[4] Technical conditions include maximum power, frequency range, out-of-band emissions limits, geographical licence area, and out-of-area emission limits.

devices within a defined geographic area within frequencies specified on the licence, subject to the conditions included on the licence. The licence type is proposed to be scalable, enabling its use for authorising different-sized geographic areas and bandwidths. Unlike other apparatus licence types—which typically align with specific uses and purposes—the AWL type will be capable of authorising a variety of services, uses, applications and technologies.

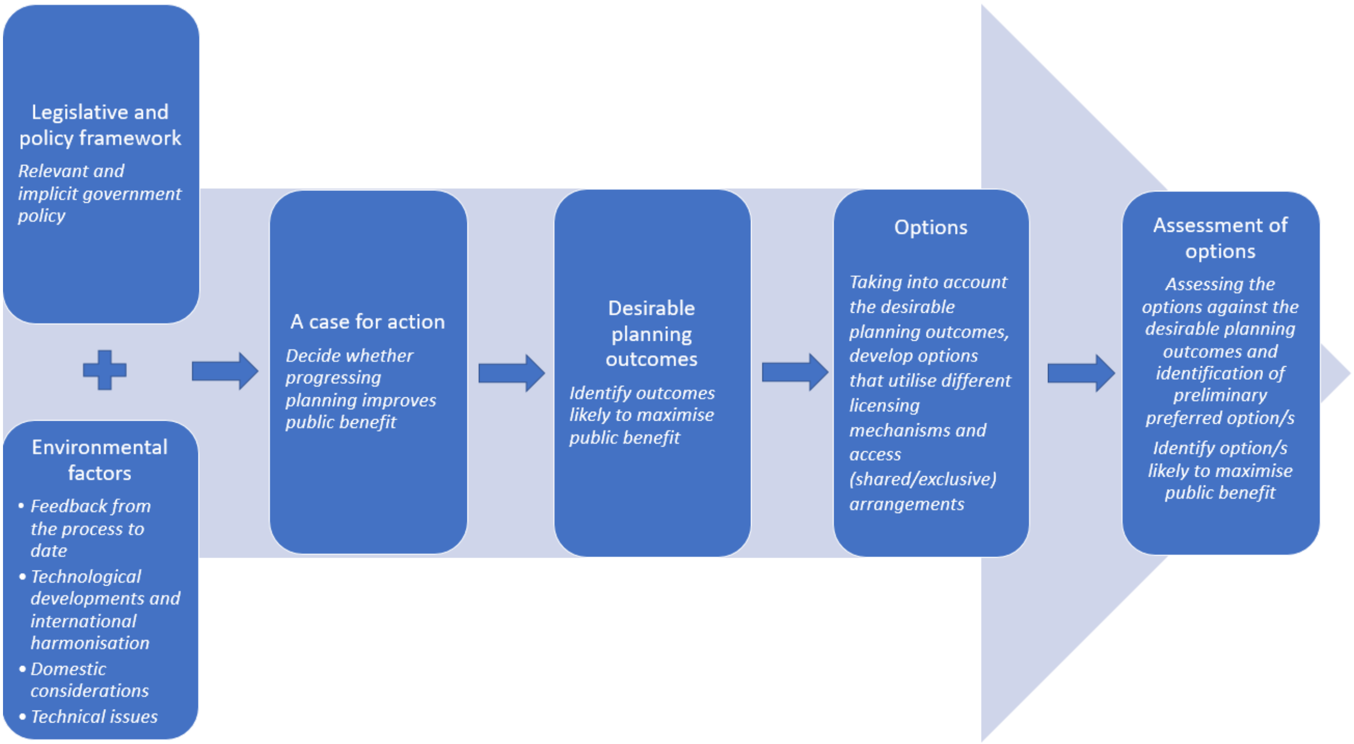
Class licences are a standing authorisation to access spectrum without the need to apply to the ACMA for an individual licence (hence no fees or taxes are paid), subject to the conditions of the relevant class licence. These conditions can be, among others, technical, geographic and/or pertain to the type of use or class of user.

Spectrum planning options development

The ACMA promotes the object of the Act and relevant government policy through a balanced application of market and regulatory mechanisms.

Figure 1 describes the approach the ACMA has used in developing and assessing preliminary replanning options for the 3700–4200 MHz band. The ACMA will continue to apply this general approach as it considers the responses to this paper and decides on the outcomes for the 3700–4200 MHz band.

Figure 1: Spectrum planning options framework



Issues not within the scope of this paper

The following issues are not within the scope of this paper.

Apparatus licence tax arrangements

A review of the apparatus licence tax arrangements that apply to different services is not within scope of this paper. The ACMA is seeking feedback from industry on its general review of apparatus licence taxes as part of the consultations on the implementation of the Spectrum Pricing Review and its annual work program, the FYSO.[5,6] Interested parties are invited to provide the views on apparatus licence taxes in the 3700–4200 MHz band as part of these processes.

Detailed licensing and allocation arrangements

Detailed licensing and allocation arrangements will be considered as part of any possible re-allocation process after a suitable replanning option is determined. Some licensing and allocation methods are described in the replanning options and assessment of options sections of the paper where relevant to aid discussion.

Other mid band frequency ranges

The scope of this paper is restricted to the 3700–4200 MHz band. While the relationship and technical coexistence with other bands with similar characteristics and uses are considered in the development of options, possible changes to arrangements in other bands (such as the 3.4 GHz and 3.6 GHz bands) are outside the scope of this paper.

Engagement in international activities

The scope of this paper does not extend to Australia's strategies or positions on WRC-23 agenda items (some of which include the 3600–3800 MHz band in some regions). These matters are dealt with separately through relevant ACMA and Department of Infrastructure Transport Regional Development and Communications-led preparatory processes. Stakeholders interested in these processes can get more information from the ACMA website or by contacting either the ACMA's International Radiocommunications Section (IRS@acma.gov.au) or the Department's International Radiocommunications Section (WRC@communications.gov.au).

Next steps

Table 1: Indicative timeline for progressing consideration of the 3700–4200 MHz band

Planning stage	Milestone	Date
Stage 3— Preliminary replanning	Release: *Replanning of the 3700–4200 MHz band* options paper	22 July 2020
	Submissions due to options paper	2 September 2020
	Release: Outcomes paper for the 3700–4200 MHz band	No earlier than Q4 2020
Stage 4— Replanning	Commencement of replanning stage, if applicable	No earlier than Q1 2021

[5] Information about the consultation process for the implementation of the Spectrum Pricing Review can be found at https://www.acma.gov.au/consultations/2020-02/implementation-spectrum-pricing-review-consultation-072020.

[6] Information about the consultation process for the Draft Five-year spectrum outlook 2020–24 can be found at https://www.acma.gov.au/consultations/2020-04/draft-five-year-spectrum-outlook-2020-24-consultation-092020.

As illustrated in Table 1, a decision on whether some or all of the 3700–4200 MHz band will be progressed to the replanning stage is expected by the final quarter of 2020.

The final form of actions taken in the replanning stage depend on the final replanning option chosen. In the event the ACMA believes the best replanning option involves re-allocating spectrum for the issue of spectrum licences, the following steps would be undertaken:

> The ACMA will consult on giving the Minister for Communications, Cyber Safety and the Arts (the Minister) a written recommendation to make a spectrum re-allocation declaration (section 153F of the Act) for the relevant frequencies and areas identified in the final option chosen. This would also include consultation on the recommended re-allocation period.[7]

> If the ACMA gives the Minister a written recommendation, the Minister may make a decision on whether or not to make a re-allocation declaration (section 153B).

> If the Minister makes a re-allocation declaration, the ACMA commences development of a technical framework and relevant allocation instruments for the re-allocated spectrum.

> Once this work is finalised, the spectrum will be released to the market. The ACMA normally uses a price-based allocation (an auction) when re-allocating spectrum in cases where demand is expected to be greater than supply.

In the event the ACMA believes the best replanning option does not involve re-allocating spectrum for the issue of spectrum licences, it would commence development of any necessary technical frameworks and/or allocation instruments for the release of the spectrum by an administrative allocation of apparatus licences.

[7] The re-allocation period specified in the re-allocation declaration sets the period of time that apparatus licences in spectrum flagged for re-allocation will continue to be re-issued and protected. It is possible for both spectrum licences and apparatus licences to be in effect concurrently during a re-allocation period. This occurs if the issue and commencement of a spectrum licence is deferred until the end of the re-allocation period. In that case, during any re-allocation period, spectrum licensees can negotiate with incumbent apparatus licensees for them to cease operation earlier. Alternatively, incumbent apparatus licensees could negotiate with spectrum licensees for ongoing access to the spectrum. Otherwise, at the end of the re-allocation period, any existing apparatus licences are cancelled.

The process to date

Consultation

On 7 August 2019, the ACMA released the 2019 discussion paper. The paper sought industry views on the potential uses of the 3700–4200 MHz band considering the latest international trends and domestic demands.

The 2019 discussion paper provided an overview of usage of the 3700–4200 MHz band at the national level and an overview of international developments. It identified incumbent and new interests in the 3700–4200 MHz band for the following spectrum application or service uses:

> Wide area (WA) WBB applications. These are WBB services that generally use network deployments over large, often contiguous, geographical areas, such as those traditionally undertaken by mobile network operators (MNOs) or some fixed telecommunication providers such as NBN Co. WA WBB users benefit from the certainty provided by long term, largely exclusive, access to spectrum, often (but not exclusively) through spectrum licences.

> Local area (LA) WBB applications. These are WBB services (often fixed) provided over smaller, local geographical areas to subscriber or private networks, such as those provided by wireless internet providers (WISPs), miners, local governments and utilities etc. LA WBB users often benefit from increased flexibility in geographic access to spectrum to tailor their service areas. Apparatus licences issued 'over the counter' are usually the preferred licensing and allocation mechanism.

> FSS. In the 3700–4200 MHz band, this refers to space to earth services received by apparatus licensed earth stations. These could be at major facilitates with multiple earth stations (sometimes referred to as gateways), individual, bidirectional Very Small Aperture Terminals (VSAT), and Television Receive Only (TVRO) applications.

> Fixed PTP. These are used, among other things, for data backhaul, and to provide USO telephony services by Telstra.

The ACMA sought feedback from stakeholders about their spectrum interests in the 3700–4200 MHz band and sought views on a range of questions. A summary of submissions is contained at Appendix A.

Summary of submissions

Twenty-three submissions were received, and can be found on the ACMA's website. Several themes emerged from the consultation.

Divergent views

The submissions had divergent opinions on the future planning of the 3700–4200 MHz band, but confirmed a strong interest in new applications being accommodated in the 3700–4200 MHz band:

> Satellite industry stakeholders generally either rejected changes in the 3700–4200 MHz band or requested continued protection for FSS.

> MNOs and equipment manufacturers were generally of the view that the 3700–3800 MHz segment should be allocated for spectrum licensing for WBB in areas identical to those used by the 3.6 GHz band spectrum licences, and that the 3800–4000 MHz segment should be considered for spectrum licensing in capital cities, where there are few incumbent FSS assignments.

- NBN Co requested the allocation of 100 to 200 MHz of spectrum for fixed WBB isolated from other uses, and Cambium Networks requested that all 500 MHz be allocated for fixed WBB.
- WISP stakeholders generally promoted localised WBB applications in all or part of the 3700–4200 MHz band, Australia-wide, with strong support for Dynamic Spectrum Allocation (DSA) if possible, or apparatus licensing, including AWLs.
- Four submissions supported DSA arrangements in the 3700–4200 MHz band, and Telstra did not object to DSA being considered in areas outside those potentially allocated for spectrum licensing.

Incumbent PTP services

Telstra noted use of an undisclosed number of PTP links to support USO telephony services. Telstra requested that any alternative arrangements proposed be carefully considered to ensure its USO requirements can still be met.

Incumbent coordinated and apparatus licensed FSS

Participants in the satellite industry stated that restacking[8], clearing[9] or geographically relocating any significant number of FSS stations is likely to be difficult, due to the capital costs of either relocation or technology alternatives. Frequency changes may also have regional implications, due to satellites covering multiple countries, and the ability to retune potentially affected telemetry and marker beacons on satellites which may operate at edges of the 3700–4200 MHz band is unclear. Submissions generally stated continuing demand for FSS in the 3700–4200 MHz band.

Unlicensed FSS earth stations

There were different views on the future protection of unlicensed FSS earth stations in the 3700–4200 MHz band. This includes consumer TVRO and commercial TVRO use, as well as other unlicensed earth stations. Measat recommended allocating a specific segment of the 3700–4200 MHz band to support ongoing TVRO use. Telstra requested implementing measures to prevent existing unlicensed TVROs to become licensed.

Several submissions also wanted protection for currently unlicensed FSS earth stations that are used, for example, for the reception of international broadcast program content.

Demand for WBB

There were differing views expressed on whether parts of the 3700–4200 MHz band should be made available for WBB, with some stating that, as no WBB has been rolled out in the adjacent 3.6 GHz band yet, the demand in the 3700–4200 MHz band is unknown. Various submissions highlighted other potential bands for WBB use.

The mobile industry generally considered there is a requirement for 100 to 200 MHz for WBB in the 3700–4200 MHz band. NBN Co was also in favour of progressing to the preliminary replanning stage and sought 200 MHz. Only VHA, which holds spectrum licences mainly at the top of the 3.6 GHz band directly adjacent to the 3700–4200 MHz band, indicated that it urgently wanted part of the 3700–4200 MHz band allocated to WBB. VHA suggested decoupling planning in the 3700–3800 MHz segment from the 3800–4200 MHz segment in order to expedite decision making.

[8] Changing frequency to another part of the 3700–4200 MHz band.

[9] Moving services from part or all of the 3700–4200 MHz band to another FSS band.

Wireless Avionics Intra-Communication (WAIC)/radio altimeters

The potential for interference and the need to protect these services was highlighted by Boeing and Airservices Australia but no information was provided to assist the ACMA in improving draft compatibility studies.

Embargoes

Telstra, Optus and AMTA recommended extending an existing embargo in the 3700–4200 MHz band or introducing spectrum embargoes during the planning process to prevent new services in areas where new WBB services are being considered.

International developments

The 2019 discussion paper provided a summary of international developments in the 3700–4200 MHz band. Since the release of that paper, additional developments of note include:

> The US Federal Communications Commission (FCC) decided to auction the 3700–3980 MHz segment of the 3700–4200 MHz band for 5G (i.e. WBB) use, preserving the 4000–4200 MHz segment for FSS use.[10] Some satellite operators have announced their intention to participate in an accelerated clearance program that includes relocation payments.

> In March 2020, Ofcom made a statement to award the 3.6–3.8 GHz band to mobile services, 'clearing fixed links from the band, and have given notice that satellite use will no longer be taken into account for spectrum management purposes'.

> In June 2020, the Ministry of Science and ICT in Korea announced it would reallocate the 3700–4000 MHz band for 5G use. This is in addition to the existing arrangements for 5G in the 3420–3700 MHz band.

> In December 2019, Ofcom introduced shared access licences in the 3800–4200 MHz band, including low power and medium power types to permit mobile and fixed WBB in the band.

> The April 2020, Global mobile suppliers association (GSA) 5G device ecosystem report announced that there are over 160 devices available in the 5G NR n77 and n78 bands (that cover some or all of the 3700–4200 MHz band) in various form factors.

> The final acts of WRC-19 under Resolution 811 identified the following issues for consideration at WRC-23:

  > Agenda item 1.2 to consider identification of the frequency bands 3 300–3 400 MHz (Region 2), 3 600–3 800 MHz (Region 2), 6 425–7 025 MHz (Region 1), 7 025–7 125 MHz (globally) and 10.0–10.5 GHz (Region 2) for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 245 (WRC–19).

  > Agenda item 1.3 to consider primary allocation of the band 3 600–3 800 MHz to mobile service within Region 1 and take appropriate regulatory actions, in accordance with Resolution 246 (WRC-19).

The 'C-band National Spectrum Positions – May 2020' brief available from the Global Mobile Suppliers Association (GSA) website gives a detailed snapshot of allocations considered globally in the 3700–4200 MHz band. Many countries currently have implemented or are planning allocations to WBB in various forms in the 3700–3800 MHz range and some in frequency ranges above that.

Domestic developments

[10] The FCC chairman wrote to Congress members on 18 November 2019, announcing the decision. The letters can be found at https://www.fcc.gov/chairman-pais-letters-congress. The chairman then formally announced the proposal on 6 February 2020.

The 2019 discussion paper sought information and views from stakeholders on future requirements of incumbent services in the 3700–4200 MHz band as well as new services such as WBB on a shared and exclusive use basis. The paper discussed:

> Preserving existing arrangements for ESPZs as detailed in RALI MS44 Frequency coordination procedures for the earth station protection zones.

> Preserving existing arrangements for building material analysis transmitters/ground penetrating radar and ultra-wideband (UWB) detailed in the Radiocommunications (Low Interference Potential Devices) Class Licence 2015 (the LIPD).

> Preserving arrangements for existing apparatus licensed radiodetermination services.

> Not supporting or providing protection from interference for unlicensed FSS use (including any TVRO, gateways and VSATs).

In March 2020, the House of Representatives Standing Committee on Communications and the Arts finalised the paper *The Next Gen Future: Inquiry into the deployment, adoption and application of 5G in Australia*. The government has yet to respond to the report. A key recommendation from this paper was:

The Committee recommends that spectrum allocation be finalised expeditiously and that the Australian Communications and Media Authority, in conjunction with the Department of Communications and Australian Competition and Consumer Commission, investigate how future spectrum auctions can promote improved market competition for the benefit of consumers.

The case for action

Identifying those spectrum use(s) most likely to maximise the public benefit derived from the band, is informed by an analysis of existing arrangements in the band and whether potential future uses of the band can be accommodated. This analysis is informed by technology developments occurring in the international environment as well as changes in spectrum demand occurring in the Australian market.

Technological developments and international harmonisation

Evolution in wireless communication technologies continues to improve the productive capability of the radiofrequency spectrum by allowing for more efficient use (for example by greater spectral efficiency and enabling new services to be delivered). By using the spectrum more efficiently, there is potential for more value to be derived from its use. Technology standards, for example those developed through 3GPP for wireless broadband, often drives these changes and are important in enabling economies of scale to be developed.

International spectrum harmonisation decisions of International Telecommunication Union (ITU) and decisions by national regulators reflect the extent to which spectrum is used for common purposes globally. Collectively, harmonisation, standardisation and international regulatory developments are important indicators of global trends informing factors such as economies of scale and global roaming.

The 2019 discussion paper noted that the 3700–4200 MHz band, in whole or in part, forms key 5G profile bands under the 3GPP (see Glossary) NR FR1 n77 (3300–4200 MHz) and n78 (3300–3800 MHz) bands. The 5G suite of technologies can be used for a wide variety of WA WBB and LA WBB applications. High performance point to multipoint (PMP) systems to support LA WBB deployments have also become available in parts of the 3700–4200 MHz band using similar access technologies to 5G, such as massive MU-MIMO OFDM[11] and beamforming.

International developments show there are numerous countries investigating or making parts of the 3700–4200 MHz band available for WA or LA WBB type applications. This indicates there will be WBB equipment available for use in all or part of the 3700–4200 MHz band. It is considered likely that economies of scale for such equipment will also develop, to further drive demand for, and the viability of WBB use of the 3700–4200 MHz band in Australia.

Use of the 3700–4200 MHz band for fixed links has declined over time. In addition to the analysis in the 2019 discussion paper, it has declined heavily in the United States with the Federal Communications Commission announcing in February clearance from the 3700–4000 MHz band. Use is also restricted in the United Kingdom. An EU Report indicated little use in 3400–3800 MHz in most countries and some reports of expected reducing use. A second EU Report indicates that fixed services (not including point to multipoint) have decreased by a factor of 3 from 2010 to 2016.

[11] Multiple user - multiple input multiple output, orthogonal frequency division multiplexing.

There have been some recent developments in FSS technology in the 3700–4200 MHz band. Satellites have started to use more localised C-band beams (for example, Intelsat 39 has 5 C-band beams) which may enable regional or area specific frequency use in the future. Nonetheless, many international regulatory decisions have trended towards less emphasis on FSS use of the band and more on WBB opportunities.

Consequently, the trend internationally is moving towards improving opportunities for WBB access to the 3700–4200 MHz band and less for FSS and PTP applications.

Domestic considerations

The social and economic benefits of WA WBB, as typified by services provided by MNOs and NBN Co., have been clearly articulated in numerous papers, including those produced by the Australian Mobile Telecommunications Association (AMTA)[12,13] and the Department of Infrastructure, Transport, Regional Development and Communications,[14] as well as in the regional telecommunications review. To realise these benefits and to continue to deliver new and evolving services, access to appropriate spectrum is required by WA WBB operators. Therefore, in part, determining whether WA WBB should be accommodated in the 3700–4200 MHz band depends on whether the net incremental value of WA WBB in this spectrum is likely to be greater than other services.

Similarly, the needs of WISPs, local governments, miners, utility companies and other localised or site-based wireless network operators are well documented (for example through submissions to various ACMA consultations such as the FYSO and the 3.6 GHz process).

Appendix B: Domestic considerations discusses the range of potential future uses of the 3700–4200 MHz band. A key conclusion is that there is likely to be a case for additional spectrum availability for WBB (both WA and LA) in the 3700–4200 MHz band. In addition, it is noted that the optimal allocation and licensing framework for each form of WBB is likely to be different.

The unique propagation characteristics of mid band spectrum and the global/regional distribution nature of many satellite systems operating in the band indicate that it remains valuable for FSS purposes. However, the limited licensed use of the band currently in Australia, supporting a relatively small number of large satellite facilities and discrete earth stations, and the availability of ESPZs, means that there may be opportunities to accommodate new uses while retaining the benefits of FSS use in the band.

The use of the 3700–4200 MHz band by PTP services is also identified and may indicate alternative delivery options for this spectrum use. However, it is noted that Telstra currently have regulatory requirements around the USO that may make retaining some use in the 3700–4200 MHz band for this use important.

Current regulatory arrangements in the 3700–4200 MHz band are optimised to support the current mixture of uses in Australia: apparatus licensed PTP links and coordinated FSS earth stations, and various low power class licensed devices.[15]

[12] AMTA State of the Industry Report, Mobile Nation: The economic and social impact of mobile technology, Deloitte Access Economics, Feb 2013.

[13] AMTA State of the Industry Report, 5G Mobile - enabling businesses and economic growth Deloitte Access Economics, October 2017.

[14] Impacts of 5G on productivity and economic growth, Bureau of Communications and Arts Research, April 2018.

[15] While there is no radiodetermination service allocation in the band, a number of radiodetermination licences have been issued consistently with section 10(7) of the *Australian Radiofrequency Spectrum Plan 2017*.

Given the discussion above, it appears that the mix of uses that are likely to maximise the overall public benefit in the band is changing to include different types of WBB. Catering for WBB in the band also supports the government's policy to support spectrum access suitable for 5G network deployments. As the current framework does not support WBB or 5G uses, the ACMA's view is that a clear case exists for reviewing, and potentially changing, the spectrum management framework in the band.

The ACMA has consequently decided to change the planning status of the band to preliminary replanning. This will consider the needs of and options for existing services in the 3700–4200 MHz band as well as new arrangements to support WBB. The planning stages are outlined in the FYSO.

Desirable planning outcomes for the 3700–4200 MHz band

A mix of uses is most likely to maximise the public benefit from use of the 3700–4200 MHz band. Existing and new uses identified for the 3700–4200 MHz band present potentially competing demands for access to spectrum. This is particularly the case in areas of high demand for access to spectrum such as cities and other large population centres. The reason is that deployments of one service can affect the ability of another service to deploy in the same or nearby area (referred to as spectrum denial). So, while options for sharing are generally considered when introducing new services, this needs to be weighed against the potential reduction in utility and access to spectrum it could cause to both existing and new services. In some cases, exclusive access and licensing arrangements may be the most appropriate approach.

The ACMA has identified several desirable planning outcomes for the band. In forming these desirable planning outcomes, the ACMA has considered the legislative and policy environment technological developments and international harmonisation issues, relevant domestic considerations and submissions to the 2019 discussion paper.

The ACMA acknowledges that any changes in spectrum management arrangements may impact existing uses and users (i.e. licensees) operating in the 3700–4200 MHz band. In assessing options, the ACMA identifies impacts on existing users and uses and, where possible, considers options for sharing or alternative arrangements that could enable the continued provision of these services (albeit potentially in a different way in the band or in another band). If an option does foresee loss of access for incumbent licensees, the ACMA can consider implementing any changes over time to reduce the impact so that incumbent licensees are provided with a clearly defined and adequate period to make the changes.

The desirable planning outcomes for the review of the 3700–4200 MHz band are outlined below with the linkage back to the legislative and policy environment identified:

1. Introduce WA WBB and LA WBB uses with frameworks suitable for both. Doing so is consistent with the legislative and policy framework work by:
   > Maximising the overall public benefit from using the spectrum (paragraph 3(a) of the Act).

   > Provide a responsive and flexible approach to meeting the needs of spectrum users (paragraph 3(c) of the Act).

   > Encourage the use of efficient radiocommunications technologies so that a wide range of services of adequate quality can be provided (paragraph 3(d) of the Act).

   > Support the communications policy objectives of the Commonwealth Government (paragraph 3(f) of the Act) by making spectrum for 5G available in a timely manner (5G–Enabling the future economy strategy).

2. Support a range of continuing uses in the band, in particular:
   A. Ongoing coordinated FSS use in some form and maintain the existing policy of not supporting or protecting unlicensed FSS earth stations. The ACMA will consider the specific circumstances of, and where possible mitigate the impact on, individual incumbent licensed FSS users. Doing so is consistent with the legislative and policy framework by:

a) Maximising the overall public benefit from using the spectrum (paragraph 3(a) of the Act).
b) Provide a responsive and flexible approach to meeting the needs of spectrum users (paragraph 3(c) of the Act).
c) Encourage the use of efficient radiocommunications technologies so that a wide range of services of adequate quality can be provided (paragraph 3(d) of the Act).

B. PTP use in some form. The ACMA will consider the specific circumstances of, and where possible mitigate the impact on, individual incumbent licensed PTP services, especially those involved in the delivery of USO services. Doing so is consistent with the legislative and policy framework by:

a) Maximising the overall public benefit from using the spectrum (paragraph 3(a) of the Act).
b) Provide a responsive and flexible approach to meeting the needs of spectrum users (paragraph 3(c) of the Act).
c) Encourage the use of efficient radiocommunications technologies so that a wide range of services of adequate quality can be provided (paragraph 3(d) of the Act).
d) Support the communications policy objectives of the Commonwealth Government (paragraph 3(f) of the Act) by supporting USO services.

C. Radiodetermination services operated by the Department of Defence. Doing so is consistent with the legislative and policy framework by making adequate provision of the spectrum for use by agencies involved in the defence or national security of Australia, law enforcement or the provision of emergency services (subparagraph 3(b)(i) of the Act).

D. ESPZs, as detailed in RALI MS44, to ensure there are long term options for FSS in the entire 3700–4200 MHz band. Doing so is consistent with the legislative and policy framework by:

a) Maximising the overall public benefit from using the spectrum (paragraph 3(a) of the Act).
b) Providing a responsive and flexible approach to meeting the needs of spectrum users (paragraph 3(c) of the Act).
c) Encouraging the use of efficient radiocommunications technologies so that a wide range of services of adequate quality can be provided (paragraph 3(d) of the Act).

E. Class licence arrangements for building material analysis/ground penetrating radar and UWB devices. Doing so is consistent with the legislative and policy framework by:

a) Maximising the overall public benefit from using the spectrum (paragraph 3(a) of the Act).
b) Providing a responsive and flexible approach to meeting the needs of spectrum users (paragraph 3(c) of the Act).

c) Encouraging the use of efficient radiocommunications technologies so that a wide range of services of adequate quality can be provided (paragraph 3(d) of the Act).

3. Ensure coexistence with adjacent band services is addressed. This includes radio altimeters operating above 4200 MHz, and existing spectrum and apparatus licensed services below 3700 MHz. Doing so is consistent with the legislative and policy framework by:

   > Maximising the overall public benefit from using the spectrum (paragraph 3(a) of the Act).

   > Providing a responsive and flexible approach to meeting the needs of spectrum users (paragraph 3(c) of the Act).

   > Encouraging the use of efficient radiocommunications technologies so that a wide range of services of adequate quality can be provided (paragraph 3(d) of the Act).

4. Comment is sought on the case for action and desirable planning outcomes for the 3700–4200 MHz band, including the supporting information at Appendices A, B and C.

Replanning options

The ACMA has identified several options for replanning the 3700–4200 MHz band that aim to address the identified desirable planning outcomes:

> Option 1
> Introduce arrangements to allow for WBB exclusively in one frequency segment, with no change to current arrangements in the remaining segment.
> Option 2
> Introduce arrangements to allow for WBB sharing with existing services in one frequency segment, with no change to current arrangements in the remaining segment.
> Option 3
> Introduce arrangements to allow for WBB both exclusively and shared with existing services in some segments, with no change to current arrangements in the remaining segment.

Each option is essentially a different combination of the same variables, which are:

> the services or applications that may be allocated, either new or existing, considering wide area (WA) and local area (LA) WBB applications, FSS earth receive and fixed PTP links
> whether allocations are proposed to be exclusive or shared
> potential licensing mechanisms
> the geographic area(s) within which a service or services may be allocated, and
> the frequency range(s) which any new arrangements apply.

Options that propose changes to PTP arrangements assume that changed arrangements are technically practicable.

Together with the release of this options paper, the ACMA has released spectrum Embargo 78 on the issue of new apparatus licences in the 3700-4000 MHz range. This is to preserve future replanning options and to minimise the effect that any possible future change in use might cause. It is noted this embargo does not apply to FSS applications in ESPZs.

