

# Replanning the 2 GHz band Options paper

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# Executive summary

In 2012 the Australian Communication and Media Authority (ACMA) provided interim access to the 2 GHz band (1980–2010 MHz and 2170–2200 MHz) for television outside broadcast (TOB) services, pending a future review of the long-term arrangements for the band. Providing interim access for TOB services was intended to assist the transition of TOB services in the 2.5 GHz (2500–2690 MHz) to new arrangements in bands adjacent to the 2 GHz band. These changes occurred as part of the digital dividend process, which resulted in the issue of spectrum licences in the 2.5 GHz band (2500–2690 MHz)<sup>1</sup> and were completed in 2016.<sup>2</sup>

The ACMA has observed increasing interest in the 2 GHz band for new applications including mobile satellite, wireless broadband and direct air-to-ground communications. Operators seeking to deliver these services in the 2 GHz band have emerged as the primary access seekers in the replanning process to date. As a result, the ACMA considers that a clear case exists for reviewing and potentially changing the spectrum management arrangements in the band.

This paper represents the preliminary replanning stage of the 2 GHz band replanning process. It follows the 2019 consultation, [Planning of the 2 GHz band](#), which detailed the initial investigation stage of that process. Following consideration of responses to the discussion paper, the ACMA has decided to continue with the 2 GHz replanning process by progressing to the next stage, known as preliminary replanning.

This paper analyses planning issues for each of the applications or services interested in using the band, as well as any sharing and coexistence issues. We have identified three broad replanning options for the 2 GHz band. In developing these options, we have taken into account responses to the 2019 discussion paper, emergent demand for alternative services, requirements for continued operation of TOB services, as well as a range of factors embedded in the current legislative and policy environment for radiofrequency spectrum management in Australia. The foremost of the latter considerations is the statutory requirement to maximise the overall public benefit derived from using the spectrum.

A common theme in submissions to the 2019 discussion paper was that the available quantity of spectrum in the 2 GHz band (2 x 30 MHz, or 60 MHz in total) is unlikely to be sufficient to support all interested services with dedicated spectrum. With that understanding, we have developed the following three options for stakeholder consideration, each with a focus on supporting a single service:

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<sup>1</sup> Refer [Radiocommunications Spectrum Conversion Plan \(2.5 GHz Mid-band Gap\) 2012](#) and [Radiocommunications Spectrum Marketing Plan \(2.5 GHz Band\) 2012](#).

<sup>2</sup> Transition was completed when the re-allocation period specified in the [Radiocommunications \(Spectrum Re-allocation\) Declaration No. 2 of 2011](#) for the Perth area ended on 31 January 2016 and existing licences were cancelled.

- > **Option 1: Television outside broadcast**—this option responds to industry feedback seeking continued incumbency and certainty for TOB services. It includes the possibility of unlocking the guard band between TOB and adjacent wireless broadband services for Australia-wide satellite internet-of-things (IoT) applications.
- > **Option 2: Wireless broadband**—this option provides for accommodation of new wireless broadband services, including both wide-area and local-area services, as well as direct air-to-ground services. It also provides spectrum for satellite IoT services Australia-wide in the restricted band (guard band) protecting adjacent band TOB services. One of the key considerations in assessing this option is the impact on existing TOB services versus the benefits of introducing new services. This paper seeks additional evidence from TOB operators on the potential costs and other impacts that may arise from relocation to alternative spectrum under this option.
- > **Option 3: Mobile-satellite service**—this option responds to strong demand for additional spectrum for mobile-satellite services (MSS), including those that propose deployment of a complementary ground component (a terrestrial network used to augment satellite services generally in higher population areas) and/or the delivery of IoT services. As with Option 2, this option has the greatest impact on existing TOB services and the same considerations will apply.

These options were assessed against a set of desirable planning outcomes and a cost benefit analysis to identify a preferred option that the ACMA considers is most likely to maximise the overall public benefit derived from using the band. As a result of this analysis, we have identified Option 3 as the ACMA's preliminary preferred option for replanning the 2 GHz band.