When reading this section, note that:

> The geographic area terms ‘metro centres’, ‘regional areas’ and ‘remote areas’ are defined in Appendix A. These definitions are the same as those identified by the Minister for spectrum licensing in the 3.6 GHz band and, while indicative of the ACMA’s thinking, may subsequently change because of information provided in submissions to this paper.
> While breakpoints between frequency segments have been indicated in the options, they are indicative only and are based on the analysis in Appendix B: Domestic considerations. Appropriate values for any option depend upon several factors including feedback to this paper, the demand for specific applications, technology readiness including standards, and service compatibility such as with the adjacent band radio altimeters.

> The existing arrangements for building material analysis transmitters/ground penetrating radar and UWB transmitters operating in the 3700–4200 MHz band, set out in the LIPD Class Licence, are considered to be appropriate and therefore are proposed to be maintained under all options considered for the 3700–4200 MHz band.

> The existing arrangements for licensed radiodetermination services currently operating in the 3700–4200 MHz band in remote locations are currently considered appropriate and therefore are proposed to be maintained under all options considered for the 3700–4200 MHz band.

> The existing co-ordination arrangements in the 3700–4200 MHz band for the FSS in the ESPZs, as described in RALI MS44, are currently considered appropriate and therefore are proposed to be maintained under all options considered for the 3700–4200 MHz band. The ESPZ section in Appendix B: Domestic considerations discusses the ESPZs.

> This paper is limited to considering arrangements for the FSS downlink in the 3700–4200 MHz band only and not for the associated FSS uplink band (5925–6425 MHz band). The ACMA may undertake further work on the associated uplink band, when the scope of any changes determined for the downlink band are clear.

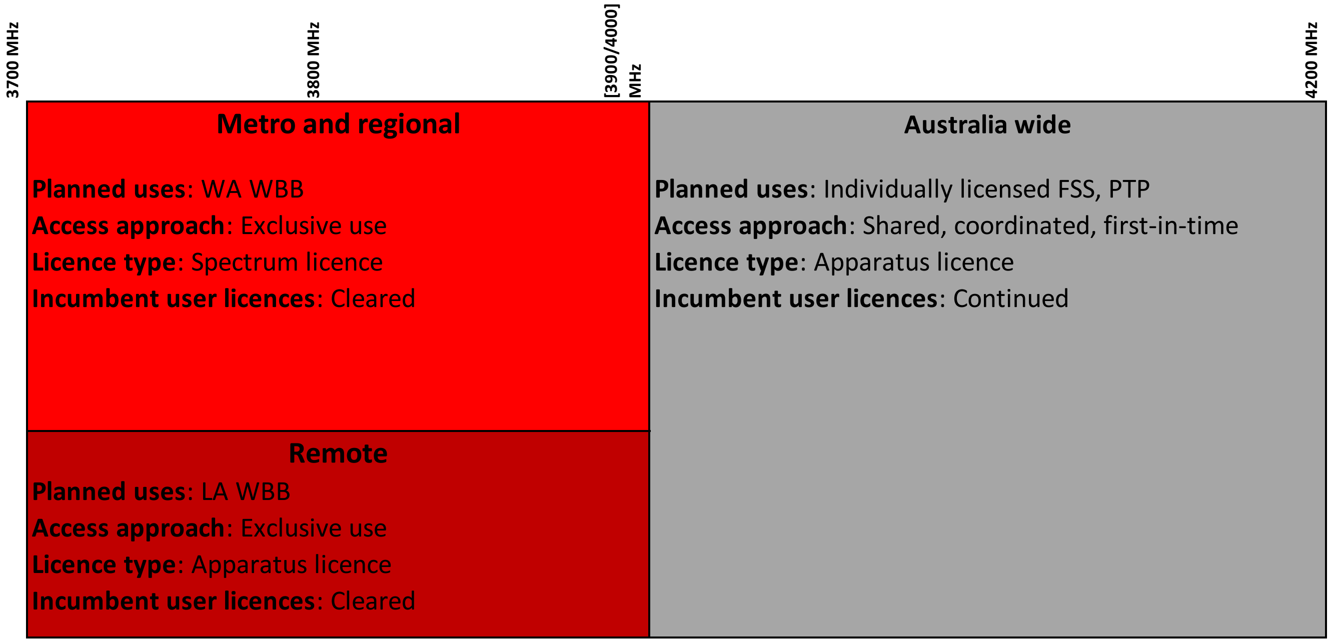
Comment is sought on the proposed options, including appropriate values for frequency segment breakpoints as well as any alternative options.

Option 1

Introduce arrangements to allow for WBB exclusively in one frequency segment, with no change to current arrangements in the remaining segment.

Option 1 clears incumbent users from a frequency segment for use by new services and retains a second segment for incumbent service under current arrangements.

Figure 2: Illustration of Option 1



Changes by frequency segment

3700–3900 or 4000 MHz

> Clear the frequency range of incumbent FSS and PTP apparatus licences Australia-wide.

> Issue spectrum licences, optimised for WA WBB deployments, in metro and regional areas.

> Introduce arrangements for apparatus licensed (PMP or AWL) LA WBB applications in remote areas.

> Remove arrangements for new coordinated apparatus licensed FSS and PTP services.

3900 or 4000 MHz–4200 MHz

> No change. Continue shared, coordinated, first-in-time apparatus licence arrangements for FSS and PTP Australia wide.

Under this option, spectrum is provided for WA WBB in metro and regional areas on an exclusive basis. Spectrum is provided for LA WBB in remote areas on an exclusive basis.

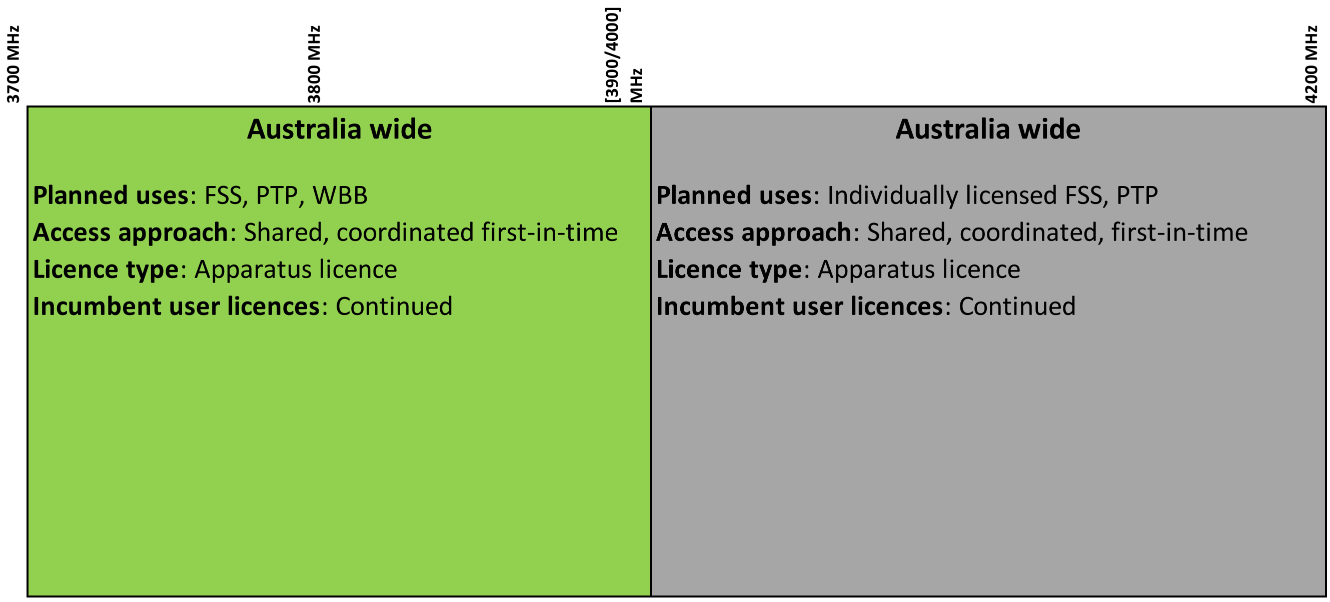
Spectrum available for FSS and PTP services is reduced Australia wide.

Option 2

Introduce arrangements to allow for WBB sharing with existing services in one frequency segment, with no change to current arrangements in the remaining segment.

Option 2 introduces arrangements for new services in a frequency segment on a shared basis with incumbent services and retains a frequency segment for incumbent services under current arrangements.

Figure 3: Illustration of Option 2



Changes by frequency segment

3700–3900 or 4000 MHz

> Introduce shared arrangements for apparatus licensed, WBB (e.g. AWL or PMP). This would support WA and LA WBB applications on a first-in-time shared, coordinated basis with FSS and PTP Australia wide.

3900 or 4000 MHz–4200 MHz

> No change. Continue shared, coordinated, first-in-time apparatus licence arrangements for FSS and PTP Australia wide.

Under this option, spectrum is provided for WBB in all areas on a shared basis.

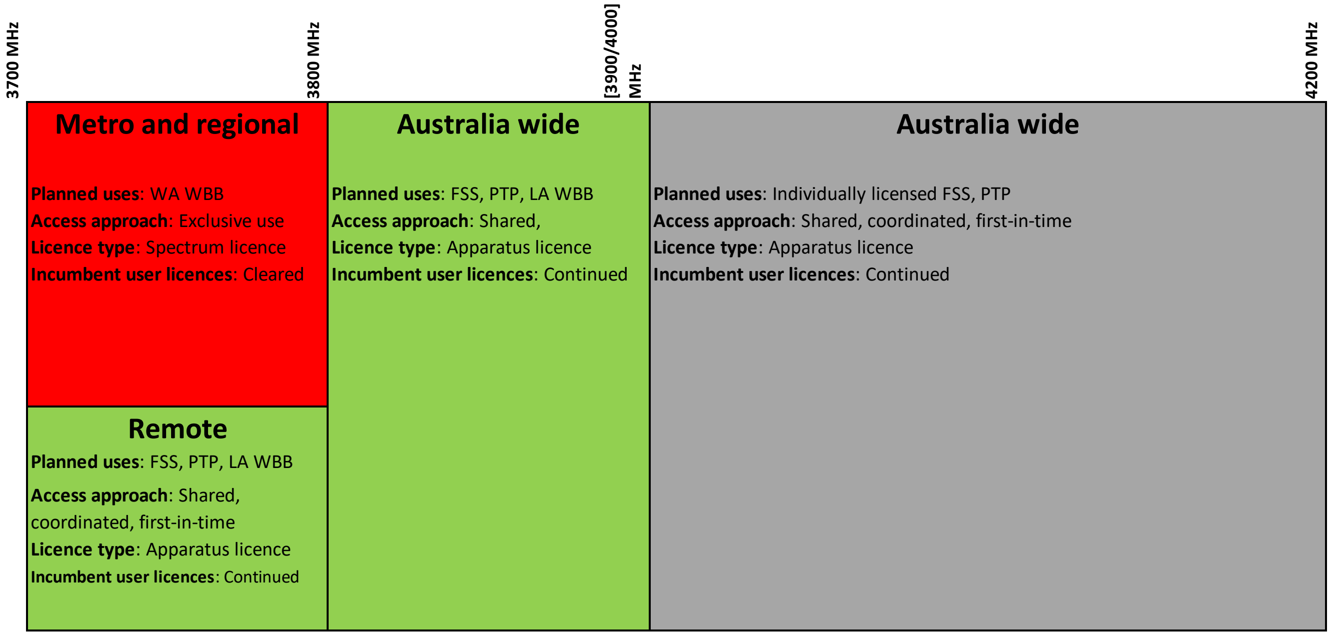
Spectrum for FSS and PTP services are maintained across the whole band.

Option 3

Introduce arrangements to allow for WBB both exclusively and shared with existing services in some segments, with no change to current arrangements in the remaining segment.

Option 3 clears incumbent users in a frequency segment in metropolitan and regional areas. It introduces new services on a shared basis in remote areas in the same segment and Australia-wide in a second frequency segment. It retains a frequency segment for incumbent services under current arrangements.

Figure 4: Illustration of Option 3



Changes by frequency segment

3700–3800 MHz

> Issue spectrum licences, optimised for WA WBB deployments, in metropolitan and regional areas.

> Remove arrangements for coordinated apparatus licensed FSS and PTP services in metropolitan and regional areas.

> Introduce arrangements for apparatus licensed (AWL or PMP) to support LA WBB applications on a shared, coordinated, first-in-time basis with FSS and PTP services in remote areas.

3800–3900 or 4000 MHz

> Introduce arrangements for apparatus licensed (AWL or PMP) services to support LA WBB applications on a shared, coordinated, first-in-time basis with FSS and PTP services Australia wide.

3900 or 4000–4200 MHz

> No change. Continue shared, coordinated, first-in-time apparatus licence arrangements for FSS and PTP Australia wide.

Under this option, spectrum arrangements are provided for WA WBB in metropolitan and regional areas. Spectrum is provided for LA WBB in metro, regional and remote areas on a shared basis.

Spectrum available for FSS and PTP is reduced in metropolitan and regional areas but maintained in remote areas.

Table 2: summary of options by service type

Option	FSS space to earth	WA WBB	LA WBB	Fixed PTP
Option 1	3700–3900 or 4000 MHz Cleared from the segment Australia wide 3900 or 4000–4200 MHz Provision Australia-wide via shared, coordinated first-in-time apparatus licence (AL)	3700–3900 or 4000 MHz Exclusive provision in metro and regional areas via spectrum licence (SL) 3900 or 4000–4200 MHz No provision	3700–3900 or 4000 MHz Exclusive provision in remote areas via AL 3900 or 4000–4200 MHz No provision	3700–3900 or 4000 MHz Cleared from the segment Australia wide 3900 or 4000–4200 MHz Provision Australia-wide via shared, coordinated first-in-time AL
Option 2	3700–3900 or 4000 MHz Provision in metro and regional areas via shared, coordinated first-in-time AL 3700–4200 MHz Provision Australia-wide via shared, coordinated first-in-time AL	3700–3900 or 4000 MHz Provision in metro and regional areas via shared, coordinated first-in-time AL, for WA or LA WBB 3900 or 4000–4200 MHz No provision	3700–3900 or 4000 MHz Provision in metro and regional areas via shared, coordinated first-in-time AL, for WA or LA WBB 3900 or 4000–4200 MHz No provision	3700–3900 or 4000 MHz Provision in metro and regional areas via shared, coordinated first-in-time AL 3700–4200 MHz Provision Australia-wide via shared, coordinated first-in-time AL
Option 3	3700–3800 MHz Cleared from the segment in metro and regional areas. Provision in remote areas via shared, coordinated first-in-time AL 3800–3900 or 4000 MHz Provision Australia-wide via shared, coordinated first-in-time AL 3900 or 4000–4200 MHz Provision Australia-wide via shared, coordinated first-in-time AL	3700–3800 MHz Exclusive provision in metro and regional areas via SL 3800–4200 MHz No provision	3700–3800 MHz Provision in remote areas via shared, coordinated first-in-time AL 3800–3900 or 4000 MHz Provision Australia wide via shared, coordinated first-in-time AL 3900 or 4000–4200 MHz No provision	3700–3800 MHz Cleared from the segment in metro and regional areas. Provision in remote areas via shared, coordinated first-in-time AL 3800–3900 or 4000 MHz Provision Australia-wide via shared, coordinated first-in-time AL 3900 or 4000–4200 MHz Provision Australia-wide via shared, coordinated first-in-time AL

Possible option variations

Incumbent use of PTP and FSS is low in Melbourne, Canberra, Adelaide and Brisbane metro areas ('low incumbency metros'). The cost of clearing incumbent services in the 3800–3900/4000 MHz segment for exclusive WBB use could therefore be low and result in higher public benefit. A variation of Option 3 could be to clear incumbent services in low incumbency metro areas in the 3800–3900/4000 MHz segment but keep shared arrangements proposed in Perth, Sydney, regional and remote areas.

Another variation could be to allow coordinated LA WBB in parts of the band that allowed shared arrangements above 3900/4000 MHz, provided there is sufficient protection of services in adjacent bands. This may require the use of technical conditions on the LA WBB (such as lower powers) to achieve coexistence.

Implementation considerations

Consideration needs to be given to the length of transition periods to any new arrangements, especially to an appropriate reallocation period for any geographical area and frequency segment that may be subject to a spectrum reallocation declaration in the 3700–4200 MHz band. It may be desirable to grandfather certain incumbent FSS or PTP licences even under options proposing to clear a frequency segment, for example PTP services identified as critical to ongoing USO use. In these cases, the method to be able to retain certain services will depend upon the licence type (SL or AL).

For Options 2 and 3, where segments propose sharing of WBB with FSS and PTP, it may be possible to develop an AWL scheme to suit all three service types. This could involve determining a power flux density (PFD) limit that applies at an AWL boundary. A licensee would then need a licence that covered an area large enough so that:

> If transmitting, the signal level from the transmitter does not exceed the PFD limit at the licence boundary.

> If receiving, the PFD permitted at another licensee's boundary is not likely to cause interference to the receiver. This may require a potential FSS receive licensee to have a licence that covered a large enough area to avoid interference depending upon the technical circumstances.

A potential PTP licensee may have a licence that covers multiple areas per link or even a corridor, subject to where they can/cannot meet the prescribed PFD limit; to permit the transmitting end and to protect the receiving end.

Where time synchronised TDD services exist, additional considerations may have to been made to accommodate non-synchronised systems. The 26 GHz and 28 GHz bands allocation processes are considering suitable AWL schemes and will inform the future possible outcomes in the 3700–4200 MHz band. For Options 2 and 3, additionally, decisions would need to be made whether to grandfather existing FSS and PTP services under their current licence type or transition them to an AWL scheme.

Comment is sought on possible variations to the proposed options and implementation considerations.

Assessment of options

The ACMA has undertaken a preliminary assessment of the options against the *Desirable planning outcomes* for the 3700–4200 MHz band, is informed by a preliminary quantitative cost benefit assessment.

Feedback received to this assessment will inform the ACMA's further consideration of the replanning options.

Comment is sought on the discussion and outcomes of the assessment of options, including the cost benefit analysis and its assumptions. This includes any evidence for the value placed on the band for WBB and FSS use.

Assessment against the desirable planning outcomes

Desirable planning outcomes 1 and 2A are discussed in detail below as each option addresses these outcomes differently. These desirable planning outcomes represent potentially competing use cases. Consequently, they are largely the focus of the assessment.

While each option addresses planning outcome 2B differently, as detailed in the Consideration of spectrum requirements and options for PTP section of Appendix B, the ACMA has analysed the demand for PTP. It concludes that any nominal amount of spectrum provided for PTP use should be sufficient. All options provide some spectrum for PTP use Australia wide and are therefore considered to meet the needs of PTP. Therefore, there is no difference between options for objective 2B.

Each option addresses planning outcomes 2C to 3 effectively in the same way, and hence offer no scope for differentiation between options, they are therefore not discussed further.

Desirable planning outcome 1

To introduce WA WBB and LA WBB uses with frameworks suitable for both.

WA WBB

As detailed in Appendix B, the ACMA has analysed the expected supply and demand of mid-band spectrum for WA WBB suitable for wide-bandwidth 5G services. International standards and developments as well as whether a viable equipment ecosystem exists or is likely to evolve for a band were considered. This analysis identified the amount of additional spectrum in the 3700–4200 MHz band that would enable four WA WBB operators to gain access to 100 MHz and 80 MHz of spectrum in metro and regional areas respectively across the broader 3400-4200 MHz band.

The results of the ACMA's analysis showed that up to 100 MHz of additional spectrum in metro and regional areas of the 3700–4200 MHz band would meet this notional target. While access to this amount of spectrum is not necessarily required to deploy a viable service, it would enable operators to realise the full potential of 5G and maximise the return on their investment.

Options 1 and 3 both provide at least 100 MHz of additional spectrum optimised for WA WBB and are therefore considered to meet the needs for WA WBB and are rated high for WA WBB.

Option 2 is unlikely to enable some or all WA WBB operators to gain access to larger contiguous bandwidths in many areas. This is because the proposed shared access arrangements do not provide access to spectrum in a manner optimised for WA WBB (e.g. through largely exclusive access arrangements). The spectrum denial caused by incumbent services could also reduce the amount of spectrum available and fragment access to the band in many areas. This option is rated low for WA WBB.

LA WBB

As detailed in Appendix B, the ACMA has analysed the supply and demand for mid-band spectrum for LA WBB suitable for fixed/mobile private WBB networks. International standards and developments, as well as whether a viable equipment ecosystem exists or is likely to evolve for a band, were considered. This analysis identified the amount additional spectrum in the 3700–4200 MHz band that would enable three LA WBB operators to gain access to 40 MHz to 100 MHz of spectrum across the broader 3400–4200 MHz band, in a particular area.

The ACMA's analysis indicates that, this outcome could be supported, if in the order of 100 MHz to 200 MHz of additional spectrum in regional and metropolitan areas of the 3700–4200 MHz band was made available for LA WBB use.

Option 1 provides for no arrangements in metropolitan and regional areas in a manner optimised for LA WBB uses (i.e. all WBB access would be via spectrum licensing, which is better suited for WA WBB use). It is consequently rated low for LA WBB.

Option 2 provides the potential for access to sufficient spectrum under arrangements that could be used for LA WBB use (e.g. under apparatus licensing, including potentially through AWLs). However, the spectrum would be shared between FSS, PTP, WA WBB and LA WBB uses. Consequently, there is the potential for contention for access to the band under this option. This would reduce the total amount of spectrum available for LA WBB use in different areas. It may also require the use of market-based mechanisms, such as an auction, to manage demand from competing interests. Such an approach has generally not been favoured by LA WBB operators as they may find it difficult to compete with larger operators and the since the geographic area may not be well tailored for their local service offerings. This option is rated as medium for LA WBB.

Option 3, which provides arrangements suitable for LA WBB (along with spectrum optimised for WA WBB to avoid contention). The ACMA considers that this option would best meet the needs of LA WBB in metropolitan and regional areas. It is rated high for LA WBB.

Table 3: Desirable planning outcome 1 assessment rating

Option	WA WBB rating	LA WBB rating
1	H	L
2	L	M
3	H	H

Desirable planning outcome 2A

To support a range of continuing uses for the band, in particular ongoing coordinated FSS use in some form and maintain the existing policy of not protecting unlicensed FSS earth stations. The ACMA will consider the specific circumstances of, and where possible mitigate the impact on, individual incumbent licensed FSS users.

Submissions to the 2019 discussion paper indicated that there is still interest in accessing the 3700–4200 MHz band for FSS, but there were different views on whether this demand is increasing or decreasing.

It is acknowledged that FSS operators would prefer not to be geographically restricted in order to maximise business opportunities and reduce complexity in their deployments. Therefore, any option that excludes FSS from large areas may limit the potential benefits realised from such use. This needs to be balanced against the needs of other services wanting to access the same spectrum (often in areas of greater population), where appropriate.

As will be discussed in Appendix B, existing use is high in the Sydney and Perth metropolitan areas across the 3700–4200 MHz band but relatively low in other areas.

Consequently, options can be considered from two perspectives—general opportunities for FSS uses into the future, and the impact that the option would have on incumbent licensees, especially in Sydney and Perth. All options would address Objective 5 of preserving ESPZs, which ensures opportunities for FSS across the entire band at several discrete locations.

Option 1 has the most impact on existing and future FSS use across the lower part of the band (the exact extent will be dependent on the frequency range chosen for the option) across all geographies. It is rated low for FSS.

Option 2 would have the least impact on future FSS use across the entire band Australia-wide and has no impact on incumbent users—including the major usage in Sydney and Perth. It is noted that the deployment of WBB services could limit the ability of FSS operators to deploy new services in some areas. This option is rated high from the perspective of current and future FSS opportunities.

Option 3 reduces the impact on current and future FSS use compared to Option 1. However, it still imposes constraints on FSS use in the 3700–3800 MHz band in metro and regional areas, compared to Option 2. It is rated medium for FSS.

Table 4: Desirable planning outcome 2A assessment rating

Option	FSS rating
1	L
2	H
3	M

Quantitative cost benefit analysis

Where evidence is available, a quantitative analysis is also undertaken, to inform the overall planning decisions for the band.

The quantitative analysis, when undertaken, reflects a cost/benefit evaluation. This analysis is detailed in Appendix F: Cost benefit analysis. The value placed on the spectrum by the 'new' incoming use may form a proxy for the benefit (using previous prices paid for equivalent spectrum as a guide), while estimated costs for existing uses are calculated from the necessary expenditure incumbent users would incur by having to retune or purchase new equipment to allow a new use to enter the band. This quantitative cost benefit analysis is generally based on a 'constant output' case, that assumes the current services can continue to be delivered (via some form) under the options being considered. Where an incumbent use would have no alternative mechanism for supply, the loss of that service is considered qualitatively within the overall assessment of options.

While potentially providing some useful insights—especially in comparing options—it is acknowledged that there are limitations to a quantitative cost benefit analysis.

Firstly, all inputs are estimates, often with large margins between point estimates. Precise data is either impossible to acquire (e.g. future auction outcomes) or unavailable to obtain in practice (exact knowledge of equipment related costs and user business decisions, etc).

The assessment of each option then integrates the outcomes of the quantitative preliminary cost benefit analysis, together with consideration of relevant qualitative factors to assist in determining the public benefit derived.

Each option is analysed using currently available information and assigned a rating of high (H), medium (M), or low (L) according to the extent to which the option addresses the factor being considered. A rating is assigned relative to the other options under consideration, rather than to some external, absolute, ideal.

The preliminary cost benefit concludes that the option with the highest net benefit is option 3 and the one with the lowest is Option 2. It considers that the benefits of providing spectrum for use by WA and LA WBB services is greater than the costs incurred by affecting incumbent FSS and PTP services. Many costs and benefits are, however, difficult to quantify. It is noted that for FSS, continued access to the band, regardless of the option, is provided long term within the ESPZs.

A key influence for the costs is the relative number of FSS gateways that may need to relocate under each option, as well as which of them may be able to retune to other segments of the 3700–4200 MHz band. The analysis indicates that, under current licences and assumed parameters, there is only a small difference in affected FSS gateway numbers, hence cost, between Options 1 and 3. However, there is likely to be large differences in unquantifiable benefits due to the difference in restrictions upon future FSS deployments between those options.

The cost benefit analysis is intended to be updated with information obtained in feedback to this paper. Consequently, the ACMA will review this analysis before making any decisions on planning arrangements in the 3700–4200 MHz band.

Summary

The approach that is likely to maximise the public benefit from use of the 3700–4200 MHz band is likely to include a combination of arrangements for FSS, WA WBB, LA WBB and PTP.

Option 1 was given a low rating for both FSS and LA WBB but the highest for WA WBB. It (marginally) had the second-best net benefit under the preliminary cost benefit analysis. It is rated low to medium overall.

Option 2 was given the highest rating for FSS but scored low and medium for WA and LA WBB uses respectively. It had the lowest net benefit under the preliminary cost benefit analysis. It is rated medium overall.

Option 3 was rated either high or medium for all objectives (i.e. no low rating). It had the highest net benefit under the preliminary cost benefit analysis. It is rated high overall.

Consequently, Option 3 appears most likely to provide an outcome that leads to the highest public benefit of the band.

Table 5: Overall assessment rating summary

Option	WA WBB rating	LA WBB rating	FSS Rating	Cost benefit analysis rating	Overall rating
1	H	L	L	M	L/M
2	L	M	H	L	M
3	H	H	M	H	H

Conclusion of the assessment of the options

The assessment against the desirable planning outcomes has identified Option 3 as maximising the overall public benefit and is therefore the ACMA preliminary preferred replanning option.

Option 3:

> Maximises—by ensuring the efficient allocation and use of the spectrum—the overall public benefit derived from using the radiofrequency spectrum.

> Provides a responsive and flexible approach to meeting the needs of spectrum users by providing a mix of service types and allocation methods in the 3700–4200 MHz band.

> Encourages the use of efficient radiocommunication technologies so that a wide range of services of an adequate quality by introducing new service types into the 3700–4200 MHz band.

> Supports the communications policy objectives of the Commonwealth Government by providing spectrum that can be utilised for 5G technologies.

> Supports the communications policy objectives of the Commonwealth Government by retaining spectrum that can be utilised for FSS technologies.

> Supports the communications policy objectives of the Commonwealth Government by retaining spectrum that can be utilised for PTP technologies that may still be required to support the future of the USO.

The option meets the desirable planning outcomes as follows:

> A segment for excusive WA WBB uses in metropolitan and regional areas.

> Segments for shared LA WBB Australia wide.

> Retaining access to the whole band for FSS and PTP use in remote areas.

> Retaining access to the whole band for FSS use at ESPZs.

> Segments for shared FSS and PTP use Australia wide.

> A segment for FSS and PTP use only Australia wide.

> Existing arrangements for LIPD and radiodetermination devices remaining the same.

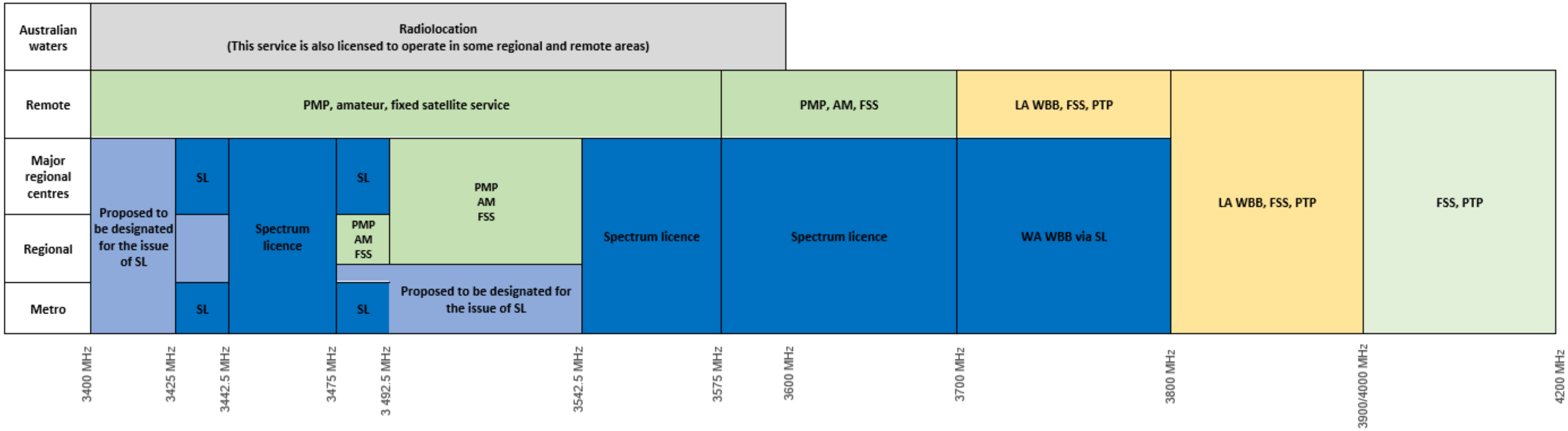
> Coexistence with adjacent band services below 3700 MHz could be enabled via the development of appropriate technical conditions, for example adoption of the same synchronisation requirement that applies to 3.4 GHz spectrum licences.

> Coexistence with adjacent band radio altimeters operating above 4200 MHz could be enabled via the implementation of a suitable guard band and possibly coordination criteria. Based on current and impending allocations around the world in the 3700–4200 MHz band, the ACMA considers that a guard band of no more than 200 MHz would be sufficient in this case. Smaller guard bands (potentially with coordination arrangements) could be considered when more detailed parameters for radio altimeters performance are obtained.

The ACMA invites comment on its preliminary preferred option.

It is useful to show the overall possible arrangements, including proposed decisions in the 3400–3575 MHz band, across the whole of 3400–4200 MHz band. A possible arrangement for Option 3 is included at Figure 5. It has been colour coded by similar service type or service type grouping.

Figure 5: 3400–4200 MHz possible planning arrangements—Option 3



Key:
PMP: Point-to-multipoint
PTP: Point-to-point
FSS: Fixed satellite service
AM: Amateur
SL: Spectrum licence
WA WBB: Wide-area wireless broadband
LA WBB: Local-area wireless broadband

Invitation to comment

Making a submission

The ACMA invites comments on the issues set out in this options paper.

> Online submissions can be made via the comment function or by uploading a document. Submissions in Microsoft Word or Rich Text Format are preferred.

> Submissions by post can be sent to:

The Manager, Wireless Broadband
Spectrum Planning and Engineering Branch
Australian Communications and Media Authority
PO Box 78
Belconnen ACT 2616

The closing date for submissions is **COB, Wednesday 2 September 2020**.

Consultation enquiries can be emailed to freqplan@acma.gov.au.

Publication of submissions

The ACMA publishes submissions on our website, including personal information (such as names and contact details), except for information that you have claimed (and we have accepted) is confidential.

Confidential information will not be published or otherwise released unless required or authorised by law.

Privacy

Privacy and consultation provide information about the ACMA's collection of personal information during consultation and how we handle that information.

Information on the *Privacy Act 1988* and the ACMA's privacy policy (including how to access or correct personal information, how to make a privacy complaint and how we will deal with the complaint) is available at acma.gov.au/privacypolicy.

Glossary

Term	Definition
3.4 GHz band	Refers to the 3400–3575 MHz frequency range
3.6 GHz band	Refers to the 3575–3700 MHz frequency range
3GPP	3rd Generation Partnership Project—an international body responsible for the standardisation of (cellular) mobile (including broadband) telecommunications, including the 2G, 3G, 4G and (soon) 5G technology standards.
5G	5G refers to the fifth generation of mobile technology, in line with the International Mobile Telecommunications-2020 (IMT-2020) Standard of the International Telecommunication Union and the associated releases of the 3rd Generation Partnership Project (3GPP).
Act	*Radiocommunications Act 1992*
Apparatus licence	An apparatus licence authorises, under the Act, the use of a radiocommunications device, in a particular frequency range and at a particular geographic location for a period of up to five years.
ASMG	Australian Spectrum Map Grid—used to define geographical areas over which spectrum licences are issued. The HCIS is used to define the cells that make up the ASMG. The ASMG is described in detail in the document: The Australian spectrum map grid 2012. See also HCIS.
Class licence	A standing authorisation under the Act for the operation of an unlimited number of radiocommunications devices operating within a set of conditions specified within the authorisation.
Coordination	The process of assessing the interference potential that existing licensed services and a proposed new service will have on each other. Coordination is generally deemed to fail if the level of interference exceeds the ACMA's protection criteria for the services involved.
DSA	Dynamic Spectrum Allocation or Dynamic Shared Access, both terms for changing spectrum use dynamically in time.
Embargo	A spectrum embargo is a policy notice of intent by the ACMA to restrict the allocation and issue of new licences in a frequency range for a time, to support replanning of that frequency range. Spectrum may still be able to be accessed on an exceptional basis through an application for an exemption to the embargo. Embargoes are published on the ACMA website.

Term	Definition
HCIS	Hierarchical Cell Identification Scheme—a naming convention developed by the ACMA that applies unique 'names' to each of the cells of the ASMG. Each five-minute of arc square cell in the ASMG is assigned a unique identifier, derived from the cell's position in a hierarchically arranged grouping of cells. The hierarchy has four levels. A detailed description of the HCIS is available on the ACMA website. See also ASMG.
FSS	Fixed satellite service. In the 3700–4200 MHz band, this refers to space to earth services received by apparatus licensed earth stations. These could be at major facilitates with multiple earth stations (sometimes referred to as gateways), individual, bidirectional VSAT and TVRO applications.
FWA	Fixed wireless access.
Ku band	An FSS frequency band using frequencies of about 12 GHz space to earth and 14 GHz earth to space.
MBB	Mobile broadband.
LA WBB	WBB services (often fixed) provided over smaller, local geographical areas to subscriber or private networks such as those provided by WISPs, miners, local governments and utilities, etc.
MNO	Mobile network operator.
PMP	Point-to-multipoint.
PTP	Point-to-point.
PTS	Public telecommunications service.
Re-allocation of spectrum	Under section 153B of the Act, the minster can re-allocate specific frequencies and areas for the issue of spectrum (or apparatus) licences. A result of this process is the cancellation of incumbent apparatus licences in the identified areas at the end of a defined timeframe known as the re-allocation period.
Re-allocation period	The period before incumbent apparatus licenses that fall wholly or partially within the frequencies and areas to be re-allocated under section 153B of the Act will be cancelled. The re-allocation period is required to be a minimum of two years.
Spectrum licence	Issued under the Act and authorises the use of a frequency band within a geographic area for a period of up to 15 years. The geographic area can vary in size, up to and including the entire country.

Term	Definition
TDD	Time Division Duplex—a technique where downlink and uplink communications use the same frequency but are separated by the allocation of different slots. This means uplink and downlink communications cannot occur at the same time.
TVRO	Television Receive Only.
WA WBB	WBB services generally using network deployments over large, often contiguous, geographical areas such as those traditionally undertaken by MNOs or some fixed telecommunication providers such as NBN Co.
VSAT	Very Small Aperture Terminals.
WBB	Wireless broadband.
WISP	Wireless Internet Service Provider.

Appendix A: Summary of submissions

Overview

The ACMA released the consultation Planning of the 3700–4200 MHz band on 7 August 2019. The consultation period closed on 13 September 2019, with the last submission received on 20 September 2019. Twenty-three public submissions were received from:

> The Australian Broadcasting Corporation (ABC)
> Airservices Australia
> The Australian Mobile Telecommunications Association (AMTA)
> The Australian Safeguards and Non-proliferation Office (ASNO) within the Department of Foreign Affairs and Trade (DFAT)
> The Australian Subscription Television and Radio Association (ASTRA)
> Boeing Australia
> Cambium Networks
> The Communications Alliance Satellite Systems Working Group (CA SSWG)
> Eutelsat
> Huawei Technologies (Australia)
> Inmarsat
> Intelsat
> Lockheed Martin – Australia (LMA)
> MEASAT Satellite Systems
> Motorola Solutions
> NBN Co
> Nokia
> Optus
> The Special Broadcasting Service (SBS)
> SES
> Telstra
> Vodaphone Hutchison Australia (VHA)
> The Wireless Internet Service Providers Association of Australia (WISPAU).

The public submissions can be found on the 3700–4200 MHz band consultation page.

Summary of respondent positions

Overall, the submissions had divergent views about planning of the 3700–4200 MHz band.

Satellite industry and user stakeholders generally either rejected changes in the 3700–4200 MHz band or wanted continued protection for all incumbent FSS as well as ensuring that other WBB bands be proven to be fully utilised before any significant changes in the 3700–4200 MHz band were proposed. These submitters were of the view the 3700–4200 MHz band is essential for FSS use and geographical or frequency relocation is considered impractical and too costly. The CA SSWG presented two slightly different views as their stakeholders were unable to agree to a single view.

MNO industry and equipment stakeholders were generally of the view that Scenario C[16] was preferred, with use of the 3700–3800 MHz segment allocated to spectrum licensing for WBB in geographical areas identical to that used for the 3.6 GHz band spectrum licenses, and the 3800–4000 MHz segment considered for low incumbency capital cities. Views differed on the priority of planning in this band compared with others in the planning process such as optimisation of the 3.4 GHz band, and allocation of the 900 MHz, 26 GHz and 28 GHz bands. Only VHA requested immediate action in the 3700–3800 MHz segment. NBN Co was of a view that a 100 MHz to 200 MHz segment of the 3700–4200 MHz band should be allocated to fixed wireless services and be frequency and geographically isolated from other users in order to provide unfettered use. NBN Co considered the planning of this band a lower priority compared with others in the planning process such as optimisation of the 3.4 GHz band, and the allocation of the 26 GHz and 28 GHz bands.

WISPAU and Motorola had a view the 3700–4200 MHz band should preferably introduce innovative sharing techniques such as Dynamic Spectrum Access (DSA) or a Dynamic Spectrum Sharing Model (DLSM) for localised WBB systems across the whole of Australia. WISPAU strongly expressed opinions that existing licensing mechanisms are no longer fit for purpose. WISPAU would support apparatus licences, including AWLs “if the ACMA is either unwilling or incapable of implementing” DSA.

Cambium Networks supported the use of the 3700–4200 MHz band for last mile fixed point to point and point to multipoint services across the whole of Australia using apparatus licences, including AWLs, or DSA licensing mechanisms.

Summarised responses to each issue for comment

Responses to each of the sixteen issues for comment are summarised below, where a submission directly addressed the question rather than restating an existing position, or unrelated to the scope of the 2019 discussion paper.

Question 1

Are there any other international developments in the 3700–4200 MHz band that the ACMA should be aware of?

MEASAT provided information on current plans for the 3700–4200 MHz band in Malaysia, Singapore, Thailand and Indonesia. Only Malaysia is considering WBB in

[16] The 2019 discussion paper discussed possible scenarios for comment and this options paper proposes replanning options.

3400–3800 MHz, but sharing studies are being done in relation to FSS use in the region.

Optus highlighted that the Ofcom proposed local licensing arrangement in the 3700–4200 MHz band should be carefully qualified as there are geographical, duration and MNO proximity constraints associated with the concept of sharing in the 3700–4200 MHz band.

Boeing highlighted the impact of changes in the 3700–4200 MHz band for FSS use upon the wider region, and the different FSS users in the US compared with Australia meaning a planning approach for the 3700–4200 MHz band in the US may not translate into an appropriate approach for Australia.

SES and Intelsat reiterated that the 3700–4200 MHz band is not identified for IMT by the ITU, nor is there an agenda item for WRC-19.

Question 2

What are the future requirements of point-to-point links and FSS earth stations in the 3700–4200 MHz band? Does this differ by geographical area and/or segment of the 3700–4200 MHz band?

Telstra stated that some of its point-to-point links in the 3700–4200 MHz band are used telephony Universal Service Obligation (USO) services, and those links need to be protected and grandfathered, with Frequency Division Duplex (FDD) channel 7 at least needing to remain.

Intelsat disagreed that FSS use was decreasing in the 3700–4200 MHz band simply because fewer FSS earth station apparatus licences have been issued. They also pointed out that the band is heavily used for satellite communications in the Asia-pacific region, which includes Australia for a wide variety of services.

SBS stated that while there is a trend towards the use of fibre for international program exchange, there is a need to continue the use of this band for receipt of overseas content well into the future. ASTRA noted that technology choice for delivery is for the source broadcaster to determine.

The ABC stated that it is heavily dependent on the 3700–4200 MHz band to meet its charter obligations to gather, produce and distribute content domestically and internationally.

The ASNO stated that the 3700–4200 MHz band is used for VSAT terminals at their Comprehensive nuclear-test-ban treaty organisation (CTBTO) monitoring stations and there are insufficient redundant communications systems for the stations, requiring continuing use of FSS in the 3700–4200 MHz band.

The CA SSWG foresee ongoing need for the existing users of the 3700–4200 MHz band and existing systems should remain protected from interference.

WISPAU stated that existing point to point and FSS use is likely to remain constant.

MEASAT, Boeing, Eutelsat, Inmarsat and Intelsat generally viewed FSS use to remain the same or increase (Intelsat).

Optus observed PTP and FSS services decreasing in the 3700–3800 MHz segment, but both Telstra and Optus stated there is demand in Sydney and Perth for FSS above 3800 MHz. Both suggested there could be scope to consider 3800–4000 MHz for WBB use. However, Optus suggested this be delayed to a later date, while Telstra suggested Perth and Sydney be excluded from consideration at this time.

Question 3

If licensed point-to-point links and FSS earth stations are affected by replanning activities in the 3700–4200 MHz band, what alternative deployment options could be considered?

The SBS stated that a geographic relocation of FSS to ESPZs would be costly, time consuming and would increase annual backhaul costs. Given the spread of FSS operators, it will not be practical either to restack FSS services within the 3700–4200 MHz band.

ASTRA detailed why each alternative was not practicable and hence not supported.

AMTA supported the investigation of suitable ESPZs to assist in clearance of the incumbered portions of the 3700–4200 MHz band identified in Perth and Sydney, allowing a uniform allocation and licensing regime across all capital cities.

The CA SSWG stated that migrating USO point-to-point links to higher frequency bands is not possible due to the types of propagation paths involved, and that FSS alternative deployment options depended on the licensing models.

Optus believes that point-to-point migration to other bands is already underway and further mechanisms may be unnecessary. They believe use of the ESPZs for the FSS warrants investigation but moving FSS away from the 3700–4200 MHz band is unlikely.

Boeing supported the concept of ESPZs, but it should be a long-term ambition and further discussion should be separate to this consultation.

Eutelsat observed that restacking FSS appears complex, especially for international links, and that geographical relocation of teleports does not seem practical. Migrating to Ku band is also not considered possible where the uplink is in a country with harsh climate conditions. Eutelsat note that telemetry and ranging carriers are usually at the 3700–4200 MHz band edges and any replanning would create difficulties for in orbit and planned satellites.

Huawei considered that the small number of point-to-point services remaining in metropolitan areas can be reallocated from the 3700–4200 MHz band where practicable. For affected FSS geographic, in-band and out-of-band migration as well as alternate wired technology could be considered.

Inmarsat considered there is no need for FSS to be affected by any introduction of new services in the 3700–4200 MHz band as protection measures can be developed to ensure their protection from WBB systems.

LMA noted that many FSS networks have hardwired telemetry links in the 3700–4200 MHz band with no ability to restack, and these are heavily used during Transfer orbit support services (TOSS) and In orbit testing (IOT) operations as well as during regular operations. Any FSS that uses telemetry needs to be protected across the whole of the 3700–4200 MHz band.

The ABC stated that while Internet protocol (IP) and point-to-point fibre might be delivery alternatives to FSS this would be at much greater expense to the ABC and a greater failure risk. Use of Ku band may be possible but again reliability may be inferior due to rain fade performance. The ABC distribute content to the Pacific and the 3700–4200 MHz band is uniquely able to provide this.

Telstra stated that their point-to-point links for USO services have unique reliability requirements over long distances and all such links must be grandfathered. Telstra consider that most FSS in the 3700–4200 MHz band can be returned to above 4000 MHz, but some may need to remain in the 3800–4000 MHz segment. Relocation costs to move FSS to ESPZs may make it unviable.

The ASNO stated that it was administratively very difficult to relocate any FSS associated with its monitoring stations due to the international treaty nature of the arrangements.

Question 4

In the event arrangements are made for new services in the 3700–4200 MHz band, do stakeholders have any comments on the ACMA’s proposal to maintain the existing arrangements for Radiodetermination and LIPD devices, and the existing policy around TVRO systems?

The SBS noted that unlicensed FSS systems may gain the benefit of umbrella protection from nearby licensed FSS, but that a more rigorous approach to protecting FSS from interference is essential in the future under any changes to the 3700–4200 MHz band.

AMTA, Optus and Telstra re-iterate their opposition to ultra-wide band LIPD devices stating these should be apparatus licensed.

MEASAT recommend partitioning a segment of the 3700–4200 MHz band for TVRO specific use.

The ABC stated that some TVRO FSS services are critical to the news and content gathering functions of the ABC and its charter obligations and would be applicable to other broadcasters. A more proactive approach to protect these critical services is essential.

Question 5

What are the future requirements for WBB services in the 3700–4200 MHz band and what arrangements should be considered? Does this differ by geographical area and/or segment of the 3700–4200 MHz band?

Telstra, VHA, Optus, AMTA, Huawei and Nokia generally consider that a minimum 100 MHz bandwidth is required per operator for WBB in the 5G mid-band (~3–6 GHz), in metro and near metro areas, and should be given exclusive access. The 3700–3800 MHz segment should be prioritised, but other segments should be considered, with potential consideration to other licensing types.

NBN Co proposes that a segment of 100-200 MHz for fixed wireless WBB uses is required, isolated geographically and in frequency from other WBB uses in the 3700–4200 MHz band. Spectrum and apparatus licensing areas should be the same as for the 3.6 GHz band.

The CA SSWG considers that demand for fixed WBB would be in regional and remote areas.

WISPAU stated the current focus for manufacturers is the lower end of the 3700–4200 MHz band, driven by global spectrum availability, but the whole of the 3700–4200 MHz band and Australia should be made available for WBB under a dynamic spectrum licensing system.

Boeing may consider fixed WBB use in areas geographically removed from FSS, and below 4000 MHz in order to protect WAIC and radio-altimeter services.

MEASAT stated that there is current demand does not warrant use of the 3700–4200 MHz band for WBB.

Intelsat believed that existing and emerging FSS and MSS can be used to meet WBB needs.

Cambium Networks stated that ideally all 500 MHz should be made available for fixed WBB applications.

Question 6

What WBB deployment scenarios should be considered for the 3700–4200 MHz band? Should use be limited to one scenario or should more flexible arrangements be implemented?

Cambium Networks suggested a range of fixed wireless options need to be supported including PTP and PMP.

The CA SSWG view was that a single scenario is unlikely.

WISPAU was of the view that all forms of technology should be permitted, with no restrictions on deployment type.

VHA considered both mobile and fixed WBB deployments, and both Optus and Telstra envisaged macro, small cell, in-building and low power mobile WBB, as well as noting pros and cons of small cells in terms of coverage vs interference to FSS.

Huawei stated that deployment scenarios will vary with the business case of the operator.

ASTRA stated that any WBB deployment should be strictly limited with the emphasis on the protection of incumbent FSS services.

Intelsat noted that satellite will play a vital role in the future 5G ecosystem.

Question 7

What is the current and planned availability of fixed and mobile WBB equipment in the 3700–4200 MHz band?

Cambium Networks stated that use of Software Defined Radios (SDR) enable the rapid development of new solutions, and while current fixed WBB solutions support 3.3–3.9 GHz, it is simple to develop equipment across the whole of the 3700–4200 MHz band.

NBN Co noted that its fixed WBB equipment will generally be limited in availability to the same frequency ranges as available equipment for mobile WBB operators.

AMTA, VHA, Telstra, Huawei, and Optus stated that equipment is readily available for 3GPP band n78 (3300–3800 MHz) and will soon become available for n77 (3300–4200 MHz). However, AMTA commented that the existing 3.6 GHz spectrum licence core conditions concerning out of band emissions mean that global equipment scale is unable to be taken advantage of.

WISPAU noted that available equipment is concentrated in the 3700–3800 MHz segment of the 3700–4200 MHz band.

Question 8

Is there interest in the use of other new service types in the 3700–4200 MHz band?

CA SSWG expressed that there are new satellite opportunities that the 3700–4200 MHz band could be used for associated with the Internet of Things (IoT), using Dynamic Spectrum Management (DSM) or class licences.

Question 9

What services/applications should be accommodated in the 3700–4200 MHz band?

Satellite industry and user stakeholders generally wanted continued protected access to the 3700–4200 MHz band for FSS, including for new innovative satellite-based applications such as high throughput Geostationary orbit (GEO) in the 3700–4200 MHz band. The CA SSWG presented two slightly different views as their stakeholders were unable to agree to a single view, with one view supporting use of the 3700–3800 MHz segment for new services such as WBB.

MNO industry and equipment stakeholders were generally of the view that at least a segment of the 3700–4200 MHz band be allocated to WBB for at least metro cellular services, with varying degrees of acknowledgement for some continued PTP and FSS use.

Huawei mentioned the use of 5G to support drone operations with various applications including public safety, transport, monitoring, agriculture and site operations.

NBN Co was of a view that a 100 MHz to 200 MHz segment of the 3700–4200 MHz band should be allocated to fixed wireless services and be frequency and geographically isolated from other users in order to provide unfettered use.

Telstra provided a detailed table of describing proposed services by frequency, geography and licensing basis. Services include all existing service types plus IMT and FWA.

Nokia suggested the use of 3800–4200 MHz for private wireless networks.

WISPAU and Motorola had a view the 3700–4200 MHz band should introduce WBB systems across the whole of Australia using DLSM.

Cambium Networks supported the use of the 3700–4200 MHz band for last mile fixed PTP and PMP services for smart city applications, Wi-Fi backhaul, sensor backhaul, closed circuit television backhaul, data for mining operations and land mobile radio backhaul.

Question 10
Which frequencies ranges should be made available for these services/applications?

Satellite industry and user stakeholders generally wanted continued protected access to the whole band for FSS. The CA SSWG presented two slightly different views as their stakeholders were unable to agree to a single view, with one view supporting use of the 3700–3800 MHz segment for new services but with the whole of the 3700–4200 MHz band still available for FSS. ASTRA stated any use should be preferably limited to 3700–3800 MHz.

MNO industry and equipment stakeholders were generally consistent with support of spectrum Scenario C, with 3700–3800 MHz be allocated to WBB as the first priority, and 3800–4000 MHz as a second priority. Nokia suggested the use of 3800–4200 MHz for private wireless networks.

Huawei proposed that spectrum scenario B1 of the discussion paper was an alternative ahead of progression to Scenario C, focussing on the 3700–3800 MHz segment for WBB but progressing to other segments at defined points in the future.

NBN Co were of a view that a 100 MHz to 200 MHz segment of the 3700–4200 MHz band should be allocated to fixed wireless services.

WISPAU and Motorola had a view the whole band should be made available to new access seekers using DLSM.

Cambium Networks stated that ideally the whole 500 MHz of the 3700–4200 MHz band should be made available for FWA applications.

Question 11
Which geographic areas should be made available for these services/applications?

Satellite industry and user stakeholders generally wanted continued protected access for FSS to deploy in the whole of Australia, provided coordination was possible. The CA SSWG presented two slightly different views as their stakeholders were unable to agree to a single view, with one view supporting Australia wide use for the whole range of services. ASTRA stated new services should not be permitted in the Sydney metro area due to the high density of incumbents.

MNO industry and equipment stakeholders were generally consistent with the view that WBB geographic areas should align with those used for the 3.6 GHz band. Exclusive access for WBB in defined metro and regional areas and shared access in others.

NBN Co was of a view that a segment of the 3700–4200 MHz band allocated to fixed wireless services should be geographically isolated from any other services and align with the areas identified for spectrum and apparatus licensing in the adjacent 3.6 GHz band.

WISPAU and Motorola had a view the whole of Australia should be made available to new access seekers using DLSM.

Cambium Networks stated that ideally the whole of Australia should be made available for FWA applications, except for the ESPZs.

Question 12

On what basis should access be provided? Should access be granted on an exclusive or shared basis, on a coordinated or uncoordinated basis, et cetera?

Satellite industry and user stakeholders generally wanted shared, co-ordinated access for any new services to ensure FSS continued access. Boeing noted that the proposed use of DSA for the Citizen band radio service (CBRS) band in the US may not be applicable in Australia due to the different services in the 3700–4200 MHz band. The ABC stated that WBB licensing should be exclusive and separate from and FSS frequencies.

MNO industry and equipment stakeholders were generally consistent with the view that exclusive access for any segment and region allocated to WBB, with some support for shared co-ordinated access for a secondary segment.

NBN Co's view was interpreted as preferring exclusive access for any segment and region allocated to FWA, with geographic and frequency separate from all other users.

WISPAU, Nokia and Cambium Networks had a general view that a DSA model like that used in the US in the CBRS band should be considered. Motorola suggested DSA in the 3800–4200 MHz segment.

Question 13

What licensing mechanisms are appropriate (spectrum, apparatus or class licensing)?

Satellite industry and user stakeholders, where they responded, generally wanted continued apparatus licensing for FSS. One view by the CA SSWG was that spectrum licensing was the least attractive for new services due to the long tenure and potential for freezing out of innovation, and that apparatus licensing (including AWLs) should be considered. ASTRA stated no class licensing of new services so there could be an emphasis on co-ordination with existing FSS.

MNO industry and equipment stakeholders were generally consistent with the view that spectrum licensing should be used in a 3700–3800 MHz or 3800–4000 MHz segment allocated to WBB, but it was premature to wholly decide above 3800 MHz and apparatus licensing may be appropriate in certain regional and remote areas. Telstra presented a detailed table proposing arrangements by service, frequency and geographical area.

NBN Co's view was that considerations on licensing type would more appropriately include the proposed planning arrangements, fee regime and consider certainty of tenure.

WISPAU, Nokia and Cambium Networks had a general view that a DSA model like that used in the US in the CBRS band should be employed. Motorola suggested DSA in the 3800–4200 MHz segment. WISPAU considered that if the ACMA is unwilling to implement DSA then apparatus licences (including AWLs) should be used for new services.

Cambium Networks supports apparatus licences (including AWLs) and potentially new dynamic licensing models for FWA services.

Question 14

If arrangements for WBB specifically are implemented in the 3700–4200 MHz band, are the proposed interference management techniques with services in the 3.6 GHz band suitable? Are any other techniques proposed? Are there any other compatibility issues with the 3.6 GHz band the ACMA should consider?

There were varying views within the satellite industry and user stakeholders, but all wanted strong protection arrangements for FSS. Intelsat stated that the interference management techniques in the 3.6 GHz band were not suitable for the 3700–4200 MHz band due to higher FSS usage, and co-frequency sharing between WBB and FSS is not possible, requiring consideration of guard bands, separation distances and strict Out of Band Emission (OOBE) requirements for WBB. Inmarsat supported that the 3.4 GHz RAG should be enough. LMA supported a similar geographical 'carve out' around Uralla as per the 3.6 GHz band arrangements. The ABC stated that WBB licensing should be exclusive and separate from and FSS frequencies.

MNO industry and equipment stakeholders were generally consistent with the view that similar arrangements to the 3.6 GHz band were supported, but Nokia and VHA proposed revision to 3.6 GHz band OOBE limits if WBB were allocated to the 3700–3800 MHz segment.

WISPAU did not support the use of synchronisation requirements as it was too prescriptive, preventing innovation. A tiered DSA arrangement would better suit interference management needs in the 3700–4200 MHz band.

Cambium Networks saw no issue in being able to co-ordinate and co-locate FWA equipment, noting TDD synchronisation techniques.

NBN Co noted that a frequency segment and geographical isolation may minimise the need for a fall-back synchronisation condition.

Question 15

Should the ACMA consider extending existing apparatus and spectrum licence arrangements in the 3.6 GHz band into the 3700–3800 MHz band or another segment of the 3700–4200 MHz band?

There were varying views within the satellite industry and user stakeholders, but all wanted strong protection arrangements for FSS. Intelsat stated that the interference management techniques in the 3.6 GHz band were not suitable for the 3700–4200 MHz band due to higher FSS usage, and co-frequency sharing between WBB and FSS is not possible, requiring consideration of guard bands, separation distances and strict OOBE requirements for WBB. Inmarsat supported that the coordination arrangements in the Radiocommunications Advisory Guidelines (Managing Interference from Spectrum Licensed Transmitters – 3.4 GHz Band) 2015 and the Radiocommunications Advisory Guidelines (Managing Interference to Spectrum Licensed Receivers – 3.4 GHz Band) 2015 should be enough. LMA supported a similar geographical 'carve out' around Uralla as per the 3.6 GHz band arrangements. The ABC stated that WBB licensing should be exclusive and separate from FSS frequencies.

MNO industry and equipment stakeholders were generally consistent with the view that spectrum licensing arrangements to the 3.6 GHz band should carry across in the 3700–3800 MHz segment if allocated to WBB, potentially to any other segments allocated to WBB but there was also support for a wider variety of arrangements in any second segment.

WISPAU considered that if the ACMA is unwilling to implement DSA then apparatus licences (including AWLs) should be used for new services.

Cambium Networks felt a large part of the 3700–4200 MHz band should have different models using apparatus licences (including AWLs) or DSA arrangements for FWA.

NBN Co had no view based on the available information.

Question 16

Is there any additional information available that would assist the ACMA in assessing compatibly of potential new WBB services in the 3700–4200 MHz band with WAIC and radio altimeter systems in the 4200–4400 MHz band?

Optus considered that any new allocations in the 4000–4200 MHz segment should carefully consider implication to WAIC and radio altimeter systems.

Boeing stated in summary that WBB should not operate in the 4000–4200 MHz segment due to potential interference but is willing to assist the ACMA in any additional studies.

LMA requested that sharing and compatibility studies be conducted by the ACMA before any consideration of WBB in the 3700–4200 MHz band but noted that large guard bands were likely required.

Airservices Australia agreed that existing studies came to different conclusions but that it is difficult to summarise the behaviour of the wide range of radio altimeter equipment deployed. It noted that the International Civil Aviation Organization (ICAO) should have recommended practices to assist in assessment early in 2020 but noted that mitigations such as power and geographical restrictions may be required.

Appendix B: Domestic considerations

This chapter examines relevant domestic considerations that influence the assessment of the best use of the 3700–4200 MHz band. This includes:

> Domestic developments in neighbouring bands, being the future arrangements of the 3400–3575 MHz band and the arrangements being implemented in the adjacent 3575–3700 MHz band.

> Arrangements and potential demand for services in the 3700–4200 MHz band or with an interest in gaining access to the 3700–4200 MHz band, including WA WBB and LA WBB, PTP and FSS (including gateway, VSAT and TVRO earth stations) and existing LIPD Class Licence, radiodetermination service and scientific non-assigned licence arrangements.

> Arrangements in the adjacent 4200–4400 MHz band.

Arrangements in the 3400–3700 MHz band

Outcomes of the 3400–3575 MHz (3.4 GHz) band optimisation process

Following a period of consultation, the ACMA released the *Optimising arrangements for the 3400–3575 MHz band Planning decisions and preliminary views* paper in November 2019.

A summary of the arrangements planned for the 3400–3575 MHz band are illustrated in Figure 6 and includes:

> Maintaining existing arrangements for radiolocation services and devices operating under class licences.

> Extending existing ESPZs in eastern Australia to cover those parts of the band not already subject to spectrum licensing (the 3400–3442.5 MHz and 3475–3542.5 MHz frequency ranges).

> Restacking (or retuning) incumbent amateur, PMP, and NBN Co's 3.5 GHz PTS licences to achieve consolidated arrangements in the band.

> Once restack is complete, and subject to decisions by the Minister, commencing processes to convert NBN Co's 3.5 GHz PTS licences to spectrum licences. This will enable licence trades or variations to occur between NBN Co and Optus to defrag their spectrum holdings.

> Developing arrangements for PMP licensing in those parts of the band that are not identified for spectrum licensing. This includes:

  > 50 MHz in major regional centres

  > between 35 and 67.5 MHz in regional areas

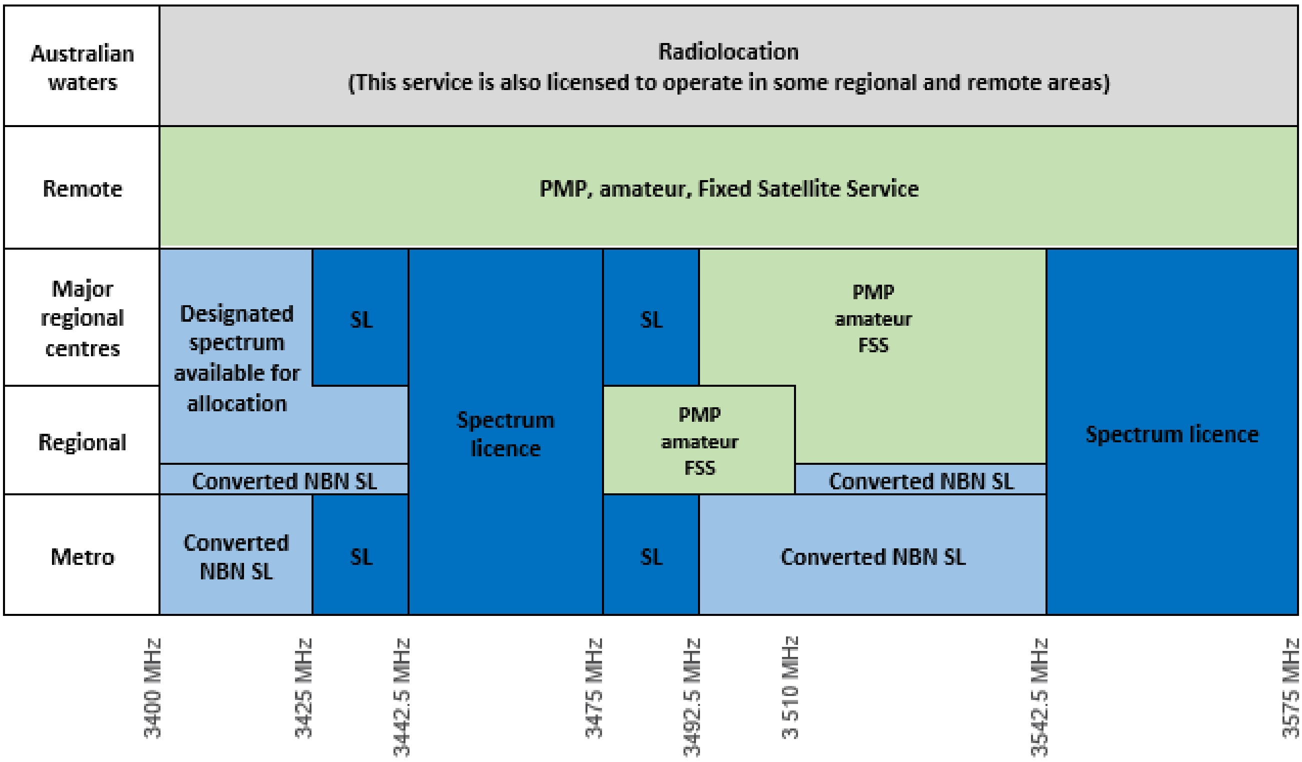
  > 300 MHz in remote areas (when combined with existing arrangements in the 3575–3700 MHz band).

> PMP arrangements are expected to be of interest to localised wireless broadband operators such as WISPs, miners and other industry verticals.

> Excising unused urban areas from NBN Co's 3.5 GHz PTS licence and making them available for use by other wireless broadband operators (referred to in this paper as urban excise). This involves:
    > Engaging with industry to develop interference management criteria to and from urban excise areas.
    > Determining the utility of urban excise areas and an appropriate licensing approach to make them available.
> Subject to a decision to designate additional spectrum for the issue of spectrum licences by the Minister, allocating 25 MHz and 42.5 MHz of spectrum in major regional centres and defined regional areas, respectively. This may also include the allocation of urban excise areas. If it does not, these areas will be made available via other appropriate means.

Figure 6: Final planning arrangements for the 3400–3575 MHz band

FSS = fixed satellite service, PMP = point-to-multipoint, SL = spectrum licence



Arrangements in the 3575–3700 MHz (3.6 GHz) band

The ACMA released the *Future use of the 3.6 GHz band: Decisions and preliminary views* paper in September 2017. Consultation on proposed legislative instruments to implement the decisions was conducted in May 2018. An auction of spectrum licences was subsequently concluded in December 2018.

A summary of outcomes of the review of the 3.6 GHz band that are relevant to the consideration of planning options for the 3700–4200 MHz band are:

- The issue of spectrum licences in defined metropolitan and regional areas across the whole of the band with a re-allocation period for affected PMP, PTP and FSS of up to seven years, dependent on the area.
- The excision of areas for ESPZs near Moree, Quirindi, Roma and Uralla from spectrum licensing.
- Spectrum licences issued as a result of the auction as well as existing spectrum licences in the 3.4 GHz band are available from the ACMA's website. The associated legislative instruments that form the technical framework for spectrum licences in the 3425–3492.5 MHz and 3542.5–3700 MHz bands are also available from the ACMA's website.

The ACMA has also recently consulted on and implemented changes to unwanted emission limits for 3.4 GHz spectrum licences which also covers this band.

Summary of 3400–3700 MHz considerations

Developments in the 3.4 GHz and 3.6 GHz bands have resulted in a significant amount of spectrum being made available in large contiguous geographical areas for spectrum licensing, under a technical framework that suits WA WBB applications. In addition, some additional spectrum will also be made available under apparatus licensed mechanisms that suit LA WBB applications. These developments are considered when assessing supply and demand for WA WBB and LA WBB in the assessment of options chapter and in sections of this chapter.

Arrangements in the 4200–4400 MHz band

Arrangements in the 4200–4400 MHz band have not changed since the release of the 2019 discussion paper.

The Australian Radiofrequency Spectrum Plan 2017 allocates the 4200–4400 MHz band to aeronautical radionavigation and aeronautical mobile receive services. Aircraft currently operate radio altimeter systems in the band in order to determine their altitude. There use is licensed under the Radiocommunications (Aircraft and Aeronautical Mobile Stations) Class Licence 2016.

At WRC-15, footnote 436 was added to the aeronautical mobile allocation to state that the 4200–4400 MHz aeronautical mobile service was exclusively for the use of wireless avionics intra-communications (WAIC) to allow for the heavy and expensive wiring used in aircraft to be replaced by wireless systems.

WRC-15 also added footnote 438 to the pre-existing aeronautical radio-navigation allocation. This stated that the use of the frequency band 4200–4400 MHz by the aeronautical radionavigation service is reserved exclusively for radio altimeters installed on board aircraft and for the associated transponders on the ground. Due to the nature of the services provided in the 4200-4400 MHz band, the ACMA maintains that any changes in the 3700–4200 MHz band need to consider and afford protection to these services.

Consideration of spectrum requirements and options for WBB

Given the different considerations relevant to WA WBB and LA WBB uses, these are discussed separately below.

WA WBB

A wide range of views were expressed in submissions about the future use of the 3700–4200 MHz band for WA WBB applications. WA WBB applications are defined as deployments requiring large contiguous geographical areas such as those traditionally undertaken by large MNOs or some fixed telecommunication carriers such as NBN Co. Some stakeholders supported allocation of spectrum for WA WBB where others wanted a demonstration that recent allocations that can be used for WA WBB, such as the 3.6 GHz band, required further spectrum allocation after existing rollouts have been completed.

To assess the merits of a potential allocation for WA WBB in the 3700–4200 MHz band, the ACMA has considered the following:

> International trends and regulation, including other mid-band spectrum (1–6 GHz frequency range) options being considered for WBB under WRC-23 agenda items 1.2 and 1.3.

> Domestic interest and existing spectrum provisions for WA WBB in the adjacent 3575–3700 MHz and 3400–3575 MHz bands. Together with the 3700–4200 MHz band these fit within the 3GPP New Radio (NR) n77 (3300–4200 MHz) and n78 (3300–3800 MHz) bands.

Indicated spectrum requirements

In submissions, mobile industry generally considered that a minimum of 100 MHz of mid-band spectrum was desired per 5G operator in all areas. In its submission, NBN Co indicated that an additional 100 MHz to 200 MHz of spectrum would be desired in the 3700–4200 MHz band to support their needs.

The maximum channel bandwidth that is currently supported in the n77 and n78 bands is 100 MHz. Consequently, depending on the service they are seeking to deliver it may be desirable and efficient for an operator to have at least 100 MHz of contiguous spectrum to be able to realise the full potential of 5G and maximise a return on their investment. While there may be options for operators to re-farm existing spectrum holdings with 3G and 4G deployments, there is a lag time (of several years) before such an investment makes commercial sense and a sufficient number of 5G capable handsets are adopted by consumers. The 3400–4200 MHz frequency range is currently the only mid-band spectrum that is supported by international standards that has a viable equipment ecosystem capable of enabling individual operators to gain access to 100 MHz of contiguous spectrum.

The ACMA has considered information provided by the mobile industry, vendors and NBN Co developing replanning options in the 3700–4200 MHz band. This information identifies that commercially viable 5G networks can still be deployed with access to bandwidths less than 100 MHz. Therefore, while options for access to 100 MHz of spectrum are considered in the replanning options developed, the ACMA believes that when assessing these options, the benefits of providing access to more spectrum for WBB services has to be balanced with effect on and needs of existing services.

Analysis of existing spectrum allocations in the 3400–3700 MHz band

The table below details the spectrum availability for WA WBB applications in the 3400-3700 MHz band that are suitable for 5G. It includes currently available spectrum and spectrum that will be made available in the future because of ACMA planning decisions.

Table 6: Approximate existing spectrum in 3400-3700 MHz for WA WBB applications

Band	Metropolitan areas	Major regional centres	Regional areas
3400–3575 MHz	175 MHz[17]	125 MHz	107.5 MHz to 140 MHz
3575–3700 MHz	125 MHz	125 MHz	125 MHz
Total allocation	300 MHz	250 MHz	227.5 MHz to 265 MHz

In remote areas, given the lower density of potential WA WBB deployments, arrangements like those in the 3400–3700 MHz band (i.e. under apparatus licensed arrangements) have also been considered. It is expected that competing access to spectrum by both WA WBB and LA WBB in remote areas will increase demand for licences in some remote areas. However, due to lower density of deployments and the large amounts of spectrum already available (300 MHz in the 3400–3700 MHz band) we expect this demand can be met in most cases. However, in specific areas of high demand, such as large towns and the Pilbara in Western Australia, additional spectrum for WBB may be beneficial to meet current and emerging demand from multiple LA WBB and WA WBB operators.

Summary of possible spectrum requirements for WA WBB in the 3700–4200 MHz band

Table 7: Possible WA WBB spectrum requirements assuming four operators provides an estimate of the potential spectrum needs of WA WBB in the 3700–4200 MHz band in different areas. This assumes:

> Sufficient spectrum is provided to support four different WA WBB operators.

> Each operator can gain access to 100 MHz and 80 MHz in metro and regional (including major regional centres) respectively. 100 MHz is assumed for metro areas based on advice provided in submissions to the 2019 discussion paper. 80 MHz is assumed in regional areas due to the lower population density which would result in lower network capacity requirements.

[17] This assumes that the existing 3.4 GHz band NBN spectrum licences in metropolitan areas will be reallocated for WBB use and prove to have useful utility.

Table 7: Possible WA WBB spectrum requirements assuming four operators

Region	Total mid-band spectrum desired	Currently available spectrum	3700–4200 MHz spectrum desired
Metropolitan areas	400 MHz+	300 MHz	100 MHz
Major regional centres	320 MHz+	250 MHz	70 MHz
Regional areas	320 MHz+	227.5MHz to 265 MHz	55 MHz to 92.5 MHz

Options for addressing possible spectrum requirements in the 3700–4200 MHz band

Frequency segments suitable for WA WBB could be allocated via spectrum licensing or an AWL framework. These licensing mechanisms are best suited to WA WBB deployments as large contiguous geographic areas can be licensed. Different segments and arrangements could potentially be allocated in different geographical areas.

A potential benefit of an AWL approach is that either exclusive use by new users or allowing existing users as well via incumbered licences could be allocated more easily. For the latter approach, this could allow existing FSS and PTP services to continue operating indefinitely within any AWL licence framework.

Given the quanta of spectrum desired for WA WBB in the 3700–4200 MHz band, 3GPP band limits and equipment availability it may be appropriate to provide for WA WBB primarily in the 3700–3800 MHz range. Doing so would extend the existing arrangements for WA WBB in the directly adjacent 3.6 GHz band. It would therefore create conditions to enable current WA WBB licensees to expand their existing spectrum holding and then consolidate them via market mechanisms such as trading.

Local area WBB

Spectrum and licensing needs of LA WBB operators often from those of WA WBB operators. LA WBB applications are defined as deployments of smaller, localised, or private networks such as those provided by wireless internet service providers (WISPs), miners, local government, campuses, factories and utilities using wireless (generally fixed but may be mobile) broadband networks. There is also likely[18] to be increasing interest in other private industrial uses as use cases for 5G and similar technologies develop.

Indicated Spectrum Requirements

Submissions to the 2019 discussion paper did not indicate firm spectrum requirements for individual LA WBB stakeholders. However, Cambium Networks and WISPAU stated that ideally all the 3700–4200 MHz band should be made available Australia-wide for LA WBB applications.

[18] See various Ericsson insights and reports available at https://www.ericsson.com/en/networks/trending/insights-and-reports

It would be desirable to be able to support multiple operators in a given area and to provide enough spectrum for each operator's business case to be viable. Based on an assessment of licences previously held in the 3.6 GHz band, up to three operators are deployed in some areas. While on average there is around one to two operators in an area, there are some areas spectrum demand is expected to be higher. This includes metropolitan areas, significant population centres and other hotspot locations such as the Pilbara in Western Australia.

One reference indicates that 40 MHz to 100 MHz of spectrum is desirable for each operator for LA WBB.[19] The upper limit of 100 MHz aligns with similar requirements stated by WA WBB operators. The lower limit of 40 MHz aligns with some advice provided by LA WBB operators to the 3.6 GHz band review process.

Like WA WBB, some submissions to the 2019 discussion paper indicated that equipment is currently available at the lower end of the 3700–4200 MHz band, especially the 3700–3800 MHz range. Cambium Networks indicated that equipment is available in the 3300–3900 MHz range. Equipment availability in the upper portions of the 3700–4200 MHz band is expected to increase over time as more countries make spectrum available in this range.

Analysis of spectrum alternatives

There are arrangements in other bands that could be used to provide LA WBB services. Arrangements for Broadband Wireless Access (BWA), Public Telecommunications Service (PTS) and Point to Multipoint (PMP) services are available. Table 8: LA WBB existing spectrum options summarises the mid band options for LA WBB.

Table 8: LA WBB existing spectrum options

Frequency band	Spectrum available	Region available
3.4 GHz band	Future arrangements include 35 MHz to 60 MHz in regional areas and 175 MHz in remote areas via PMP apparatus licensing	Regional and remote areas
3.6 GHz band	125 MHz via BWA apparatus licensing	Remote areas
5.6 GHz band	40 MHz via PMP apparatus licensing	Regional areas

[19] E.g. https://www.netcomm.com/assets/NetComm-Mobile-Ecosystem-5G-business-Case.pdf

Summary of possible spectrum requirements for LA WBB in the 3700–4200 MHz band

Table 9 provides an estimate of the potential spectrum needs of LA WBB in the 3700–4200 MHz band in different areas. This assumes:

> Sufficient spectrum is provided to support three different LA WBB operators in each area. For cases where there may be more than three operators wishing to deploy in an area, less spectrum would then be available per operator.

> Each operator needs between 40 MHz and 100 MHz in any area.

Table 9: Possible LA WBB spectrum requirements assuming three operators

Region	Total mid-band spectrum desired	Currently available spectrum	3700–4200 MHz spectrum desired
Metropolitan areas	120 MHz to 300 MHz	Nil	120 MHz to 300 MHz
Regional areas	120 MHz to 300 MHz	75 MHz to 100 MHz	20 MHz to 225 MHz
Remote areas	120 MHz to 300 MHz	300 MHz	Nil

Options for addressing possible spectrum requirements in the 3700–4200 MHz band

Frequency segments could be allocated for LA WBB use via PMP Apparatus Licensing or a suitable AWL framework could be developed. Different segments and arrangements could potentially be allocated in different geographical areas. Different segments than those allocated to WA WBB could also be identified to reduce geographic buffer zones between the service types.

Given the current equipment availability for LA WBB in the 3700–4200 MHz band, it may be appropriate to provide for LA WBB primarily in the 3700–3900 MHz range. If necessary, this range could extend to 4000 MHz as equipment in the n77 band and proprietary equipment become available.

While the 2019 discussion paper and submissions discussed views on DSA techniques for licensing of WBB services, the ACMA is not specifically proposing use of DSA in the 3700–4200 MHz band. The ACMA released the *New approaches to spectrum sharing - Next steps* paper in May 2020, which outlines the ACMAs current views on the use of spectrum sharing.

While allocation methods are out of the scope of this paper, there will be interest in how to provide spectrum in a manner best suited for certain classes of users such as LA WBB operators. In general, there appears to be no immediate need for additional spectrum for WBB in remote areas. However, in specific areas of high demand, such as large towns and the Pilbara in Western Australia, additional spectrum for WBB may be beneficial to meet current and emerging demand by multiple LA WBB and WA WBB operators. The ACMA therefore considers that arrangements could still be introduced on a co-ordinated basis with PTP and FSS in specific frequency segments given the low incumbency of those services in these areas.

Consideration of spectrum requirements and options for FSS

The 3700–4200 MHz band[20] is important for some satellite operators due to the potentially wide area regional footprints provided as well as the resilience of the frequencies to rain fade in tropical areas. Access to enough spectrum in this band is an important component to meet the ongoing capacity requirements of numerous broadcast, broadband and other satellite systems. In submissions there was some support to consider moving services to ESPZs but noted the difficulties of clearing large amounts of spectrum, especially in Sydney and Perth.

Indicated spectrum requirements

Submissions generally acknowledged there will be continuing demand for FSS in the 3700–4200 MHz band and highlighted the importance of being able to maintain existing services. Some submissions supported protecting unlicensed FSS use, including consumer TVRO typically used for personal reception of overseas television broadcasts and, commercial TVRO used for broadcast program ingest interchange and unlicensed gateways.

No case has been identified to provide protection to unlicensed TVRO services in the 3700–4200 MHz band. For commercial TVRO and FSS gateway operators, it is considered reasonable for them to coordinate and license their services in order to obtain protection from interference and pay for the spectrum denial that may be caused in the surrounding area.

Analysis of existing use

Table 10 indicates the number of FSS device registrations in the RRL by geographic area and frequency segment, as of June 2020. It indicates heavy use in some metropolitan areas, Perth, and Sydney, but little use, especially in the 3700–3900 MHz range, in other areas.

[20] Also referred to commonly as part of the C-band in the receiving context.

Table 10: Number of FSS registrations by region and frequency segment

Region	3700–3800 MHz	3800–3900 MHz	3900–4000 MHz	4000–4100 MHz	4100–4200 MHz	Total
FSS metro total	**50**	**68**	**44**	**25**	**32**	**219**
FSS Sydney	25	33	26	15	9	108
FSS Perth	22	34	17	10	17	100
FSS Melbourne	1	1	0	0	3	5
FSS Canberra	2	0	0	0	2	4
FSS Adelaide	0	0	1	0	1	2
FSS Brisbane	0	0	0	0	0	0
FSS regional total (ex ESPZ)[21]	**2**	**0**	**0**	**1**	**10**	**13**

It is noted that, since the release of the 2019 discussion paper, some services have been cleared from Sydney and Perth in the 3700–3900 MHz range but these cities still have a high concentration of FSS services.

In Perth, as of June 2020, assignments in the 3700–3800 MHz segment were located around Landsdale, Lockridge and Henderson. Assignments in the 3800–3900 MHz segment were located around Bayswater and Landsdale, using large (greater that 9 m) diameter earth station antennas.

Figure 7 shows the location of assignments in Perth with assignments in 3700–3800 MHz in red, 3800–3900 MHz in blue and locations with both 3700–3800 MHz and 3800–3900 MHz assignments in purple.

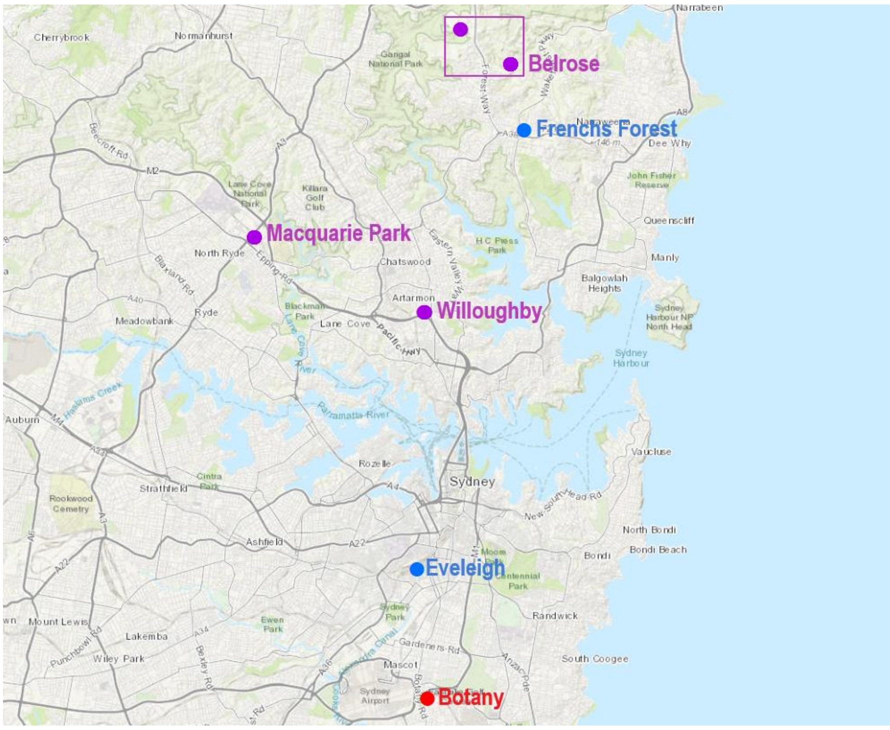
[21] Excluding device registrations in the Earth Station Exclusion Zones

Figure 7: FSS assignments around Perth

In Sydney, as of June 2020, assignments in the 3700–3800 MHz range were located at Botany, Willoughby, Macquarie Park and Belrose. Assignments in the 3800–3900 MHz range were located at Eveleigh, Willoughby, Macquarie Park, Frenchs Forest and Belrose.

Figure 8 shows assignments around Sydney with assignments in 3700–3800 MHz in red, 3800–3900 MHz in blue and locations with both 3700–3800 MHz and 3800–3900 MHz assignments in purple.

Figure 8: FSS assignments around Sydney



Consideration of ESPZs

ACMA has previously identified several ESPZs located in regional and remote areas near Mingenew (Western Australia), Uralla (NSW), Quirindi (NSW), Moree (NSW) and Roma (Queensland). The areas encompassed by these ESPZs are defined in [Radiocommunications assignment and licensing instruction (RALI) MS44](). The intention of ESPZs are to provide ongoing protection for existing earth stations and preserve access to spectrum for the deployment of new earth stations in numerous bands used by the satellite industry.

The 3700–4200 MHz band is one of the bands where protection is afforded at ESPZs. Only Quirindi, Moree and Roma provide protection for communication with satellites in geostationary orbit (GSO) in this band. Only Mingenew and Uralla provide protection for non-geostationary (NGSO) satellites for transfer orbit satellite services (TOSS) and similar applications. Uralla is only protected for NGSO receive and is a much smaller geographic area than the others.

While the Mingenew site is well established, Roma, Quirindi and Moree sites in eastern Australia were chosen with a view to review and select one or two of them as permanent ESPZs.[22]

As of June 2020, the only ESPZs that have device registrations in the 3700–4200 MHz band are Uralla and Mingenew. In the corresponding earth to space transmit band, 5925–6425 MHz, similarly the only ESPZs with registrations are Uralla and Mingenew.

[22] Uralla was established to protect the existing services there. The *Future use of 3.6 GHz - decisions and preliminary views* paper noted that ‘the long-term viability of this site may be reviewed in the future, given increasing international interest in the 3700–4200 MHz band for use by wide-area broadband services’.

The Roma ESPZ currently has four earth receive registrations in the 18 GHz band, and six earth transmit registrations in the 28 GHz band, all licensed to NBN Co as part of their gateway there. The Moree and Quirindi ESPZs have no FSS registrations in any FSS band considered under RALI MS44.

Options for provision of possible alternative arrangements in the 3700–4200 MHz band

Acknowledging continuing demand in the 3700–4200 MHz band, the ACMA has identified a variety of options for FSS use of the 3700–4200 MHz band. This includes an option providing ongoing protection for existing services and support for new services being deployed. However, other options with reduced access to the 3700–4200 MHz band are also considered. These include:

> Restacking—consolidating use to one or more segments of the 3700–4200 MHz band.

> Clearing—moving use to different bands or delivery technique.

> Relocating—moving to an ESPZ or other areas with low spectrum demand from competing services.

> Reducing existing and new FSS use to a limited number of existing teleports/gateway locations in areas of high spectrum demand for competing services.

Restacking, clearing or relocating FSS stations will come at a cost to operators. It is expected that relocating services would have the highest associated costs while restacking would have the lowest. The costs associated with these options are estimated in Appendix F: Cost benefit analysis. Some approaches that could reduce impact and limit the number of existing services affected include:

> minimising changes to a small frequency range to limit the number of existing services affected

> minimising changes to specific geographic areas and/or

> using regulatory arrangements to protect incumbent FSS services when introducing new services and with potentially different arrangements for new FSS services.

The ACMA acknowledges that in some cases relocation of services may not be practical. For example, earth stations located on offshore mining rigs are site dependant and may not be practically moved to a different location and still provide the same service. Additionally, restacking services may not always be possible as service delivery could be limited to a set range of frequencies. Furthermore, the ability for operators to restack is likely to diminish as the amount of spectrum available for retuning reduces. As stated in the 2019 discussion paper and in the planning objectives section of this paper, the ACMA does not intend to afford protection to unlicensed services operating in the 3700–4200 MHz band.

Consideration of spectrum options for PTP

Indicated spectrum requirements

Radiocommunications allocation and licensing instruction (RALI) FX3 defines arrangements for PTP in the 3580–4200 MHz band (the 3.8 GHz PTP band). This includes a channel plan with seven paired 40 MHz channels. The entire band is available for use in remote areas.

However, only the 3790–4200 MHz portion is available in metropolitan and regional areas. This is because new licences in the range 3710–3790 MHz are currently restricted in metropolitan and regional areas under Embargo 73. This embargo was designed to reduce potential spectrum denial to spectrum licenced WBB services in the adjacent 3.6 GHz band. Services in the range 3580–3700 MHz in metropolitan and regional areas have been reallocated as a result of the *Radiocommunications (Spectrum Re-allocation—3.6 GHz Band for Adelaide and Eastern Metropolitan Australia) Declaration 2018*, *Radiocommunications (Spectrum Re-allocation—3.6 GHz Band for Regional Australia) Declaration 2018* and *Radiocommunications (Spectrum Re-allocation—3.6 GHz Band for Perth) Declaration 2018* (the 3.6 GHz reallocation declarations[23]).

Telstra (see the summary of submissions section) expressed the desire to maintain some PTP arrangements in this band. This was due to other PTP bands being less suitable for the delivery of USO services over long distance radio paths, especially those over water. To support these services, Telstra suggested retaining the highest frequency paired channel (3830–3870 / 4150–4190 MHz) as a minimum. Optus believes that PTP migration to other bands is already underway and further mechanisms may be unnecessary. The other major PTP licensee in the 3700–4200 MHz band, Digital Distribution Australia, did not provide a submission to the 2019 discussion paper. However, it is noted they are in the process of moving services affected by the 3.6 GHz re-allocation declarations to other bands or delivery techniques.

While the USO applies Australia-wide, it is understood that use of the 3700–4200 MHz band for PTP links involved in USO is limited to regional and remote areas. Under the government's announced Universal Service Guarantee, 'use (of) Telstra's existing copper and wireless networks in rural and remote Australia for the provision of voice services in NBN Co fixed wireless and satellite areas' will continue. However, the Department of Infrastructure, Transport, Regional Development and Communications is also looking at trialling alternative ways to deliver voice telephone services in rural and remote areas.

Table 11 presents the number of PTP links recorded on the RRL by region and frequency segment of the 3700–4200 MHz band as of June 2020. In this case licences are only held by Telstra and Digital Distribution Australia. As noted in the 2019 discussion paper, use of this band has also been in decline over the past 20 years. This suggest operators have tended to use alternative bands above 6 GHz or other delivery techniques such as fibre to deliver services.

[23] The full range that was reallocated was 3575–3700 MHz.

Table 11: PTP bidirectional links by region and frequency segment[24]

Region	3700–3800 MHz	3800–3900 MHz	3900–4000 MHz	4000–4100 MHz	4100–4200 MHz	Total
PTP in metro areas	8	3	7	6	5	29
PTP in regional areas	47	36	11	32	54	180
PTP in remote areas	4	2	0	3	3	12

The 3.8 GHz PTP band extends from 3580 MHz to 4200 MHz. Consequently, any changes to arrangements in the 3700–4200 MHz band may also affect any PTP services in 3580–3700 MHz (channels 1–3, 3590–3710 MHz). These channels, however, are already affected by the *decisions in the 3575–3700 MHz band* as well as Embargo 73. Consequently, under normal arrangements:

> In remote areas all channels are currently available for use.

> In regional and metropolitan areas only channels 6 and 7 are available for new services.

> In regional and metropolitan areas channels 4 to 7 are used for existing services only.

Options for provision of possible alternative arrangements in the 3700–4200 MHz band

Given use in the band is declining, information provided in submissions to the 2019 discussion paper and the previous analysis, it is expected that access to spectrum for PTP use in the 3700–4200 MHz band can be reduced in all areas if other services require access. There are numerous other bands available for PTP, as defined in RALI FX3, which will be suitable in most cases. The Methods to implement reduced spectrum use by PTP section discusses ways to reduce spectrum use by PTP within the 3700–4200 MHz band. Another option is whether the ACMA adopts a policy of restricting the deployment of new PTP in the band.

Apart from retuning within the 3700–4200 MHz band, links may also transition to other PTP bands or other technologies such as fibre optic links. For similar cases in other bands, transition periods have typically been in the range of two to seven years. In the case of the 3700–4200 MHz band, and given the same licensees (and potentially services) apply in this case, for any segment of the band that incumbent PTP licences are affected, there may be benefit in aligning the end of any transition period with that in the adjacent 3.6 GHz band. In regional areas the end of the transition period is in March 2025.

[24] A link may be represented in two frequency segments due to channelling arrangements.

Consideration of spectrum options for other services in the 3700–4200 MHz band

Low interference potential devices

The LIPD Class Licence sets arrangements for the following devices to operate across the 3700–4200 MHz band:

> building material analysis transmitters and ground penetrating radars operating in the 30-12400 MHz range

> UWB transmitters operating in the 3100–4800 MHz band.

Operation of devices under the LIPD Class Licence is on a 'no interference and no protection' basis with other licensed services. In their submissions, Optus and Telstra reiterated their concerns that class licensed, rather than apparatus licensed, use of UWB ground and wall penetrating radar devices make the identification and resolution of interference more difficult.

While these concerns can be applied generally to all class licensed devices, the ACMA considers the low power nature of these services greatly reduces the risk of interference. Consequently, the ACMA does not see a case to change the licensing arrangements for these specific devices.

Radiodetermination

Radiodetermination does not have any allocation based on the national spectrum plan, but three assignments are registered in the remote Northern Territory. These have been licensed consistently with subsection 10(7) of the Australian Radiofrequency Spectrum Plan 2017. Submissions either supported or acknowledged the ACMA preliminary proposal in the 2019 discussion paper that arrangements for these services would not change.

Scientific apparatus licences

Services operating under scientific apparatus licences, both assigned and non-assigned, are permitted to be licensed in the 3700–4200 MHz band with conditions as per the Radiocommunications Licence Conditions (Scientific Licence) Determination 2015 ('Scientific LCD'). These licences operate on a 'no interference and no protection' basis. Both assigned (the location (site or area) of the service and the frequency of operation are recorded on the licence) and non-assigned (the location and exact frequencies of operation are not recorded on the licence) licences may be issued. For non-assigned scientific apparatus licences, operation is usually confined to a shielded room. This type of licence permits generic use of the entire radiofrequency band, though typically licensees only operate in specific bands of interest.

The ACMA intends to support the ongoing issue and operation of scientific licences in the 3700–4200 MHz as far as practical. If any spectrum is re-allocated for the issue of spectrum licences in a geographic area where scientific apparatus licences are issued, then section 153H of the Act requires that they be cancelled at the end of the defined re-allocation period. The issue of new apparatus licences once spectrum has been re-allocated and beyond the re-allocation period would then be restricted as per section 153P of the Act. This limits the issue of licences to bodies covered under paragraphs 27(1)(b) to (be) of the Act and when the ACMA is satisfied special circumstances apply. The ACMA would continue to consider requests for such licences on a case-by-case basis.

In the event any areas and frequencies are subject to a reallocation declaration, the ACMA is still considering its options for how best to manage scientific non-assigned licences to avoid having to cancel them. This could include a variation to the Scientific LCD or the application of a special condition to relevant licences to prevent operation within the affected frequency ranges.

Appendix C: Technical issues

Relevant technical coexistence considerations inform and guide the development of necessary planning and licensing frameworks. From a technical perspective the interference environment can be analysed using quantitative tools but rest on assumptions related to use of input parameters and modelling methodologies.

As arrangements for multiple services are being considered in the 3700–4200 MHz band, the potential for issues associated with sharing[25] and compatibility[26] between these services and those in adjacent bands, need to be considered when proposing and assessing possible future replanning options. This chapter outlines issues between services being considered in the 3700–4200 MHz band and, where relevant, existing co-ordination arrangements.

Sharing and coexistence between WBB and FSS

Sharing and coexistence between WBB like services, including PMP, and FSS receivers has been studied both domestically and internationally.

Sharing studies conducted by the ITU-R, including Reports ITU-R M.2109, ITU-R S.2199 and ITU-R S.2368, and ACMA internal studies conclude that large separation distances, at least in the tens of kilometres, are required if the services are to co-exist on the same frequency in a given geographic area. Significant separation distances may also be required for immediately frequency-adjacent services to avoid FSS receiver overload when the frequency separation is small or if filters are not used.

Appendix D outlines an FSS earth station sharing study which details sharing between incumbent FSS services and potential new WBB services. Results of the study were used in the cost-benefit analysis when examining FSS coexisting with WBB under the replanning options proposed.

In the adjacent 3575–3700 MHz band the ACMA has set co-ordination and protection requirements for FSS services from devices operating under a spectrum licence. These are detailed in the Radiocommunications Advisory Guidelines (Managing Interference from Spectrum Licensed Transmitters — 3.4 GHz Band) 2015 (RAG). The RAG is used to assist in the deployment of new service and protection of existing ones.

The ACMA has also previously applied RALI FX19 for co-ordination of WBB services with FSS in the 3575–3700 MHz band and for managing adjacent channel interference to FSS in the 3700–4200 MHz band. Any interference between possible future WBB services and FSS earth stations could be managed via the same mechanisms set out in the RAG. Pending identification of any frequencies made available for WBB use, the assumed filter performance of FSS earth stations in the RAG may also need to be reviewed.

Assuming mechanisms and parameters in the RAG are used for the coordination of any future WBB services and FSS earth stations, the impact of spectrum denial between these services has been assessed. The results of this assessment are provided in Appendix B.

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[25] 'Sharing' refers to the coexistence of services in the same band.

[26] 'Compatibility' refers to the coexistence of services in adjacent or nearby bands.

Sharing and coexistence between WBB and PTP

Sharing between WBB (IMT) and fixed PTP services in the 3700–4200 MHz band has been studied by the ITU under Report F.2328. This report considered several IMT deployment environments and concluded that co-channel separation distances of up to 92 km are required for PTP receivers to avoid IMT base station interference. Up to 31 km separation may also be required for PTP receivers to avoid interference from IMT User equipment (UEs) under very worst-case assumptions. Adjacent channel frequency/distance separation figures were also proposed in the report.

Coexistence between WBB and PTP is achievable through the development of appropriate coordination procedures. Similar arrangements have been successfully implemented between WBB and PTP in other bands, including the 1800 MHz, 2.1 GHz and the adjacent 3575–3700 MHz bands. The RAG requires that spectrum licensed WBB services in the 3575–3700 MHz band use RALI FX3 for co-ordination. RALI FX19 also sets out co-ordination and protection requirements between apparatus licensed WBB services and PTP services in the same 3575–3700 MHz band.

While it is considered possible for WBB to share spectrum with PTP, there is a resulting spectrum denial that accompanies this. That is, the deployment of one service will affect the ability of another to be deployed in the same or nearby areas. The effect of this is greatest in areas of medium-to-high demand for access to spectrum for WBB and PTP services. The ACMA has taken this into account when developing and accessing replanning options for the 3700–4200 MHz band.

Sharing and coexistence between WA WBB and LA WBB

WA WBB and LA WBB services can be treated largely the same from a coexistence perspective, with both service types expected to use Time Division Duplexing (TDD) in the 3700–4200 MHz band.

Cochannel interference between WBB services operated by different operators can be experienced at distances up to 100 km (potentially more under anomalous propagation conditions). These distances are usually much less for practical radio paths when terrain and clutter (i.e. trees and buildings) are considered. There are also numerous mitigation techniques operators can employ to reduce the potential for interference such as appropriate siting of base stations, lowering antenna heights, employing beam tilt and reducing power. Time synchronising the networks can also reduce interference between services that are within 60 km of each other, depending on the guard period adopted.

Adjacent channel interference can be experienced between WBB services operated by different operators. The distances at which this can occur are smaller than for the cochannel case and can be experienced in the order of tens of kilometres. Like the cochannel case, in practice, these distances are much smaller and there are numerous techniques that can be employed to reduce the potential for interference. Time synchronising the operation of networks, along with appropriate planning of services, can reduce interference between services. This approach can avoid the need for guard bands or large separation distance between frequency adjacent services to manage interference.

In the adjacent 3575–3700 MHz band the ACMA has set out co-ordination and protection requirements with LA WBB services. These are detailed in the RAG. The RAG points to the criteria set out in RALI FX19, which is used for co-ordination of LA WBB services in the 3575–3700 MHz band.

Like the 3575–3700 MHz band, the ACMA considers that sharing and coexistence between WA and LA WBB in the 3700–4200 MHz band could be managed via the development of appropriate coordination and protection criteria. Pending the outcome of the review of the 3700–4200 MHz band, the ACMA would work with industry to develop appropriate co-ordination and protection arrangements as required. However, as per statements in the 2019 discussion paper, the ACMA currently if of the view that any interference could be managed as follows:

> Cochannel coordination be managed via the use of the device boundary criteria, as stated in RALI FX19.

> Adjacent channel coordination in metropolitan and regional areas to be managed via the use of the same time synchronisation requirement that applies 3.4 GHz band spectrum licences.

Sharing and coexistence between FSS and PTP

The ability for FSS and PTP to share is well established and studied extensively by the ITU under the SF[27] series of reports. Arrangements supporting such use have been in place in numerous bands including the 3700–4200 MHz band for decades. In this case the highly directional nature of both FSS and PTP antennas help improve the ability of the services to share and minimise spectrum denial caused to prospective future service deployments. The same is applicable for the ability of PTP to share with FSS satellite receivers.

The ACMA has not published a formal RALI which describes co-ordination requirements for PTP services and FSS receivers in the 3700–4200 MHz band. However, RALI FX19, RALI MS39 and the RAG include required FSS receiver protection requirements from other service types that may be appropriate. The RAG uses the latest technical information. Consequently, for PTP and FSS coordination we consider that protection of FSS receivers to the same level as that described from spectrum licensed services in the RAG is likely to be appropriate. Coordination of PTP with FSS in the 3700–4200 MHz band is currently required under RALI FX3.

Sharing and coexistence between WBB and Radiolocation

Sharing and coexistence between IMT and radiolocation services has been studied in the adjacent 3400–3700 MHz and 3300–3400 MHz bands under Report ITU-R M.2111 and more recently in M.2481.[28] Both are in force and conclude that co-frequency sharing between land-based and maritime radiolocation services and macro base stations was not feasible in the same geographic area, with the required separation distances up to 300 km or more depending on the case. Adjacent channel separation distances were also 100 km or more. In practice some of these distances may be smaller when accounting for terrain and clutter along the propagation path. Also, in some cases, the itinerant nature of the radiolocation service may only result in interference being perceived as a reduction in system throughput for a period.

[27] The series of recommendations for 'Frequency sharing and coordination between fixed-satellite and fixed service systems'.

[28] It is noted that Report ITU-R M.2111 does not consider 5G systems. Also Working Party 5D is in the process of reviewing Report M.2481 as part of the work being conducted under WRC-23 agenda item 1.2.

ITU-R Recommendation F.1489 details a methodology for assessing the level of operational compatibility between FWA, a good substitute for WBB services, and radiolocation systems in the adjacent 3400–3700 MHz band.

As the radiodetermination services licensed for operation within the 3700–4200 MHz band are currently limited to remote areas, the ACMA would introduce appropriate co-ordination arrangements under any option proposing the introduction of WBB services in remote areas. The issue of new radiodetermination services in the 3700–4200 MHz band and associated interference management arrangements would then be considered on a case-by-case basis.

There are also radiodetermination services currently licensed to operate in in the 3100–3500 MHz band in Australia. Consequently, there would be a minimum 200 MHz frequency separation between possible WBB services in the 3700–4200 MHz band and these services. It is expected that measures in place to manage in-band and adjacent band interference between radiodetermination and WBB services in the 3400–3700 MHz band will also be sufficient for possible WBB services in the 3700–4200 MHz band.

Compatibility with services in the 3575–3700 MHz band

The 2019 discussion paper discussed possible arrangements, and sought comments on them, for coexistence between possible WBB in the 3700–4200 MHz band and FSS and WBB services in the 3575–3700 MHz band. Submissions indicated varying views on this:

> Some submissions proposed stronger protection for FSS.

> There was general support for arrangements like those currently in place in the 3.6 GHz band.

> There was a proposal to revise the 3.6 GHz band unwanted emission limits if arrangements for WBB are developed in the 3700–3800 MHz segment.

> There was some disagreement with adopting synchronisation requirements to manage interference between WBB services.

At this point of the replanning process, the ACMA continues to favour mechanisms outlined in the 2019 discussion paper. This includes adopting a time synchronisation requirement and the RAG to manage adjacent band interference in metropolitan and regional areas and adopting the same mechanisms defined in RALI FX19 for remote areas. Once planning outcomes have been determined for the 3700–4200 MHz band, the ACMA would work with industry to develop appropriate co-ordination and protection arrangements as required.

It is noted that the ACMA recently consulted on changes to the unwanted emission boundaries for spectrum licences in the 3400–3700 MHz band. As a result of this consultation process a decision was made to change the spurious emission boundary from 3740 MHz to 3840 MHz. There was no change to the protection criteria for FSS set out in the RAG.

Compatibility between WBB and radio altimeters in the 4200–4400 MHz band

Existing studies related to sharing between WBB and radio altimeters were briefly summarised in the 2019 discussion paper. No specific additional information was obtained in submissions to the 2019 discussion paper, but it was noted that the ICAO were working towards developing Standards and Recommended Practices (SARPs) for radio altimeters, including consideration of interference issues, in early 2020.

The ICAO frequency spectrum management panel (FSMP) working group (WG) has a job card for the development of radio altimeter selectivity masks to better define this critical parameter. The interference to radio altimeters is heavily dependent on an accurate selectivity mask. The item was on the agenda of the ICAO FSMP-WG/9, FSMP-WG/10 and FSMP-WG/11 meetings with no resolution to the item as yet.

The ACMA has continued to develop its own compatibility study. The report is contained at *Error! Reference source not found.*, which also includes a comparison with other international studies. It concludes that:

> there is some potential for WBB services in the 3700–4200 MHz band or nearby bands to interfere with radio altimeters, based upon current assumptions around radio altimeter performance.

> Current assumed parameters and mechanisms for radio altimeters in the study may be overly conservative and that results are highly sensitive to certain parameters.

The international developments section, and the equivalent in the 2019 discussion paper, observes that multiple jurisdictions are allocating WBB services in segments above 3800 MHz. For example, Japan has made up to 4100 MHz available for WBB services and the US plans to make up to 3980 MHz available.

Consequently, it is likely that real world interference potential is lower than predicted in the study and that interference can be further reduced through the potential mitigation mechanisms outlined in the study. The ACMA will continue to work with stakeholders to ensure that this issue is both properly understood and that the risks are acceptably mitigated.

It is likely that any arrangements for WBB, if adopted, would require some form of guard band to ensure protection of services in the 4200–4400 MHz band. Based on current and impending allocations around the world in the 3700–4200 MHz band, the ACMA considers that a guard band of no more than 200 MHz between WBB services in the 3700–4200 MHz band and radio altimeters in the 4200–4400 MHz band would be sufficient in this case. Smaller guard bands could be considered, when more detailed parameters for radio altimeters are obtained.

Methods to implement reduced spectrum use by PTP

With current channelling arrangements detailed in RALI FX3 being FDD, the following technical options may be viable to facilitate reduced spectrum allocated to PTP in the 3700–4200 MHz band:

1. Relaxing site sense requirements, duplex gap and channel pair rules so that any channels in a specific frequency range can be used (e.g. channels 7 and 1’ to 7’ if restricted to above 3800 MHz or 1’ to 7’ if restricted to above 3900 MHz or 4’ to 7’ if restricted to above 4000 MHz). This may require equipment replacement due to the ability of existing equipment to retune and filtering requirements.
2. Having a widely split allocation for PTP in the 3700–4200 MHz band of channels 7 and 7’ only (3830–3870 MHz and 4150–4190 MHz).
3. Change channelling arrangements in the 3700–4200 MHz band to better align with possible WBB frequency bands, such as defining new FDD arrangements in 3800-4200 MHz only. This may require equipment replacement.

4. Changing PTP arrangements in the 3700–4200 MHz band to a Time Division Duplex (TDD) arrangement and defining new channel arrangements. This is likely to give the most flexible outcome, the most spectrum available for PTP but would require equipment replacement and may reduce efficiency on long paths due to the large guard period required. We note that very little TDD PTP equipment in the 3700–4200 MHz band appears currently available and most are restricted to a maximum of 3900 MHz.[29]
5. A combination of any of the above and other administrative policy arrangements to allow different segments for PTP use to be available in different geographic areas, including potentially grandfathering some existing links.

For replanning options in the 3700–4200 MHz band that propose to affect existing PTP services it is assumed that technical option 1 or 4 arrangements are practicable and any changes in PTP arrangements are aligned across all geographic areas.

[29] E.g. Ubiquiti AF-3X, Albentia ARBA link LNK-130 or Cambium Networks PTP 450i

Appendix D: FSS earth station sharing study

This study identifies likely areas where WBB service deployment could be restricted due to interference to existing licensed FSS earth stations. It considers cochannel, adjacent channel and overload interference mechanisms from a macro base station to existing FSS earth stations in Melbourne and Canberra metropolitan areas. These are the metro areas with low FSS incumbency.

Appendix 4 of the *Future use of the 3.6 GHz band – Options paper* provides the results of similar studies conducted for more generic earth stations operating in Perth and Sydney in the 3575–3700 MHz band. Similar are expected for the 3700–4200 MHz band.

Some study parameters used in this study are from the Radiocommunications Advisory Guidelines (Managing Interference from Spectrum Licensed Transmitters – 3.4 GHz Band) 2015 (RAG) due to the similarities in the potential application of services to the 3700–4200 MHz band. This does not predetermine the future regulatory arrangements of the 3700–4200 MHz band. The results of this study should be viewed as indicative only.

Study parameters

Interference mechanisms

The following interference mechanisms are considered in this study:

> Cochannel interference: Caused by co-frequency emission from WBB transmitters into FSS earth station receivers.

> Adjacent channel interference: Caused by unwanted emissions from WBB transmitters that fall within the licensed bandwidth of an FSS earth station receiver.

> Receiver overload: Caused by emissions from a WBB transmitter overloading the low-noise amplifier (LNA) of an FSS earth station receiver.

Wireless broadband parameters

The WBB parameters used in the analyses are based on relevant core conditions defined for 3.4 GHz band spectrum licences and Report ITU-R M.2292 (M.2292), which contains information on parameters to use in sharing studies involving 4G systems that can be applied to this study.

Interference was modelled on a per MHz basis. This was done because it removes the need to adjust the level of received interference based on the amount of frequency overlap between the systems being studied (which can vary depending on the case). It also ensures the same level of protection is provided from a single-entry interferer for every MHz over which the receiver operates. This effectively means the study assumes that a single (or, alternatively, multiple-adjacent) WBB transmitter occupies the entire operational bandwidth of the FSS earth station receiver.

Table 12: WBB Study parameters common to co-channel and overload cases

Parameter	Unit	Value	Notes
Antenna height	m	25	From Rep. ITU-R M.2292
Maximum antenna gain	dBi	23	From RRL data
Total Radiated Power (Cochannel and overload cases)[30]	dBm/5 MHz	48	Max power for 3.4 GHz spectrum licences
Total Radiated Power in 1 MHz	dBW/MHz	11	Calculated (converted from dBm to dBW)
Maximum Effective Isotropic Radiated Power (EIRP) in 1 MHz	dBW/MHz	34	Calculated

Table 13: WBB unwanted emission levels into FSS earth station receivers for adjacent channel case

Parameter	Location	Unit	Value	Notes
Total Radiated Power	Receiver Site Swan Island No 2 SWAN ISLAND	dBW/6 MHz	-28	Calculated based on minimum frequency separation of 10 MHz and using the unwanted emission limits stated on 3.4 GHz spectrum licences (assuming AAS is used), into FSS earth station receiver bandwidth
	Met Bureau Wilson Avenue HMAS CERBERUS	dBW/36 MHz	-23	
	HMAS Harman BONSHAW	dBW/6 MHz	-28	
	Geoscience Australia SYMONSTON	dBW/1.2 MHz	-35	
Maximum Effective Isotropic Radiated Power (EIRP)	Receiver Site Swan Island No 2 SWAN ISLAND	dBW/6 MHz	-5	Calculated into receiver bandwidth
	Met Bureau Wilson Avenue HMAS CERBERUS	dBW/36 MHz	0	
	HMAS Harman BONSHAW	dBW/6 MHz	-5	
	Geoscience Australia SYMONSTON	dBW/1.2 MHz	-12	

Table 14: FSS earth station filter rejection values for receiver overload case

Parameter	Location	Unit	Value	Notes
Filter rejection	Receiver Site Swan Island No 2 SWAN ISLAND	dB	20	Calculated from conditions in RAG. For Met Bureau Wilson Avenue two cases were considered at two boundaries.[31]
	Met Bureau Wilson Avenue HMAS CERBERUS		14/49	
	HMAS Harman BONSHAW		20	
	Geoscience Australia SYMONSTON		20	

FSS earth station parameters

The site-specific FSS earth stations used in this study are those licenced in Melbourne and Canberra, metropolitan areas.

Two stations, Receiver Site Swan Island No 2 and HMAS Harman, did not likely have valid values for their antenna azimuth[32] and elevation. For Receiver Site Swan Island No 2 the antenna azimuth was estimated from satellite images (on Google Earth) and the antenna elevation calculated from the azimuth for a satellite in geostationary orbit. For HMAS Harman the worst-case scenario is modelled, with the antenna azimuth directed toward the populated area of Canberra, and the elevation calculated from the azimuth.

[30] For the adjacent channel case, the Tx Power of the BS is calculated using the 3.4 GHz spectrum licence technical framework for each FSS earth station, dependent on its bandwidth and frequencies of operation.

[31] Potential interference from WBB up to 3700 MHz and potential interference from WBB up to 3800 MHz.

[32] Values in the RRL would not point the receiving dish to a satellite within the geostationary arc.

Table 15: FSS earth station study site specific parameters

Location	Latitude	Longitude	Maximum gain (dBi)	Antenna diameter (m)	Antenna height (m)[33]	Antenna Azimuth	Antenna Elevation
Receiver Site Swan Island No 2 SWAN ISLAND	-38.24768°	144.69173°	47.9	7.2	3	-61°	24°
Met Bureau Wilson Avenue HMAS CERBERUS	-38.36378°	145.174351°	44.18	~4.8	2	-34.6°	41.1°
HMAS Harman BONSHAW	-35.348168°	149.20147°	47.9	7.2	3	-57°	30°
Geoscience Australia SYMONSTON	-35.343731°	149.158392°	38	~2.4	2	49.2°	35.6°

Table 16: FSS earth station study generic parameters

Parameter	Value	Reference
Feeder loss	0 dB	Report ITU-R S.2199
Antenna pattern	ITU-R S.465-6	RAG
Long-term protection criteria (p_0=20%)	–128.6 dBm/MHz	RAG
Overload protection criteria	-65 dBm	RAG

Propagation model and terrain

The studies were completed using:

> Visualyse Professional 7.9.7.9 with a three-second digital elevation model (DEM) from the Shuttle Radar Topography Mission (SRTM).

> Propagation model ITU-R P.452-16 with long term protection criteria (p_0=20%) as recommended in the RAG.

While the use of detailed clutter information may also help to improve sharing between MBB and FSS earth station receivers, the ACMA does not have access to reliable information to accurately model this. For this reason, additional losses due to clutter have not been directly modelled in the studies. To consider potential additional path loss due to clutter/buildings or the use of other mitigation measures (such as lower antenna height, increased antenna tilt, lower transmit power, lower unwanted emission levels etc) contours have been included to model 10, 20 and 30 dB of extra loss.

[33] Heights may not be accurate but reflect what is recorded in the RRL.

Results

Figure 9**Error! Reference source not found.** indicates compatibility between existing FSS receivers and cochannel WBB in the Melbourne area in the 3700–3900 MHz range. The red contour indicates areas where placement of a WBB station would cause FSS receiver interference with no additional mitigation measures employed. The other blue and cyan contours assume potential 10 dB and 20 dB of loss. It indicates that WBB can cause interference to FSS receivers over a large geographic area.

Figure 10 similarly indicates the possible interference zones around earth stations licensed for operation in the 3700–3900 MHz band in Canberra.

Figures 11 through 14 indicate potential interference zones to incumbent FSS services in the Melbourne and Canberra from WBB if they were deployed in an adjacent 100 MHz frequency segment (e.g. 3700–3800 MHz). This assumes receiver filtering as per the RAG and includes figures for both out of band and receiver overload mechanisms, with criteria as per the RAG. They indicate that adjacent segment/band use between FSS and WBB may be practicable with only small areas of interference around the FSS stations observed. The ability to coexist will improve the greater the frequency separation. In these figures an additional green contour assumes a potential 30 dB of loss.

Figure 9: Potential spectrum denial areas for WBB operating cochannel with incumbent FSS around Melbourne in the 3700–3900 MHz range

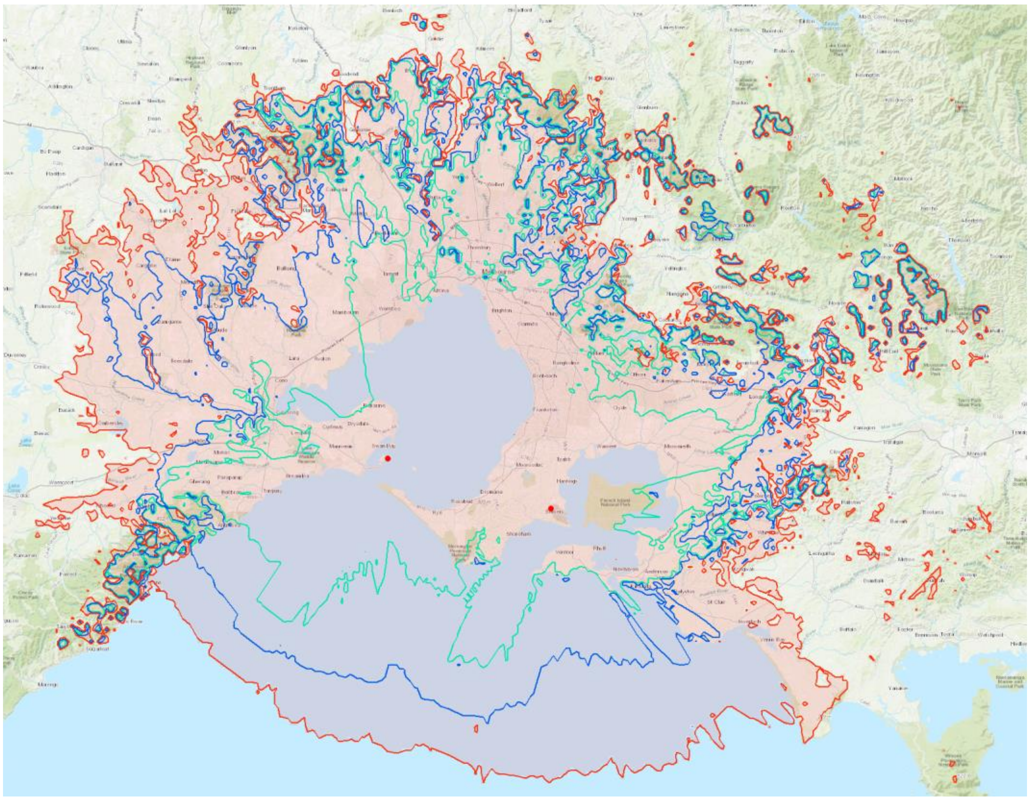


Figure 10: Potential spectrum denial areas for WBB operating cochannel with incumbent FSS around Canberra in the 3700–3900 MHz range

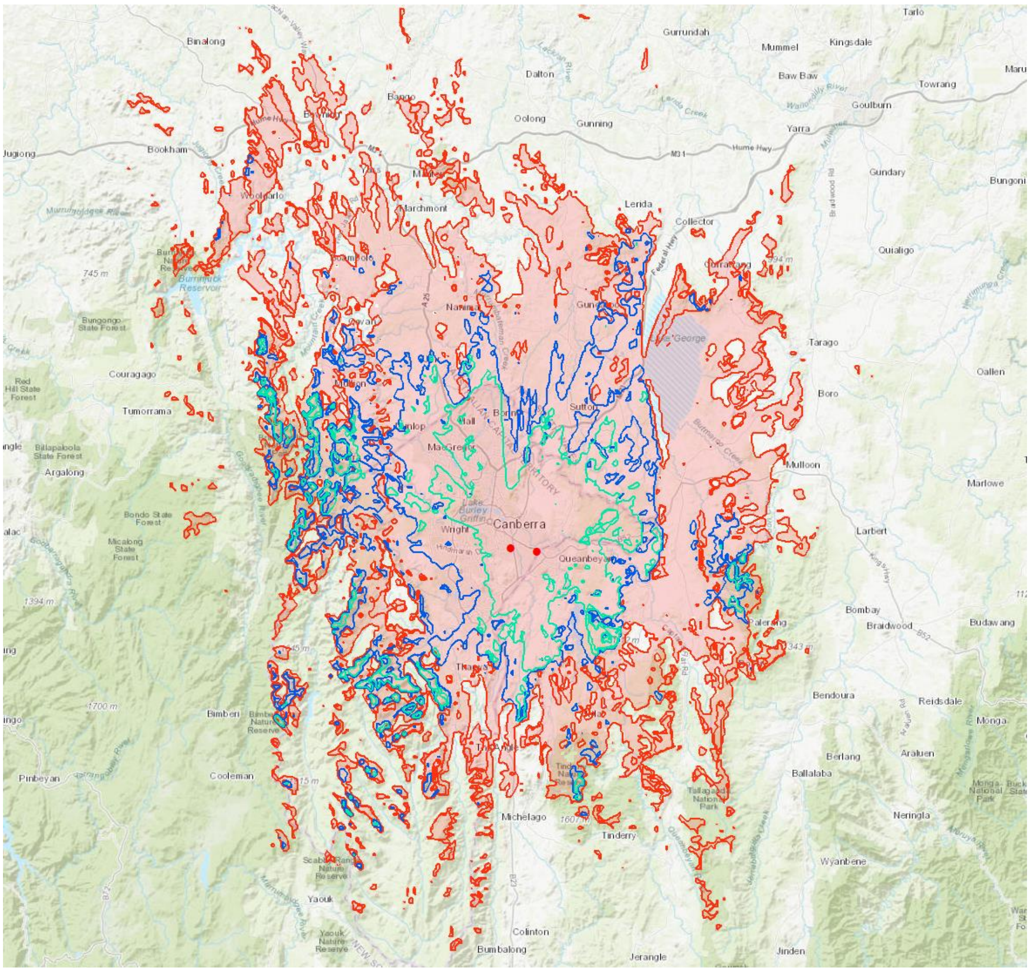


Figure 11: Potential spectrum denial areas for WBB operating adjacent channel with incumbent FSS around Melbourne in the 3700–3900 MHz range

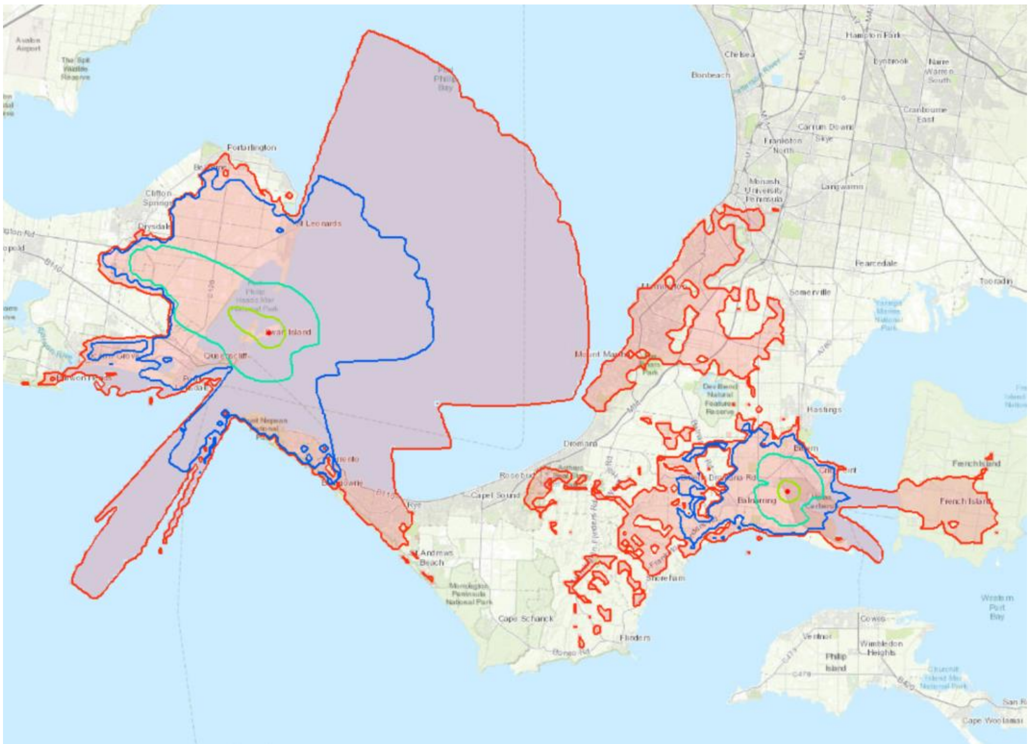


Figure 12: Potential spectrum denial areas for WBB operating adjacent channel with incumbent FSS around Canberra in the 3700–3900 MHz range

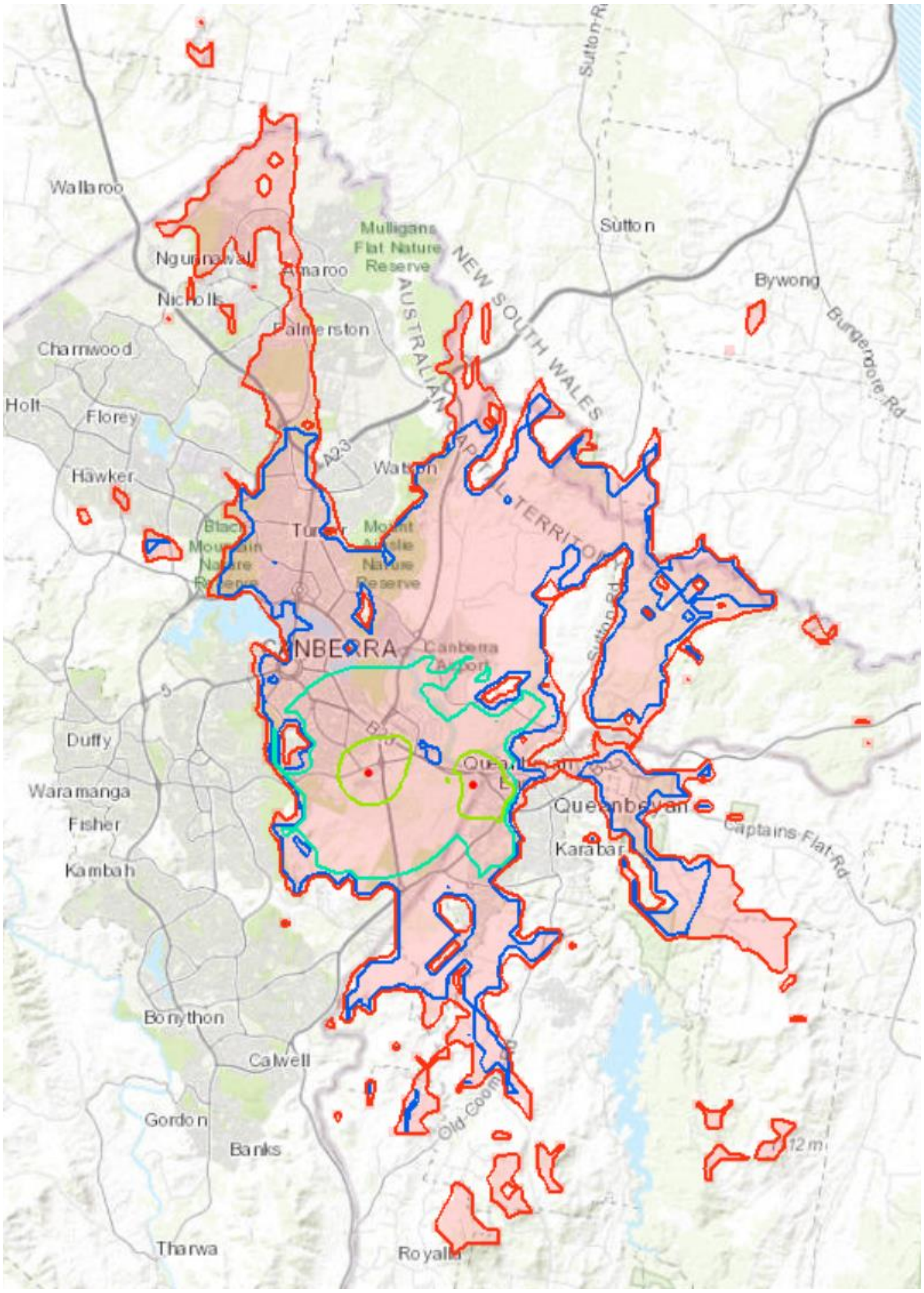


Figure 13: Potential spectrum denial areas for WBB due to receiver overload of incumbent FSS receivers around Melbourne in the 3700–3900 MHz range

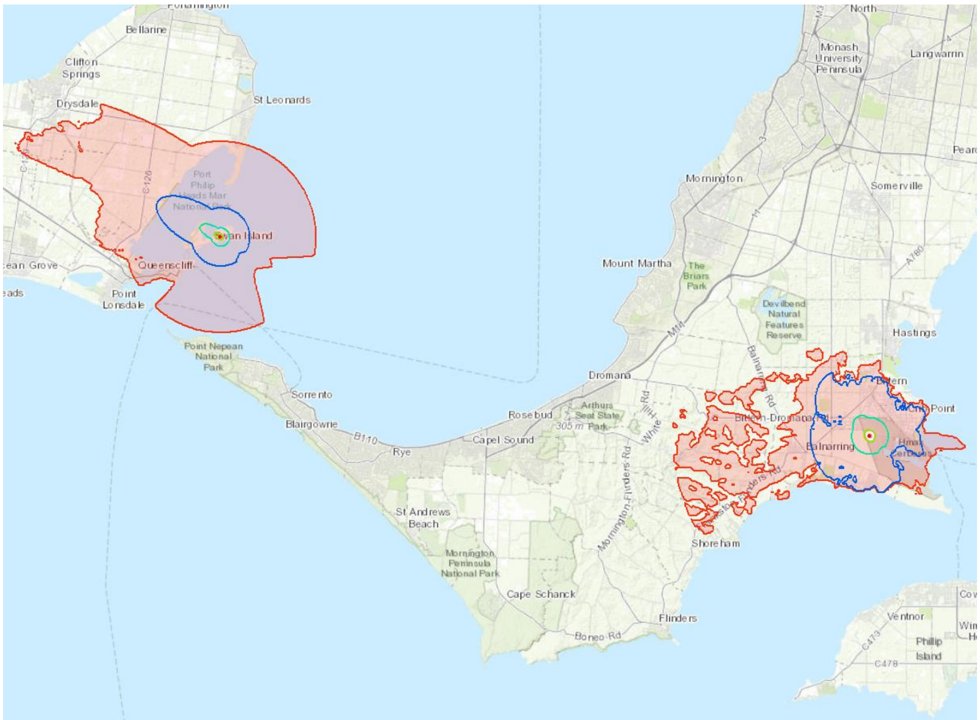
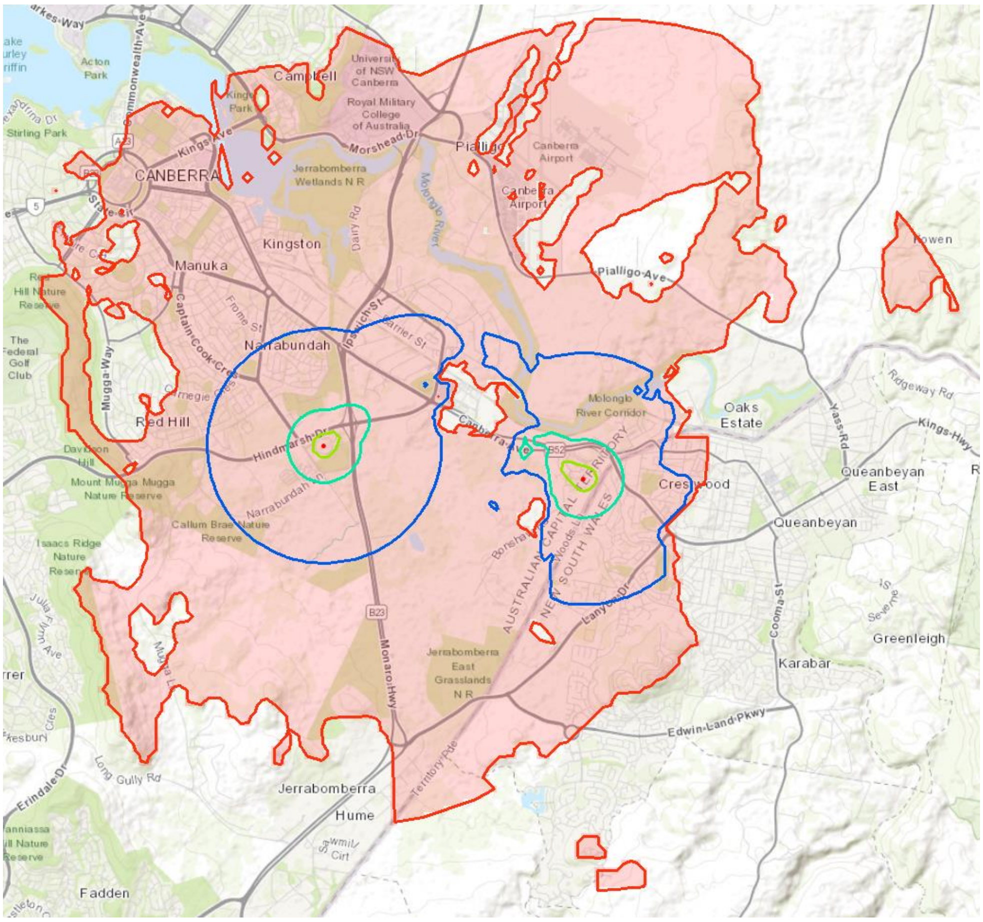


Figure 14: Potential spectrum denial areas for WBB due to receiver overload of incumbent FSS receivers around Canberra in the 3700–3900 MHz range



Appendix E: Geographical area descriptions

The ACMA has defined geographical areas to assist in the analysis of use of, and potential future use scenarios for, the 3700–4200 MHz band. A brief description of each follows:

> Metropolitan—covers all capital cities (except Darwin and Hobart). It mirrors the metro areas defined in the Radiocommunications (Spectrum Re-allocation—3.6 GHz Band for Adelaide and Eastern Metropolitan Australia) Declaration 2018 and the Radiocommunications (Spectrum Re-allocation—3.6 GHz Band for Perth) Declaration 2018.

> Regional—mirrors the regional areas subject to spectrum licensing in the 3.6 GHz band as defined in the Radiocommunications (Spectrum Re-allocation—Regional 1800 MHz Band) Declaration 2015.

> Remote—includes those areas of Australia not covered by metropolitan and Regional areas.

> Australia-wide—covers all of Australia but excludes Australian external territories.

The Australian Spectrum Map Grid (ASMG) is used to define geographical areas over which spectrum licences are issued. The Hierarchical Cell Identification Scheme (HCIS) is a naming convention developed by the ACMA that applies unique ‘names’ to each of the cells that make up the ASMG. The ASMG and HCIS are described in detail in the document *The Australian spectrum map grid 2012*.

The HCIS coordinates in Table 17: HCIS description of areas can be converted into a Placemark file (viewable in Google Earth) through a facility on the ACMA website.

Figure 15: 3700–4200 MHz band geographical area descriptions

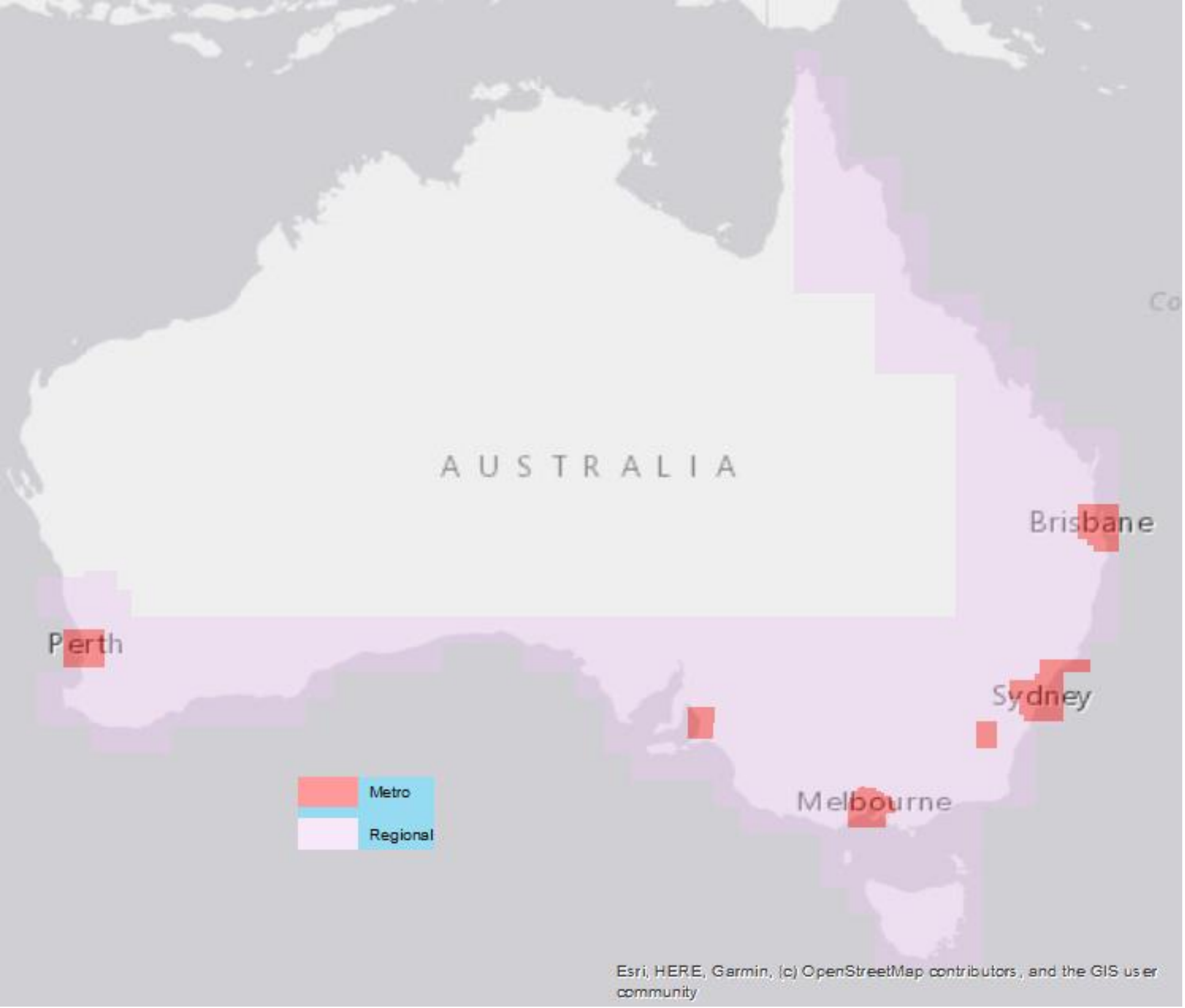


Table 17: HCIS description of areas

Area	Sub-area name	HCIS
Metropolitan	Adelaide	IW3J,IW3K,IW3L,IW3N,IW3O,IW3P,IW6B,IW6C,IW6D,IW6F,IW6G,IW6H,IW3E5,IW3E6,IW3E8,IW3E9,IW3F4,IW3F5,IW3F6,IW3F7,IW3F8,IW3F9,IW3G4,IW3G5,IW3G6,IW3G7,IW3G8,IW3G9,IW3H4,IW3H5,IW3H6,IW3H7,IW3H8,IW3H9,IW3I2,IW3I3,IW3I5,IW3I6,IW3I8,IW3I9,IW3M2,IW3M3,IW3M5,IW3M6,IW3M8,IW3M9,IW6A2,IW6A3,IW6A5,IW6A6,IW6A8,IW6A9,IW6E2,IW6E3,IW6E5,IW6E6,IW6E8,IW6E9,JW1E4,JW1E7,JW1I1,JW1I4,JW1I7,JW1M1,JW1M4
	Brisbane	NT9,NT8C,NT8D,NT8G,NT8H,NT8K,NT8L,NT8O,NT8P,NU3A,NU3B,NU3C,NU3D,NU3F,NU3G,NU3H,NT5O4,NT5O5,NT5O6,NT5O7,NT5O8,NT5O9,NT5P4,NT5P5,NT5P6,NT5P7,NT5P8,NT5P9,NT6M4,NT6M5,NT6M6,NT6M7,NT6M8,NT6M9,NT6N4,NT6N5,NT6N6,NT6N7,NT6N8,NT6N9,NT6O4,NT6O5,NT6O6,NT6O7,NT6O8,NT6O9,NT6P4,NT6P5,NT6P6,NT6P7,NT6P8,NT6P9,NU2C1,NU2C2,NU2C3,NU2D1,NU2D2,NU2D3,NU2D5,NU2D6,NU2D8,NU2D9,NU2H2,NU2H3,NU3E1,NU3E2,NU3E3,NU3E5,NU3E6,NU3E8,NU3E9,NU3I2,NU3I3,NU3J1,NU3J2,NU3J3,NU3K1,NU3K2,NU3K3,NU3L1,NU3L2,NU3L3
	Canberra	MW4D,MW4H,MW4L,MW5A,MW5B,MW5E,MW5F,MW5I,MW5J,MW1P4,MW1P5,MW1P6,MW1P7,MW1P8,MW1P9,MW2M4,MW2M5,MW2M6,MW2M7,MW2M8,MW2M9,MW2N4,MW2N5,MW2N6,MW2N7,MW2N8,MW2N9,MW4P1,MW4P2,MW4P3,MW5M1,MW5M2,MW5M3,MW5N1,MW5N2,MW5N3
	Melbourne	KX3J,KX3K,KX3L,KX3N,KX3O,KX3P,KX6A,KX6B,KX6C,KX6D,KX6E,KX6F,KX6G,KX6H,KX6I,KX6J,KX6K,KX6L,LX1I,LX1M,LX1N,LX1O,LX4A,LX4B,LX4C,LX4E,LX4I,KX3E9,KX3F5,KX3F6,KX3F7,KX3F8,KX3F9,KX3G1,KX3G2,KX3G4,KX3G5,KX3G6,KX3G7,KX3G8,KX3G9,KX3H4,KX3H5,KX3H6,KX3H7,KX3H8,KX3H9,KX3I3,KX3I6,KX3I8,KX3I9,KX3M2,KX3M3,KX3M4,KX3M5,KX3M6,KX3M7,KX3M8,KX3M9,LX1E4,LX1E7,LX1E8,LX1E9,LX1J1,LX1J4,LX1J5,LX1J6,LX1J7,LX1J8,LX1J9,LX1K4,LX1K7,LX4F1,LX4F2,LX4F4,LX4F5,LX4F7,LX4F8,LX4J1,LX4J2,LX4J4,LX4J5,LX4J7,LX4J8
	Perth	BV1I,BV1J,BV1K,BV1L,BV1M,BV1N,BV1O,BV1P,BV2I,BV2J,BV2M,BV2N,BV4A,BV4B,BV4C,BV4D,BV4E,BV4F,BV4G,BV4H,BV4I,BV4J,BV4K,BV4L,BV5A,BV5B,BV5E,BV5F,BV5I,BV5J,BV1E7,BV1E8,BV1E9,BV1F7,BV1F8,BV1F9,BV1G7,BV1G8,BV1G9,BV1H7,BV1H8,BV1H9,BV2E7,BV2E8,BV2E9,BV2F7,BV2F8,BV2F9,BV4M1,BV4M2,BV4M3,BV4N1,BV4N2,BV4N3,BV4O1,BV4O2,BV4O3,BV4P1,BV4P2,BV4P3,BV5M1,BV5M2,BV5M3,BV5N1,BV5N2,BV5N3
	Sydney	MV9I,MV9J,MV9K,MV9L,MV9M,MV9N,MV9O,MV9P,MW3C,MW3D,MW3G,MW3H,MW3K,MW3L,NV4N,NV4O,NV4P,NV5M,NV5N,NV5O,NV5P,NV7B,NV7C,NV7D,NV7E,NV7F,NV7G,NV7H,NV7I,NV7J,NV7K,NV7L,NV7M,NV7N,NV7O,NV7P,NW1A,NW1B,NW1C,NW1D,NW1E,NW1F,NW1G,NW1H,NW1I,NW1J,NW1K,NW1L,MV9D6,MV9D9,MV9E4,MV9E5,MV9E6,MV9E7,MV9E8,MV9E9,MV9F4,MV9F5,MV9F6,MV9F7,MV9F8,MV9F9,MV9G4,MV9G5,MV9G6,MV9G7,MV9G8,MV9G9,MV9H3,MV9H4,MV9H5,MV9H6,MV9H7,MV9H8,MV9H9,MW3B2,MW3B3,MW3B5,MW3B6,MW3B8,MW3B9,MW3F2,MW3F3,MW3F5,MW3F6,MW3F8,MW3F9,MW3J2,MW3J3,MW3O1,MW3O2,MW3O3,MW3P1,MW3P2,MW3P3,NV4I5,NV4I6,NV4I8,NV4I9,

Area	Sub-area name	HCIS
		NV4J4,NV4J5,NV4J6,NV4J7,NV4J8,NV4J9,NV4K4,NV4K5,NV4K6,NV4K7,NV4K8,NV4K9,NV4L4,NV4L5,NV4L6,NV4L7,NV4L8,NV4L9,NV4M2,NV4M3,NV4M5,NV4M6,NV4M8,NV4M9,NV5I4,NV5I5,NV5I6,NV5I7,NV5I8,NV5I9,NV5J4,NV5J5,NV5J6,NV5J7,NV5J8,NV5J9,NV5K4,NV5K5,NV5K6,NV5K7,NV5K8,NV5K9,NV5L4,NV5L5,NV5L6,NV5L7,NV5L8,NV5L9,NV7A2,NV7A3,NV7A4,NV7A5,NV7A6,NV7A7,NV7A8,NV7A9,NW1M1,NW1M2,NW1M3,NW1N1,NW1N2,NW1N3,NW1O1,NW1O2,NW1O3,NW1P1,NW1P2,NW1P3
Regional	-	CV,DV,IV,JV,KQ,KV,KW,LR,LV,LW,LY,MS,MT,MU,AU9,AV9,AW3,BU7,BU8,BV3,BV6,BV7,BV8,BV9,BW1,BW2,BW3,BW5,BW6,CW1,CW2,CW3,CW4,DW1,DW2,DW3,EV1,EV2,EV3,EV4,EV5,EV6,EV7,FV1,FV2,FV3,FV4,FV5,GV1,GV2,GV3,GV6,HV1,HV2,HV3,HV4,HV5,HV6,HV8,HV9,HW3,HW6,IW1,IW2,IW4,IW5,IW7,IW8,IW9,JW2,JW3,JW4,JW5,JW6,JW7,JW8,JW9,JX1,JX2,JX3,JX5,JX6,KO1,KO4,KO5,KO7,KO8,KP1,KP2,KP4,KP5,KP6,KP7,KP8,KP9,KX1,KX2,KX4,KX5,KX8,KX9,KY2,KY3,KY6,LP4,LP7,LQ1,LQ2,LQ4,LQ5,LQ7,LQ8,LX2,LX3,LX5,LX6,LX7,LX8,LX9,LZ1,LZ2,LZ3,MR1,MR4,MR5,MR7,MR8,MR9,MV1,MV2,MV3,MV4,MV5,MV6,MV7,MV8,MW6,MW7,MW8,MW9,MX1,MX2,MX3,MX4,MX7,MY1,MY4,MY7,MZ1,NS4,NS7,NS8,NS9,NT1,NT2,NT3,NT4,NT7,NU1,NU4,NU5,NU6,NU7,NU8,NU9,NV1,NV2,NV3,AU6I,AU6J,AU6K,AU6L,AU6M,AU6N,AU6O,AU6P,BU4H,BU4I,BU4J,BU4K,BU4L,BU4M,BU4N,BU4O,BU4P,BU5E,BU5F,BU5G,BU5H,BU5I,BU5J,BU5K,BU5L,BU5M,BU5N,BU5O,BU5P,BU9A,BU9B,BU9E,BU9F,BU9I,BU9J,BU9M,BU9N,BV1A,BV1B,BV1C,BV1D,BV2A,BV2B,BV2C,BV2D,BV2G,BV2H,BV2K,BV2L,BV2O,BV2P,BV5C,BV5D,BV5G,BV5H,BV5K,BV5L,BV5O,BV5P,IW3A,IW3B,IW3C,IW3D,IW6I,IW6J,IW6K,IW6L,IW6M,IW6N,IW6O,IW6P,JW1A,JW1B,JW1C,JW1D,JW1F,JW1G,JW1H,JW1J,JW1K,JW1L,JW1N,JW1O,JW1P,KX3A,KX3B,KX3C,KX3D,KX6M,KX6N,KX6O,KX6P,LX1A,LX1B,LX1C,LX1D,LX1F,LX1G,LX1H,LX1L,LX1P,LX4D,LX4G,LX4H,LX4K,LX4L,LX4M,LX4N,LX4O,LX4P,MV9A,MV9B,MV9C,MW1A,MW1B,MW1C,MW1D,MW1E,MW1F,MW1G,MW1H,MW1I,MW1J,MW1K,MW1L,MW1M,MW1N,MW1O,MW2A,MW2B,MW2C,MW2D,MW2E,MW2F,MW2G,MW2H,MW2I,MW2J,MW2K,MW2L,MW2O,MW2P,MW3A,MW3E,MW3I,MW3M,MW3N,MW4A,MW4B,MW4C,MW4E,MW4F,MW4G,MW4I,MW4J,MW4K,MW4M,MW4N,MW4O,MW5C,MW5D,MW5G,MW5H,MW5K,MW5L,MW5O,MW5P,NT5A,NT5B,NT5C,NT5D,NT5E,NT5F,NT5G,NT5H,NT5I,NT5J,NT5K,NT5L,NT5M,NT5N,NT6A,NT6B,NT6C,NT6D,NT6E,NT6F,NT6G,NT6H,NT6I,NT6J,NT6K,NT6L,NT8A,NT8B,NT8E,NT8F,NT8I,NT8J,NT8M,NT8N,NU2A,NU2B,NU2E,NU2F,NU2G,NU2I,NU2J,NU2K,NU2L,NU2M,NU2N,NU2O,NU2P,NU3M,NU3N,NU3O,NU3P,NV4A,NV4B,NV4C,NV4D,NV4E,NV4F,NV4G,NV4H,NV5A,NV5B,NV5C,NV5D,NV5E,NV5F,NV5G,NV5H,BV1E1,BV1E2,BV1E3,BV1E4,BV1E5,BV1E6,BV1F1,BV1F2,BV1F3,BV1F4,BV1F5,BV1F6,BV1G1,BV1G2,BV1G3,BV1G4,BV1G5,BV1G6,BV1H1,BV1H2,BV1H3,BV1H4,BV1H5,BV1H6,BV2E1,BV2E2,BV2E3,BV2E4,BV2E5,BV2E6,BV2F1,BV2F2,BV2F3,BV2F4,BV2F5,BV2F6,BV4M4,BV4M5,BV4M6,BV4M7,BV4M8,BV4M9,BV4N4,BV4N5,BV4N6,BV4N7,BV4N8,BV4N9,BV4O4,BV4O5,BV4O6,BV4O7,BV4O8,BV4O9,BV4P4,BV4P5,BV4P6,BV4P7,BV4P8,BV4P9,BV5M4,BV5M5,BV5M6,BV5M7,BV5M8,BV5M9,BV5N4,BV5N5,BV5N6,BV5N7,BV5N8,BV5N9,IW3E1,IW3E2,IW3E3,IW3E4,IW3E7,IW3F1,IW3F2,IW3F3,IW3G1,IW3G2,IW3G3,IW3H1,IW3H2,IW3H3,IW3I1,IW3I4,IW3I7,IW3M1,IW3M4,IW3M7,IW6A1,IW6A4,IW6A7,IW6E1,IW6E4,IW6E7,JW1E1,JW1E2,JW1E3,JW1E5,JW1E6,JW1E8,JW1E9,JW1I2,JW1I3,JW1I5,JW1I6,JW1I8,JW1I9,JW1M2,JW1M3,JW1M5,JW1M6,JW1M7,JW1M8,JW1M9,KX3E1,KX3E2,KX3E3,KX3E4,KX3E5,KX3E6,KX3E7,KX3E8,KX3F

Area	Sub-area name	HCIS
		1,KX3F2,KX3F3,KX3F4,KX3G3,KX3H1,KX3H2,KX3H3,KX3I1,KX3I2,KX3I4,KX3I5,KX3I7,KX3M1,LX1E1,LX1E2,LX1E3,LX1E5,LX1E6,LX1J2,LX1J3,LX1K1,LX1K2,LX1K3,LX1K5,LX1K6,LX1K8,LX1K9,LX4F3,LX4F6,LX4F9,LX4J3,LX4J6,LX4J9,MV9D1,MV9D2,MV9D3,MV9D4,MV9D5,MV9D7,MV9D8,MV9E1,MV9E2,MV9E3,MV9F1,MV9F2,MV9F3,MV9G1,MV9G2,MV9G3,MV9H1,MV9H2,MW1P1,MW1P2,MW1P3,MW2M1,MW2M2,MW2M3,MW2N1,MW2N2,MW2N3,MW3B1,MW3B4,MW3B7,MW3F1,MW3F4,MW3F7,MW3J1,MW3J4,MW3J5,MW3J6,MW3J7,MW3J8,MW3J9,MW3O4,MW3O5,MW3O6,MW3O7,MW3O8,MW3O9,MW3P4,MW3P5,MW3P6,MW3P7,MW3P8,MW3P9,MW4P4,MW4P5,MW4P6,MW4P7,MW4P8,MW4P9,MW5M4,MW5M5,MW5M6,MW5M7,MW5M8,MW5M9,MW5N4,MW5N5,MW5N6,MW5N7,MW5N8,MW5N9,NT5O1,NT5O2,NT5O3,NT5P1,NT5P2,NT5P3,NT6M1,NT6M2,NT6M3,NT6N1,NT6N2,NT6N3,NT6O1,NT6O2,NT6O3,NT6P1,NT6P2,NT6P3,NU2C4,NU2C5,NU2C6,NU2C7,NU2C8,NU2C9,NU2D4,NU2D7,NU2H1,NU2H4,NU2H5,NU2H6,NU2H7,NU2H8,NU2H9,NU3E4,NU3E7,NU3I1,NU3I4,NU3I5,NU3I6,NU3I7,NU3I8,NU3I9,NU3J4,NU3J5,NU3J6,NU3J7,NU3J8,NU3J9,NU3K4,NU3K5,NU3K6,NU3K7,NU3K8,NU3K9,NU3L4,NU3L5,NU3L6,NU3L7,NU3L8,NU3L9,NV4I1,NV4I2,NV4I3,NV4I4,NV4I7,NV4J1,NV4J2,NV4J3,NV4K1,NV4K2,NV4K3,NV4L1,NV4L2,NV4L3,NV4M1,NV4M4,NV4M7,NV5I1,NV5I2,NV5I3,NV5J1,NV5J2,NV5J3,NV5K1,NV5K2,NV5K3,NV5L1,NV5L2,NV5L3,NV7A1,NW1M4,NW1M5,NW1M6,NW1M7,NW1M8,NW1M9,NW1N4,NW1N5,NW1N6,NW1N7,NW1N8,NW1N9,NW1O4,NW1O5,NW1O6,NW1O7,NW1O8,NW1O9,NW1P4,NW1P5,NW1P6,NW1P7,NW1P8,NW1P9,MT4H,MT4K,MT4L,MU5G,MU5H,MU5L,MV3G,MV3H,MV3K,MV3L,MT4F9,MT4G2,MT4G3,MT4G4,MT4G5,MT4G6,MT4G7,MT4G8,MT4G9,MT4J3,MT4J6,MT4O1,MT4O2,MT4O3,MT4O6,MT4P1,MT4P2,MT4P3,MT4P4,MT4P5,MT5E4,MT5E7,MT5I1,MT5I2,MT5I4,MT5I5,MT5I7,MT5M1,MU5C8,MU5C9,MU5D7,MU5D8,MU5D9,MU5K1,MU5K2,MU5K3,MU5K4,MU5K5,MU5K6,MU5K8,MU5K9,MU6A7,MU6E1,MU6E2,MU6E4,MU6E5,MU6E7,MU6E8,MU6I1,MU6I2,MU6I4,MU6I5,MU6I7,MV3C8,MV3C9,MV3D7,MV3F3,MV3F5,MV3F6,MV3F8,MV3F9,MV3J2,MV3J3,MV3J5,MV3J6,MV3J9,MV3O1,MV3O2,MV3O3,MV3P1,NU7K4,CV,DV,IV,JV,KQ,KV,KW,LR,LV,LW,LY,MS,AU9,AV9,AW3,BU7,BU8,BV3,BV6,BV7,BV8,BV9,BW1,BW2,BW3,BW5,BW6,CW1,CW2,CW3,CW4,DW1,DW2,DW3,EV1,EV2,EV3,EV4,EV5,EV6,EV7,FV1,FV2,FV3,FV4,FV5,GV1,GV2,GV3,GV6,HV1,HV2,HV3,HV4,HV5,HV6,HV8,HV9,HW3,HW6,IW1,IW2,IW4,IW5,IW7,IW8,IW9,JW2,JW3,JW4,JW5,JW6,JW7,JW8,JW9,JX1,JX2,JX3,JX5,JX6,KO1,KO4,KO5,KO7,KO8,KP1,KP2,KP4,KP5,KP6,KP7,KP8,KP9,KX1,KX2,KX4,KX5,KX8,KX9,KY2,KY3,KY6,LP4,LP7,LQ1,LQ2,LQ4,LQ5,LQ7,LQ8,LX2,LX3,LX5,LX6,LX7,LX8,LX9,LZ1,LZ2,LZ3,MR1,MR4,MR5,MR7,MR8,MR9,MT1,MT2,MT3,MT6,MT7,MT8,MT9,MU1,MU2,MU3,MU4,MU7,MU8,MU9,MV1,MV2,MV4,MV5,MV6,MV7,MV8,MW6,MW7,MW8,MW9,MX1,MX2,MX3,MX4,MX7,MY1,MY4,MY7,MZ1,NS4,NS7,NS8,NS9,NT1,NT2,NT3,NT4,NT7,NU1,NU4,NU5,NU6,NU8,NU9,NV1,NV2,NV3,AU6I,AU6J,AU6K,AU6L,AU6M,AU6N,AU6O,AU6P,BU4H,BU4I,BU4J,BU4K,BU4L,BU4M,BU4N,BU4O,BU4P,BU5E,BU5F,BU5G,BU5H,BU5I,BU5J,BU5K,BU5L,BU5M,BU5N,BU5O,BU5P,BU9A,BU9B,BU9E,BU9F,BU9I,BU9J,BU9M,BU9N,BV1A,BV1B,BV1C,BV1D,BV2A,BV2B,BV2C,BV2D,BV2G,BV2H,BV2K,BV2L,BV2O,BV2P,BV5C,BV5D,BV5G,BV5H,BV5K,BV5L,BV5O,BV5P,IW3A,IW3B,IW3C,IW3D,IW6I,IW6J,IW6K,IW6L,IW6M,IW6N,IW6O,IW6P,JW1A,JW1B,JW1C,JW1D,JW1F,JW1G,JW1H,JW1J,JW1K,JW1L,JW1N,JW1O,JW1P,KX3A,KX3B,KX3C,KX3D,KX6M,KX6N,KX6O,KX6P,LX1A,LX1B,LX1C,LX1D,LX1F,LX1G,LX1H,LX1L,LX1P,LX4D,LX4G,LX4H,LX4K,LX4L,LX4M,LX4N,LX4O,LX4P,MT4A,MT4B,MT4C,MT4D,MT4E,MT4I,MT4M,MT4N,MT5A,MT5B,MT5C,MT

Area	Sub-area name	HCIS
		5D,MT5F,MT5G,MT5H,MT5J,MT5K,MT5L,MT5N,MT5O,MT5P,MU5A,MU5B,MU5E,MU5F,MU5I,MU5J,MU5M,MU5N,MU5O,MU5P,MU6B,MU6C,MU6D,MU6F,MU6G,MU6H,MU6J,MU6K,MU6L,MU6M,MU6N,MU6O,MU6P,MV3A,MV3B,MV3E,MV3I,MV3M,MV3N,MV9A,MV9B,MV9C,MW1A,MW1B,MW1C,MW1D,MW1E,MW1F,MW1G,MW1H,MW1I,MW1J,MW1K,MW1L,MW1M,MW1N,MW1O,MW2A,MW2B,MW2C,MW2D,MW2E,MW2F,MW2G,MW2H,MW2I,MW2J,MW2K,MW2L,MW2O,MW2P,MW3A,MW3E,MW3I,MW3M,MW3N,MW4A,MW4B,MW4C,MW4E,MW4F,MW4G,MW4I,MW4J,MW4K,MW4M,MW4N,MW4O,MW5C,MW5D,MW5G,MW5H,MW5K,MW5L,MW5O,MW5P,NT5A,NT5B,NT5C,NT5D,NT5E,NT5F,NT5G,NT5H,NT5I,NT5J,NT5K,NT5L,NT5M,NT5N,NT6A,NT6B,NT6C,NT6D,NT6E,NT6F,NT6G,NT6H,NT6I,NT6J,NT6K,NT6L,NT8A,NT8B,NT8E,NT8F,NT8I,NT8J,NT8M,NT8N,NU2A,NU2B,NU2E,NU2F,NU2G,NU2I,NU2J,NU2K,NU2L,NU2M,NU2N,NU2O,NU2P,NU3M,NU3N,NU3O,NU3P,NU7A,NU7B,NU7C,NU7D,NU7E,NU7F,NU7G,NU7H,NU7I,NU7J,NU7L,NU7M,NU7N,NU7O,NU7P,NV4A,NV4B,NV4C,NV4D,NV4E,NV4F,NV4G,NV4H,NV5A,NV5B,NV5C,NV5D,NV5E,NV5F,NV5G,NV5H,BV1E1,BV1E2,BV1E3,BV1E4,BV1E5,BV1E6,BV1F1,BV1F2,BV1F3,BV1F4,BV1F5,BV1F6,BV1G1,BV1G2,BV1G3,BV1G4,BV1G5,BV1G6,BV1H1,BV1H2,BV1H3,BV1H4,BV1H5,BV1H6,BV2E1,BV2E2,BV2E3,BV2E4,BV2E5,BV2E6,BV2F1,BV2F2,BV2F3,BV2F4,BV2F5,BV2F6,BV4M4,BV4M5,BV4M6,BV4M7,BV4M8,BV4M9,BV4N4,BV4N5,BV4N6,BV4N7,BV4N8,BV4N9,BV4O4,BV4O5,BV4O6,BV4O7,BV4O8,BV4O9,BV4P4,BV4P5,BV4P6,BV4P7,BV4P8,BV4P9,BV5M4,BV5M5,BV5M6,BV5M7,BV5M8,BV5M9,BV5N4,BV5N5,BV5N6,BV5N7,BV5N8,BV5N9,IW3E1,IW3E2,IW3E3,IW3E4,IW3E7,IW3F1,IW3F2,IW3F3,IW3G1,IW3G2,IW3G3,IW3H1,IW3H2,IW3H3,IW3I1,IW3I4,IW3I7,IW3M1,IW3M4,IW3M7,IW6A1,IW6A4,IW6A7,IW6E1,IW6E4,IW6E7,JW1E1,JW1E2,JW1E3,JW1E5,JW1E6,JW1E8,JW1E9,JW1I2,JW1I3,JW1I5,JW1I6,JW1I8,JW1I9,JW1M2,JW1M3,JW1M5,JW1M6,JW1M7,JW1M8,JW1M9,KX3E1,KX3E2,KX3E3,KX3E4,KX3E5,KX3E6,KX3E7,KX3E8,KX3F1,KX3F2,KX3F3,KX3F4,KX3G3,KX3H1,KX3H2,KX3H3,KX3I1,KX3I2,KX3I4,KX3I5,KX3I7,KX3M1,LX1E1,LX1E2,LX1E3,LX1E5,LX1E6,LX1J2,LX1J3,LX1K1,LX1K2,LX1K3,LX1K5,LX1K6,LX1K8,LX1K9,LX4F3,LX4F6,LX4F9,LX4J3,LX4J6,LX4J9,MT4F1,MT4F2,MT4F3,MT4F4,MT4F5,MT4F6,MT4F7,MT4F8,MT4G1,MT4J1,MT4J2,MT4J4,MT4J5,MT4J7,MT4J8,MT4J9,MT4O4,MT4O5,MT4O7,MT4O8,MT4O9,MT4P6,MT4P7,MT4P8,MT4P9,MT5E1,MT5E2,MT5E3,MT5E5,MT5E6,MT5E8,MT5E9,MT5I3,MT5I6,MT5I8,MT5I9,MT5M2,MT5M3,MT5M4,MT5M5,MT5M6,MT5M7,MT5M8,MT5M9,MU5C1,MU5C2,MU5C3,MU5C4,MU5C5,MU5C6,MU5C7,MU5D1,MU5D2,MU5D3,MU5D4,MU5D5,MU5D6,MU5K7,MU6A1,MU6A2,MU6A3,MU6A4,MU6A5,MU6A6,MU6A8,MU6A9,MU6E3,MU6E6,MU6E9,MU6I3,MU6I6,MU6I8,MU6I9,MV3C1,MV3C2,MV3C3,MV3C4,MV3C5,MV3C6,MV3C7,MV3D1,MV3D2,MV3D3,MV3D4,MV3D5,MV3D6,MV3D8,MV3D9,MV3F1,MV3F2,MV3F4,MV3F7,MV3J1,MV3J4,MV3J7,MV3J8,MV3O4,MV3O5,MV3O6,MV3O7,MV3O8,MV3O9,MV3P2,MV3P3,MV3P4,MV3P5,MV3P6,MV3P7,MV3P8,MV3P9,MV9D1,MV9D2,MV9D3,MV9D4,MV9D5,MV9D7,MV9D8,MV9E1,MV9E2,MV9E3,MV9F1,MV9F2,MV9F3,MV9G1,MV9G2,MV9G3,MV9H1,MV9H2,MW1P1,MW1P2,MW1P3,MW2M1,MW2M2,MW2M3,MW2N1,MW2N2,MW2N3,MW3B1,MW3B4,MW3B7,MW3F1,MW3F4,MW3F7,MW3J1,MW3J4,MW3J5,MW3J6,MW3J7,MW3J8,MW3J9,MW3O4,MW3O5,MW3O6,MW3O7,MW3O8,MW3O9,MW3P4,MW3P5,MW3P6,MW3P7,MW3P8,MW3P9,MW4P4,MW4P5,MW4P6,MW4P7,MW4P8,MW4P9,MW5M4,MW5M5,MW5M6,MW5M7,MW5M8,MW5M9,MW5N4,MW5N5,MW5N6,MW5N7,MW5N8,MW5N9,NT5O1,NT5O2,NT5O3,NT5P1,NT5P2,NT5P3,NT6M1,NT6M2,NT6M3,NT6N1,NT6N2,NT6N3,NT6O1,NT6O2,NT6O3,NT6P1,

Area	Sub-area name	HCIS
		NT6P2,NT6P3,NU2C4,NU2C5,NU2C6,NU2C7,NU2C8,NU2C9,NU2D4,NU2D7,NU2H1,NU2H4,NU2H5,NU2H6,NU2H7,NU2H8,NU2H9,NU3E4,NU3E7,NU3I1,NU3I4,NU3I5,NU3I6,NU3I7,NU3I8,NU3I9,NU3J4,NU3J5,NU3J6,NU3J7,NU3J8,NU3J9,NU3K4,NU3K5,NU3K6,NU3K7,NU3K8,NU3K9,NU3L4,NU3L5,NU3L6,NU3L7,NU3L8,NU3L9,NU7K1,NU7K2,NU7K3,NU7K5,NU7K6,NU7K7,NU7K8,NU7K9,NV4I1,NV4I2,NV4I3,NV4I4,NV4I7,NV4J1,NV4J2,NV4J3,NV4K1,NV4K2,NV4K3,NV4L1,NV4L2,NV4L3,NV4M1,NV4M4,NV4M7,NV5I1,NV5I2,NV5I3,NV5J1,NV5J2,NV5J3,NV5K1,NV5K2,NV5K3,NV5L1,NV5L2,NV5L3,NV7A1,NW1M4,NW1M5,NW1M6,NW1M7,NW1M8,NW1M9,NW1N4,NW1N5,NW1N6,NW1N7,NW1N8,NW1N9,NW1O4,NW1O5,NW1O6,NW1O7,NW1O8,NW1O9,NW1P4,NW1P5,NW1P6,NW1P7,NW1P8,NW1P9
Australia-wide	–	AR8, AR9, AS2, AS3, AS5, AS6, AS8, AS9, AT1, AT2, AT3, AT5, AT6, AT8, AT9, AU2, AU3, AU6, AU9, AV9, AW3, BR, BS, BT, BU, BV, BW1, BW2, BW3, BW5, BW6, CR, CS, CT, CU, CV, CW1, CW2, CW3, CW4, DQ, DR, DS, DT, DU, DV, DW1, DW2, DW3, EP, EQ, ER, ES, ET, EU, EV1, EV2, EV3, EV4, EV5, EV6, EV7, FP, FQ, FR, FS, FT, FU, FV1, FV2, FV3, FV4, FV5, GO3, GO4, GO5, GO6, GO7, GO8, GO9, GP, GQ, GR, GS, GT, GU, GV1, GV2, GV3, GV6, HO, HP, HQ, HR, HS, HT, HU, HV1, HV2, HV3, HV4, HV5, HV6, HV8, HV9, HW3, HW6, IO, IP, IQ, IR, IS, IT, IU, IV, IW, JO, JP, JQ, JR, JS, JT, JU, JV, JW, JX1, JX2, JX3, JX5, JX6, KO1, KO4, KO5, KO7, KO8, KP1, KP2, KP4, KP5, KP6, KP7, KP8, KP9, KQ, KR, KS, KT, KU, KV, KW, KX1, KX2, KX3, KX4, KX5, KX6, KX8, KX9, KY2, KY3, KY6, LP4, LP7, LQ1, LQ2, LQ4, LQ5, LQ7, LQ8, LR, LS, LT, LU, LV, LW, LX, LY, LZ1, LZ2, LZ3, MR1, MR4, MR5, MR7, MR8, MR9, MS, MT, MU, MV, MW, MX1, MX2, MX3, MX4, MX7, MY1, MY4, MY7, MZ1, NS4, NS7, NS8, NS9, NT, NU, NV1, NV2, NV3, NV4, NV5, NV7, NW1

Appendix F: Cost benefit analysis

This cost-benefit analysis (CBA) identifies relevant quantitative cost and benefit inputs likely to arise under each 3700–4200 MHz band replanning option. The purpose of the CBA is to support the assessment of options and inform the consideration of the option most likely to maximise the net benefit derived from replanning, as per the objects of the Act. Detail on the CBA methodology can be found in the Cost-benefit analysis methodology section.

There are three replanning options currently proposed for the 3700–4200 GHz band. The ACMA therefore considers the simplest method for this CBA is to assess the cost and benefit inputs for each option and feed this into the broader assessment of the three options in the body of this paper. This process seeks to identify which option is most net beneficial after comparing the costs and benefits of each option against the status quo, which is considered the baseline for this analysis.

While there will inevitably be variations between the estimated costs in the CBA and actual costs incurred from any change, the use of common cost estimates and methodology between options assists in identifying the relative costs difference between options.

The outcomes of this CBA will be considered as part of an integrated assessment of planning options, which also incorporates other inputs such as technical considerations, international harmonisation and government policy objectives.

Results summary

Three replanning options have been considered:

> Option 1

> Introduce arrangements to allow for WBB exclusively in one frequency segment, with no change to current arrangements in the remaining segment.

> Option 2

> Introduce arrangements to allow for WBB sharing with existing services in one frequency segment, with no change to current arrangements in the remaining segment

> Option 3

> Introduce arrangements to allow for WBB both exclusively and shared with existing services in some segments, with no change to current arrangements in the remaining segment

In summary, the results of the CBA analysis for each option are the following:

> Option 1: Is expected to be moderately net beneficial due to the benefits of WA WBB exclusive access arrangements across 3700–3900 MHz in metropolitan and regional areas. However, there is likely to be diminishing marginal benefit with WA WBB use in 3800–3900 MHz when compared with the displacement costs of licensed FSS users.

- Option 2: Is expected to be moderately net beneficial as incumbent FSS and PTP services can continue operating while enabling access to WA WBB use. This is considered less likely to maximise net benefit when compared with Options 3 and 4 due to the absence of potentially major benefits of exclusive access arrangements for WA WBB in parts of the band.
- Option 3: Is expected to be the most net beneficial as exclusive access for WA WBB in 3700–3800 MHz in metropolitan and regional areas generates significant benefits, while incumbents receive a level of protection in 3800–3900 MHz that helps mitigate displacement costs.

While this CBA has resulted in Option 3 being considered the option most likely to maximise net benefit, it should be noted that replanning decisions will involve consideration of the CBA alongside other elements of analysis identified within the Options paper.

Cost-benefit inputs for each option

For this CBA, the options are assumed to have 200 MHz made available for the introduction of new uses (that is, it assumes the frequency range 3700-3900 MHz is made available for new services), but the ACMA is seeking feedback regarding the particular quantum of spectrum that should be made available under these options and where the breakpoints should be.

To illustrate possible quantitative costs and benefits, the analysis assumes particular frequency boundaries for each planning option identified. These boundaries have not been decided on and form part of this consultation process.

As noted elsewhere in the body of the paper, these replanning options could lead to an increased interference risk to unlicensed TVRO FSS use. This has not been considered as cost inputs.

Option 1: Replanning of a frequency segment to cater for new services, no change to current arrangements in a second segment

The key aspects of Option 1 compared with the status quo are the following:

- FSS and PTP lose access to 200 MHz of bandwidth from 3700–3900 MHz Australia-wide.
- WA WBB gains access to 3700–3900 MHz on an exclusive basis (e.g. via spectrum licensing) in metropolitan and regional areas.
- LA WBB gains access to 3700–3900 MHz on an exclusive basis in remote areas.
- FSS and PTP maintain current arrangements in 3900–4200 MHz.

Option 1 includes usage changes for 200 MHz at the bottom of the band, but the ACMA is seeking feedback on whether 200 MHz is an appropriate quantum of spectrum to be made available for new uses under this option.

Option 1: Cost inputs

FSS gateway and individual FSS are the key incumbents that would be displaced from the bottom of the band Australia-wide. For the purposes of this CBA, the ACMA expects that displacing licensed FSS services from this part of the band would represent constant output cases. This assumes that incumbent licensees would be able to maintain similar services through frequency relocation (retuning equipment to different frequencies within the same band or to a different band) or geographic relocation (moving services to a new or different site).

For FSS gateway sites, retuning to a different frequency is the lower-cost option to maintain service but may not be possible in all cases. The ACMA estimates approximate retuning costs for FSS gateway sites to be $300,000 per gateway. This estimate accounts for the potential cost of a new dish, as retuning may also require the assignment to repoint in a different direction from other co-located services. We are interested to understand whether this cost assumption accurately reflects the expected costs for gateway sites.

If retuning is not a viable option for FSS gateways, there remains the potential for geographic relocation into ESPZs, which would be excluded from the regional and remote areas made available for WBB. In the highest value use analysis for the 3.6 GHz band, the estimated costs involved in geographically relocating all FSS licences from an FSS gateway site ranged between $20 million and $50 million.[34] Due to the similarity between 3.6 GHz and 3700–4200 MHz in terms of site locations and spectrum characteristics, the ACMA intends to use the same cost range per FSS gateway facility for the 3700–4200 MHz band. It should be noted that these costs are associated with establishing a new earth station facility. It is expected that costs would be significantly lower if an incumbent user were to deploy new services at an existing facility or if multiple operators join to create a new site.

Separate costs have been estimated for “individual” FSS stations. These are earth stations at locations where only one or a few FSS licences exist. The applications are still highly variable, from VSAT communications systems to large TVRO dishes. Consequently, costs to relocate are also highly variable but averages have been internally estimated depending on whether service is maintained by frequency or geographic relocation. Retuning costs for individual FSS are estimated at $30,000 per site, which can be attributed to labour costs associated with retuning and materials for a new filter. The ACMA’s initial estimate is that geographic relocation costs are between $1 million and $2 million, which involves establishing a new site.

In the table below, the ACMA has estimated the percentage of sites that could maintain service via retuning rather than geographic relocation. To calculate the total cost ranges, these percentages have been applied to the maximum potential cost if all sites retuned or relocated.[35]

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[34] The paper *Future use of the 3.6 GHz band: Highest value use–Quantitative analysis* can be found on the ACMA website. The explanation for the range of $20 million – $50 million can be found on p40–41.

[35] For example, if there are eight affected FSS gateway sites and retuning costs are equal to $300,000 per gateway, the maximum potential cost of retuning all eight FSS gateway sites is $2.4 million. Thirty per cent of $2.4 million is $720,000. It is this amount of $720,000 that has been included in the total cost range.

Table 18: FSS—estimated cost inputs for Option 1 (constant output cases)

Category	Retune per cent	Relocate per cent	Retune cost	Relocate cost	Total cost
FSS gateway—8 sites in 3700–3900 MHz in all areas	30%	70%	$300,000	$20 million–$50 million	$113 million–$281 million
Individual FSS—19 sites in 3700–3900 MHz in all areas	30%	70%	$30,000	$1 million–$2 million	$13 million–$27 million

It should be noted that the estimated quantitative cost inputs in Table 18 assume a continuation of services is possible—that is, they are considered constant output cases. It may be the case that an equivalent service is unable to be maintained, in which case the displacement of FSS would represent variable output cases. These cases are not amendable to quantification but should be noted as an alternative outcome alongside the constant output case scenario.

The other incumbent service type that would be displaced from 3700–3900 MHz is PTP. Based on data provided in the replanning process for the 3.6 GHz band, the average cost range for equipment replacement for a fixed link system was between $85,000 and $100,000.[36] For simplicity, this analysis will assume the cost is $100,000 per fixed link. Costs may be reduced provided there are opportunities for equipment retuning rather than replacement, or if incumbents can access alternative service delivery options, such as existing fibre runs. Costs may also be reduced if some incumbent PTP services are provided protection to meet USO requirements, as that would mean these services are not displaced.

Table 19: PTP—estimated cost inputs for Option 1 (constant output cases)

Category	Potential no. of affected services	Cost per service	Total cost
PTP services equipment replacement for all fixed links in 3700–3900 MHz in all areas	22 fixed links[37]	$100,000	$2.2 million

Note: Some PTP services may require ongoing protection for USO purposes—if this is the case, the potential number of affected services would decrease.

[36] The paper *Future use of the 3.6 GHz band: Highest value use–Quantitative analysis* can be found on the ACMA website. See the explanation for PTP costs on page 41.

[37] For the purpose of costing it is assumed that costs are similar for any number of links between two sites by the same licensee (that is, most capital equipment is common between multiple RF channels).

Option 1: Benefit inputs

The key beneficiaries under Option 1 are WA WBB service providers in defined metropolitan and regional areas, and LA WBB providers outside of these defined areas, as these potential users gain access to 3700–3900 MHz.

For WA WBB in defined areas, the typical method to determine the economic benefits that this use would derive from the spectrum is to use potential valuations of the spectrum as a proxy. Previous spectrum prices are often used as a guide in these circumstances, as they reflect a demonstrated willingness to pay. However, as outlined in further detail in the Cost-benefit analysis methodology section, previous spectrum prices and potential valuations of spectrum available in the future are not equivalent to projected revenue that would be generated in a price-based allocation of this spectrum.

Outcomes from the 3.6 GHz band auction, which concluded in December 2018 and was for similar spectrum to 3700–3900 MHz, can provide a guide for willingness to pay and consequently the potential economic benefits of this particular spectrum. The average price for the 3.6 GHz band auction was $0.29/MHz/pop. This price can be used as a proxy for the economic benefits derived from 3700–3900 MHz in this CBA, although the following uncertainties are noted:

- As is the case with all auctions, the 3.6 GHz band auction was subject to unique circumstances. The competitive tension varied significantly between metropolitan areas and regional areas, with metropolitan areas selling for reserve price (approx. $0.08/MHz/pop) while regional areas were bid up to an average price of approx. $0.74/MHz/pop. The prices paid in metropolitan areas in particular are unlikely to reflect private valuations of the spectrum.
- A key aspect of this CBA is the incremental economic cost or benefit of a regulatory proposal. The 3.6 GHz band auction resulted in the mid-band spectrum available for 5G WA WBB services increasing from 175 MHz to 300 MHz (that is, between 3400–3700 MHz), allowing access to sufficient spectrum to support economically viable deployment by multiple licensees. Potential users may not necessarily place as high a value on additional spectrum beyond the 300 MHz currently available as there are likely diminishing returns to the economic benefits provided by the spectrum.

It may also be the case that the incremental economic benefit of increasing spectrum available to WA WBB by 100 MHz (that is, increasing total mid-band spectrum for WA WBB to 400 MHz) may generate more economic value than *another* 100 MHz (that is, increasing total mid-band spectrum for WA WBB to 500 MHz). Access to 400 MHz means there is roughly an average of 100 MHz—the maximum channel bandwidth currently supported by 5G standards—for four potential users.[38] Consequently, there may not be as high a level of demand for more than 100 MHz of spectrum amongst potential users.

The expectation that the spectrum value will decrease as supply increases for WA WBB makes it difficult to determine a uniform proxy as the value for 3700–3900 MHz for WA WBB. As such, the ACMA considers that a value of $0.29/MHz/pop can only be used as the benefit for the first 100 MHz replanned for WA WBB. For the following 100 MHz, the top of the value range has been halved to $0.145/MHz/pop, while the bottom of the range is $0.03/MHz/pop, which is also later used for LA WBB.

[38] Further detail on spectrum requirements for WA WBB users can be found in the *Consideration of spectrum requirements and options for WA WBB* section in the body of the paper.

Table 20: WA WBB—estimated benefits for Option 1

Category	Affected population[39]	$/MHz/pop	Total benefit per 100 MHz
WA WBB using spectrum licences in all metropolitan and regional areas: 3700–3800 MHz	24.3 million	$0.29	$704.7 million
WA WBB using spectrum licences in all metropolitan and regional areas: 3800–3900 MHz		$0.03–$0.145	$72.9 million–$352.4 million

Different reference points are required to help determine the economic benefits of replanning the band for LA WBB in remote areas. An example of a demonstrated willingness to pay for regional/remote mid-band spectrum that could be used as a proxy is the $0.03/MHz/pop price placed on 3.4 GHz band spectrum licences in the expiring spectrum licence (ESL) reissue process. These prices were set in 2012 and the licences were renewed for a 15-year term in 2015, which was prior to international harmonisation of the band for 5G services.

The relatively small population in remote areas in Australia (the population outside of the 3.6 GHz metropolitan and regional areas is projected to be approximately 530,000) means that the total benefits at $0.03/MHz/pop reach $3.2 million for the whole 200 MHz in all remote areas. Potential users may find more benefit in commercial or industrial applications in remote areas (for example, in mining) rather than consumer-based services, although this assumes such users have spectrum requirements beyond what is available in 3400–3700 MHz already. These uncertainties mean that access to 3700–3900 MHz in remote areas for LA WBB may have some unquantifiable benefits, but these benefits are likely to be very minor when considered against WA WBB benefits and potential FSS gateway costs.

Option 1: Net benefit

The above cost and benefit inputs indicate that Option 1 is net beneficial, as the benefit derived from the spectrum by WA WBB in metropolitan and regional areas is expected to exceed the potential costs of displacement of FSS and PTP services.

The presence of unquantifiable costs and benefits means that the exact amount of the net benefit for any option is unable to be determined. The following table aims to illustrate the key aspects of Option 1 via a side-by-side comparison, with each column listed in order of magnitude.

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[39] The affected population is a forecast for June 2020 for the included metropolitan and regional areas, which are the same as the areas available in the 3.6 GHz band auction. The forecast is calculated by projecting national population growth since the 2016 Census (based off Australian Bureau of Statistics (ABS) data and Commonwealth Budget population forecasts), then applying this same growth ratio to the population of the affected areas at the 2016 Census date.

Table 21: Option 1 cost-benefit side-by-side comparison

Costs	Benefits
FSS gateway displacement: $113 million–$281 million. These quantifiable costs could be replaced with unquantifiable costs if services are unable to continue and displacement of FSS gateways represent a variable output case	WA WBB in metropolitan and regional areas for 3700–3800 MHz: approximately $705 million, using the average 3.6 GHz price of $0.29/MHz/pop
Individual FSS displacement: $13 million–$27 million These quantifiable costs could be replaced with unquantifiable costs if services are unable to continue and displacement of FSS gateways represent a variable output case	WA WBB in metropolitan and regional areas for 3800–3900 MHz: this is difficult to quantify as diminishing returns to the spectrum are expected for WA WBB—the estimated value range spans from approximately $73 million (at $0.03/MHz/pop) to $352 million (at $0.145/MHz/pop, which is half the average 3.6 GHz price)
PTP services equipment replacement: approximately $2.2 million. This may be reduced due to USO protections, which would also likely have a minor negative impact on benefits	LA WBB in remote areas for 3700–3900 MHz: approximately $3.2 million, based on a valuation of $0.03/MHz/pop

Option 2: Implementation of sharing arrangements to facilitate new services in a frequency segment, no change to current arrangements in a second segment

Option 2 introduces new services in a frequency segment on a coordinated basis. This option represents the most similar outcome to the status quo, with WBB services afforded the opportunity to coexist with incumbent FSS/PTP services.

The key aspects of Option 2 compared with the status quo are the following:

> FSS and PTP are able to maintain existing services in 3700–3900 MHz. In some cases, there may be limited opportunity to deploy new services due to the need to coordinate with WA WBB services. This is most likely to occur in and around areas of high population.

> WBB (either WA or LA) gains access to 3700–3900 MHz on a shared basis with FSS and PTP in all areas.

> FSS and PTP maintain current arrangements in 3900–4200 MHz.

Similar to Option 1, Option 2 includes usage changes for 200 MHz at the bottom of the band, but the ACMA is seeking feedback on an appropriate quantum of spectrum to be made available for new uses under this option.

Option 2: Cost inputs
There are very few cost inputs under Option 2. Existing services will be protected and therefore no incumbents are expected to be displaced.

Existing service types in the band, such as FSS and PTP, may experience reduced opportunities to expand as they would have to coexist with new WBB services, particularly in areas outside of Sydney and Perth where there will not be as many incumbent services protected. This potential cost input is unquantifiable as it relies on uncertain future events where new prospective FSS and/or PTP services are impacted by the presence of WA WBB or LA WBB services.

Option 2: Benefit inputs
The key benefit under Option 2 is the availability of 3700–3900 MHz for WA WBB coexistence with incumbents. There are several reasons why the benefits of this option would be diminished compared with Option 1.

> The type of access provided to WA WBB in this option is likely to be less economically beneficial as there is a greater potential for spectrum denial under sharing arrangements. Spectrum denial occurs when access to spectrum in an area by a particular service is restricted due to the need to protect existing licensed services. For co-channel sharing between WBB and FSS earth stations, the areas where access to spectrum is denied can be quite large – potentially in the order of many tens of kilometres, depending on the characteristics of each service, the local terrain and clutter.

> While the protection of incumbents reduces the economic costs of retuning or relocating them, it also means that the full benefits of moving to a new use are unable to be achieved. For instance, both Sydney and Perth are heavily encumbered with FSS facilities, which means that there is likely to be limited opportunity for users to access spectrum in these cities. Therefore, when scaling up any $/MHz/pop valuation placed on the spectrum by bandwidth and population, the population of at least Sydney and Perth would have to be removed from calculations.

> Potential WA WBB users of the spectrum are likely to be large-scale operators with national business strategies. If business cases are made on the basis of a national strategy, the inability to access spectrum in key markets like Sydney and Perth, or only access parts of a key market as would be the case for Canberra and Melbourne, may diminish the value of obtaining this spectrum.

The ACMA considers the ESL reissue price of $0.03/MHz/pop (also used as the reserve price for regional areas in the 3.6 GHz band auction) offers a more accurate reflection of WA WBB use of the band via non-spectrum licences (the valuations reflect extended multi-year durations).

Similar to Option 1, there is the potential for the value of the band to fall as more spectrum is made available—that is, 200 MHz is likely to generate a lower $/MHz/pop value than 100 MHz, leading to lower marginal economic benefit. As such, benefits are measured in 100 MHz increments.

Table 22: WA WBB—estimated benefits for Option 2

Category	Affected population[40]	$/MHz/pop	Total benefit per 100 MHz
WA WBB in 3700–3800 MHz in metropolitan and regional areas where incumbents are protected and not using spectrum licences	10.7 million	$0.03	$32.1 million
WA WBB in 3800–3900 MHz in metropolitan and regional areas where incumbents are protected and not using spectrum licences	11.9 million		$35.7 million

For Option 2, similar economic benefits to Option 1 are expected for LA WBB in remote areas. The only difference is that there may be less opportunities for LA WBB as some incumbent FSS and PTP operators will be protected, while they will also be competing with new FSS or PTP operators for any in-demand areas. These benefits are unquantifiable as the uptake of spectrum in these areas is highly uncertain.

However, due to the availability of spectrum in the 3400–3700 MHz band for LA WBB coupled with the historically lower density of deployments by FSS, PTP and LA WBB in remote areas, the impact of spectrum denial caused by sharing the band is not expected to be significant.

Option 2: Net benefit

Option 2 is also net beneficial as there would be minimal costs due to there being no forced displacement of incumbents, along with the introduction of WA WBB and LA WBB to coexist with incumbent services in different areas.

[40] The affected population refers to the population of areas that would be usable by WA WBB operators when considering there would be protection for incumbent FSS services. The affected population is first estimated by measuring the geographic effect of incumbent services on cochannel WBB deployment, as per Appendix D: FSS earth station sharing study, with population figures based on 2016 Census data. These population figures are subsequently forecast forward to the June 2020 quarter using ABS data and Commonwealth Budget population forecasts.

Table 23: Option 2 cost-benefit side-by-side comparison

Costs	Benefits
Very minor unquantifiable costs associated with FSS and PTP services losing opportunities to deploy new services in some areas by WBB presence, although ESPZs provide continued potential for expansion	WA WBB in metropolitan and regional areas for 3700–3900 MHz: likely to be lower than Option 1 due to shared access arrangements that would limit access to some areas and greater potential for spectrum denial. Example benefit using the metropolitan 3.6 GHz reserve price of $0.03/MHz/pop for the entire 200 MHz is approximately $68 million
	LA WBB in remote areas for 3700–3900 MHz: approximately $3 million–$3.5 million, based on a valuation of $0.03/MHz/pop

Option 3: Mix of reallocation and sharing arrangements to facilitate new services, no change to current arrangements in a remaining segment

Option 3 clears incumbent users in a frequency segment in metropolitan and regional areas. It introduces arrangements for new uses on a coordinated basis in remote areas in the same segment and Australia-wide in a second frequency segment.

The key aspects of Option 3 compared with the status quo are the following:

> FSS and PTP lose access to 100 MHz of bandwidth from 3700–3800 MHz in metropolitan and regional areas.

> FSS and PTP users are able to maintain existing services in 3800–3900 MHz. In some cases, there may be limited opportunity to deploy new services, if desired, due to the need to coordinate with WA WBB services. This is most likely to occur in and around areas of high population.

> WA WBB gains access to 3700–3800 MHz on an exclusive basis (e.g. spectrum licensing) in metropolitan and regional areas.

> LA WBB gains access to 3700–3800 MHz on a shared basis with FSS and PTP in remote areas.

> LA WBB gains access to 3800–3900 MHz on a shared basis with FSS and PTP Australia-wide.

> FSS and PTP maintain current arrangements in 3900–4200 MHz.

Option 3: Cost inputs

The cost inputs for Option 3 have similar characteristics to the cost inputs for Option 1, with the only difference being that incumbent FSS and PTP services would be displaced from the 100 MHz from 3700–3800 MHz rather than the 200 MHz from 3700–3900 MHz.

The additional bandwidth from 3800–3900 MHz for which access is retained by incumbent services should help reduce costs compared with Option 1. Some incumbents may not be using 3700–3800 MHz, while those that are using 3700–3800 MHz may have more opportunities to retain services via lower-cost equipment retuning as 3800–3900 MHz remains available to them. As such, the cost estimates for Option 3 assume 50 per cent probability of being able to retune, rather than the 30 per cent probability as per Option 1.

The cost per service for FSS gateway services in Table 24 assumes major geographic relocation of all C-Band services at a facility, as was the case in Option 1.

Table 24: FSS—estimated cost inputs for Option 3 (constant output cases)

Category	Retune per cent	Relocate per cent	Retune cost	Relocate cost	Total cost
FSS gateway—7 sites in 3700–3900 MHz in all areas	50%	50%	$300,000	$20 million to $50 million	$71 million to $176 million
Individual FSS—6 sites in 3700–3900 MHz in all areas	50%	50%	$30,000	$1 million to $2 million	$3 million to $6 million

There were only two fixed link systems that use 3800–3900 MHz that do not use 3700–3800 MHz, which means PTP cost inputs are similar to Option 1 as there are only two fewer fixed link services affected.

Table 25: PTP—estimated cost inputs for Option 3 (constant output cases)

Category	Potential no. of affected services	Cost per service	Total cost
PTP services equipment replacement for all fixed links in 3700–3800 MHz in all areas	20 fixed links	$100,000	$2.0 million

Note: Some PTP services may require ongoing protection for USO purposes – if this is the case, the potential number of affected services would decrease.

Option 3: Benefit inputs

The benefit inputs for Option 3 are similar to both Option 1 and Option 2.

> For 3700–3800 MHz, the benefits are identical to the first 100 MHz available for WA WBB and LA WBB under Option 1.

> For 3800–3900 MHz, the benefits are the same as for the remote areas in 3700–3800 MHz under this option but are applied in all areas.

For the benefits accruing from replanning 3700–3800 MHz, refer to the discussion and Table 20 under Option 1: Benefit inputs. These benefits use the average 3.6 GHz spectrum licence price of $0.29/MHz/pop as a guide for WA WBB economic benefits in 3700–3800 MHz. The potential benefits at that valuation equal $704.7 million.

The LA WBB benefits in remote areas are similar as well in that they are unquantifiable and will likely rely on uncertain uptake from commercial or industrial users, particularly as there is a relatively low population in these areas. This uncertainty occurs across the entire 3700–3900 MHz span.

The benefits in 3800–3900 MHz in metropolitan and regional areas are even more uncertain and are therefore also unquantifiable. There may be opportunities for new LA WBB users to derive value from the spectrum in metropolitan and regional areas outside of where incumbent FSS and PTP services are located. This value is likely to be lower than the value derived from WA WBB spectrum licences. For instance, applying a value of $0.03/MHz/pop (as per the ESL reissue process outlined in Option 1) across the entire metropolitan and regional population unaffected by protection for incumbent FSS and PTP users in 3800–3900 MHz generates economic benefits of $48.9 million. While this value is outlined in the table below, the ACMA acknowledges there is significant uncertainty surrounding the value of this economic benefit.

Table 26: WBB—estimated benefits for Option 3

Category	Affected population[41]	$/MHz/pop	Total benefit per 100 MHz
WA WBB in metropolitan and regional areas in 3700–3800 MHz	24.3 million	$0.29	$704.7 million
LA WBB in metropolitan and regional areas in 3800–3900 MHz	11.9 million	$0.03	$35.7 million
LA WBB in remote areas in 3700–3900 MHz	530,000	$0.03	$1.6 million

Option 3: Net benefit

Option 3 is considered to be net beneficial as WA WBB would be able to derive significant economic benefits from 3700–3800 MHz while FSS gateway services have greater ability to maintain services at lower cost (compared with Option 1) as they retain 3800–3900 MHz.

[41] The affected population refers to the population of areas that would be usable by WA WBB operators when considering there would be protection for incumbent FSS services. The affected population is first estimated based on 2016 Census population figures and is a forecast forward to the June 2020 quarter using ABS data and Commonwealth Budget population forecasts.

A variation on Option 3 could be to clear 3800–3900 MHz in metropolitan areas where there are minimal incumbent services. This may increase the affected population for LA WBB in 3800–3900 MHz, leading to marginally greater benefits, although this would come at the cost of displacing a slightly greater number of incumbents.

Table 27: Option 3 cost-benefit side-by-side comparison

Costs	Benefits
FSS gateway displacement: $71 million–$176 million, which could be replaced with unquantifiable costs if services are unable to continue	WA WBB in metropolitan and regional areas for 3700–3800 MHz: approximately $705 million, using the average 3.6 GHz price of $0.29/MHz/pop
Individual FSS displacement: $3 million–$6 million, which could be replaced with unquantifiable costs if services are unable to continue	LA WBB in metropolitan and regional areas for 3800–3900 MHz: an unquantifiable amount that is likely to be of considerably lower value than WA WBB services. An example valuation is $0.03/MHz/pop, which generates economic value of approximately $36 million
PTP services equipment replacement: approximately $2.0 million. This may be reduced due to USO protections, which would also likely have a minor negative impact on benefits	
Very minor unquantifiable costs associated with new FSS and PTP services potentially losing opportunities due to LA WBB presence	LA WBB in remote areas for 3700–3900 MHz: approximately $3.2 million, based on a valuation of $0.03/MHz/pop

Option comparison

Each replanning option for the 3700–4200 MHz band contains various unquantifiable cost-benefit inputs, and there is also uncertainty in the quantifiable inputs.

There are many similarities between the available replanning options, particularly with regard to 3900–4200 MHz being identical under all options. The replanning process can be broken down into replanning decisions for 3700–3800 MHz and for 3800–3900 MHz. Sharing arrangements can be considered to be net beneficial compared with the status quo as they present potential benefits for users gaining access with minimal costs for incumbents as they receive continued protection. As such, the key issues in determining which of the options is most likely to maximise net benefit are whether it is net beneficial to:

> make 3700–3800 MHz available for WA WBB on an exclusive basis in metropolitan and regional areas, thereby displacing FSS and PTP operators; and/or

> make 3800–3900 MHz available for WA WBB on an exclusive basis in metropolitan and regional areas, thereby displacing FSS and PTP operators from 200 MHz across 3700–3900 MHz.

WA WBB in 3700–3800 MHz in metropolitan and regional areas

The key point of difference between Option 2 and Option 3 is that WA WBB gains exclusive access to 3700–3800 MHz in metropolitan and regional areas under Option 3, but not under Option 2. If exclusive access arrangements for WA WBB in 3700–3800 MHz in metropolitan and regional areas are net beneficial compared with the arrangements in Option 2 (that is, WA WBB access under sharing arrangements) then Option 3 is likely to be more net beneficial than Option 2.

While Options 2 and 3 are each projected to be net beneficial in isolation, exclusive access arrangements for WA WBB in 3700–3800 MHz are expected to generate greater net benefit than sharing arrangements. This consideration is informed by the benefits of exclusive access for WA WBB at $0.29/MHz/pop totalling approximately $705 million, while the combined maximum of the cost input ranges totals approximately $186 million (that is, combining FSS gateway, individual FSS and PTP services).

While there may be unquantifiable costs and benefits that affect these cost and benefit inputs, quantitative inputs indicate that the additional benefits would significantly exceed the additional costs associated with Option 3 when compared with Option 2.

Based on current analysis, Option 3 is likely to be more net beneficial than Option 2.

WA WBB in 3800–3900 MHz in metropolitan and regional areas

If Option 3 is considered likely to be more net beneficial than Option 2, the next step is to determine whether Option 3 is likely to be more net beneficial than Option 1. These two options involve WA WBB gaining exclusive access to 3700–3800 MHz, but their respective arrangements for 3800–3900 MHz are different. Option 1 extends exclusive access arrangements for WA WBB in metropolitan and regional areas to 3800–3900 MHz, while Option 3 provides access to LA WBB on a sharing basis. Comparing the net benefit resulting from the differing arrangements for 3800–3900 MHz will help determine whether Option 1 or Option 3 is likely to maximise net benefit.

On balance, the ACMA considers that Option 3 is likely to be more net beneficial than Option 1, although it is noted that this projection relies on unquantifiable costs and benefits. The reasoning for this consideration is that replanning 3700–3800 MHz for exclusive WA WBB access means that there will already be an average of around 100 MHz of mid-band spectrum per operator (assuming four potential users)—the returns to additional spectrum beyond 100 MHz per operator are expected to diminish considerably. Furthermore, the displacement costs of replanning 3800–3900 MHz are expected to be significantly higher as there would be less opportunities for incumbent FSS and PTP to maintain services via lower-cost means if they were to lose access to 200 MHz rather than 100 MHz of bandwidth.

The ACMA therefore considers that Option 3 is likely to be more net beneficial from a CBA perspective than Option 1.

Summary

The above analysis results in the following summarised CBA results:

> Option 1: expected to be moderately net beneficial due to the benefits of WA WBB exclusive access arrangements across 3700–3900 MHz in metropolitan and regional areas. However, there is likely to be diminishing marginal benefit with WA WBB use in 3800–3900 MHz when compared with the displacement costs of licensed FSS users.

- Option 2: expected to be moderately net beneficial as incumbent FSS and PTP services can continue operating while enabling access to WA WBB use. This is considered less likely to maximise net benefit when compared with Option 3 due to the absence of potentially major benefits of exclusive access arrangements for WA WBB in parts of the band.
- Option 3: expected to be the most net beneficial as exclusive access for WA WBB in 3700–3800 MHz in metropolitan and regional areas generates significant additional benefits, while incumbents receive a level of protection in 3800–3900 MHz that helps mitigate displacement costs.

Cost-benefit analysis methodology

When undertaking a CBA for the purposes of band replanning, the ACMA assesses the impact that a regulatory proposal has on the public interest is measured as the sum of the effects on consumers, producers and government, as well as the broader social impacts on the community. The replanning decision for a particular spectrum band is therefore informed by evidence that there are alternative uses that increase the total economic value derived from using the spectrum compared to the status quo.

It is important to note that the impacts of a potential change in spectrum use are both quantitative and qualitative. Some benefits or costs may not be amenable to quantification, such as changes in the economic value placed on services by consumers, and broader social impacts (externalities). Notwithstanding this, they should be evaluated and supported with evidence to the extent possible.

Constant and variable output cases

Each cost and benefit input in this CBA has the potential to be either a constant output case or a variable output case. Further detail on what each type of case represents is outlined below.

Constant output cases

In many cases, spectrum replanning decisions will affect only the cost of delivering a given service. In these cases, the outputs of the affected parties—both those parties losing access to spectrum and those parties gaining spectrum—are unlikely to significantly change. These are referred to as 'constant output' cases. It is important to note that these cases do not always depend upon the availability of equivalent spectrum, as the same or very similar output may be achieved through non-spectrum options or through using alternative spectrum options.

Where outputs do not substantially change, the consumer benefits and broader social net benefits will be subject to zero or minimal change. In these cases, it will therefore be sufficient to only evaluate the cost implications of the reform. For displaced incumbents, this refers to the additional supply cost burden of providing an equivalent services without access to the spectrum they currently use, while for potential new users of the band it refers to the supply cost reduction that the spectrum would provide for their service provision.

Variable output cases

Spectrum replanning can also result in 'variable output' cases, in which the incremental costs and benefits of replanning extend beyond supply cost changes. In addition to estimating changes in producer surplus, it is necessary in these cases to estimate the benefit to consumer surplus and broader social net benefits.

Regarding incremental costs, this occurs when an incumbent user is unable to continue providing the same or similar services. The incremental costs associated with this change in spectrum allocation will typically refer to the discrepancy in economic welfare generated between the existing service and either a substitute service—if one exists—or no service. For instance, if a service displaced from the band is unable to be provided by alternative delivery means, this has economic welfare implications for providers of the service (the users of the spectrum) and downstream users.

On the other hand, incremental benefits under a variable output case refer to users with newfound access to the spectrum having the ability to provide new and/or improved services (for example, 5G networks). Consumers are likely to place a higher value on these services than they placed on previously available services, which would be likely to result in an increase in consumer surplus, while giving service providers the opportunity to increase producer surplus through higher prices.

Cost and benefit calculations

Costs

In constant output cases, the provider of the existing service is able to fully mitigate the impact of the change in spectrum use, albeit at an increased cost of supply. They do this by using some combination of different spectrum, additional network investment, and/or increased use of other inputs and methods of supply. In these cases, given the service continuity, it will be sufficient to only evaluate the cost implications of the reform for affected party. This will often be in the form of determining average equipment retuning or equipment replacement costs.

In contrast, variable output cases are more complex, in that it is necessary to consider the impacts on consumer surplus and externalities, in addition to the usual cost and producer surplus impacts. If no substitute service is available, the loss of all producer surplus, consumer surplus and broader net social benefits will be considered to be the incremental costs. However, if a substitute service is available, incremental costs will be incurred due to the discrepancy in value placed by consumers on the substitute service compared with the existing service, along with pricing changes. In either scenario, the consumer surplus and social benefit reductions are subjective and difficult to quantify, and therefore more suited to a qualitative analysis.

Benefits

The value placed on the applicable spectrum by potential new users is typically used as a proxy for the economic benefits of replanning the spectrum. Potential users are assumed to only invest in spectrum if it is profitable – where economic benefits such as cost reductions and the value of being able to provide new and/or improved services are equal to or greater than the amount they are willing to pay for the spectrum. Valuations should therefore be equal to or less than the economic benefits accrued from the new use, particularly once consumer surplus gains and broader social net benefits are considered.

It should be noted that discussion of spectrum valuations in this attachment is not equivalent to estimated allocation revenue. Spectrum valuations reflect the maximum amount a potential user would be willing to pay. If potential users are able to pay significantly less than their full valuation at allocation, this does not mean that the economic benefits derived from the spectrum are diminished. Rather, it means those potential users can retain more of this benefit by transferring less of the benefit to the government.