Due to the small number of TOB licences currently in the 2 GHz band, the ACMA is of the view that the majority of these services could be accommodated in the 7.2 GHz (7100–7425 MHz) band or possibly in the 8.3 GHz (8275–8400 MHz)<sup>3</sup> band, both of which support TOB services.<sup>4</sup> These bands have channels which are specifically identified for shared non-exclusive usage similar to the arrangements of the 2 GHz band. The ACMA notes that current arrangements in 7.2 and 8.3 GHz are intended to support analog technologies and seeks industry views as to whether there is need to update channel arrangements to reflect current digital technologies used. There may also be scope for increased access to ongoing TOB arrangements in the nearby 2010–2110 MHz and 2200–2300 MHz bands via discussions or third-party arrangements with licensees in those segments. The ACMA recognises that this likely already occurs to some extent but there may be further opportunities, especially in areas of low TOB use, such as regional areas and/or where the TOB operator is developing content for the relevant licensee.

We invite comment on the preliminary preferred option outlined above, and seek feedback on the issues presented in this paper to help inform further consideration of the options and development of planning outcomes that best meet the objective of maximising the overall public benefit derived from allocation and use of spectrum.

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<sup>3</sup> The ACMA understanding is that equipment availability for the 8.3 GHz band is limited, as such 8.3 GHz is seen as a more of a long-term option supporting future growth.

<sup>4</sup> Refer channel arrangements for these bands in [RALI FX3](#): Microwave fixed services.



# 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.

The ACMA is seeking comment on:

1. The feasibility of the timing of any potential commencement of replanning.
2. The case for action and desirable planning outcomes for the 2 GHz band, including the supporting appendices.
3. The proposed band replanning options, including appropriate values for frequency segment breakpoints as well as any alternative options.
4. Variations to the proposed options and implementation considerations.
5. Discussion and outcomes of the assessment of options, including the cost-benefit analysis and its assumptions.
6. The ACMA's preliminary preferred option.

# Introduction

## Background and purpose

In August 2019, the ACMA released a [discussion paper](#) on the initial investigation stage of the 2 GHz band replanning process. The paper identified domestic and international considerations for future use of the 2 GHz band and invited comment on possible changes to planning arrangements for the band. The consultation closed on 13 September 2019, with 18 submissions received.

Following considering of submissions, the ACMA has decided to progress the band to the preliminary replanning stage of the ACMA's spectrum replanning process.

The purpose of this paper is to present analysis and options and seek feedback to inform the next step in the ACMA's consultation process for 2 GHz band replanning activities. It presents high-level options for replanning and allocating services in the 2 GHz band, considering information received in submissions to the 2019 discussion paper.

The 2 GHz band is currently used for television outside broadcast (TOB) services on a shared and non-exclusive basis for short-term applications such as covering special events. There are currently 23 active licences in the band, held by 10 organisations.<sup>5</sup> These comprise a mixture of area-wide and site-specific apparatus licences. The site-specific licences are located in Sydney, Melbourne, Adelaide and Perth.

## Legislative and policy environment

Managing spectrum efficiently and effectively for the benefit of all Australians is a key priority for the ACMA.<sup>6</sup> The ACMA draws on a range of legislative and administrative tools and overarching guidance in executing these functions.

### 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 provision 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 Australian Government.

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

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<sup>5</sup> As of April 2020.

<sup>6</sup> ACMA [Corporate plan 2019-20](#).

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.

[Australia's Tech Future](#), released in December 2018, sets out the Australian Government strategy for Australia's tech future. The strategy presents a vision that Australians have access to world-class digital infrastructure in their personal and working lives with the following outcomes:

- > Australians have reliable, secure and affordable access to high-speed broadband and mobile communications.
- > Australia's communications sector is sustainable and competitive.
- > Australia's world-leading navigation and positioning infrastructure supports emerging technologies.
- > Australia's researchers have the specialised high-performing computing and data infrastructure needed to stay ahead in everything from health to agriculture.

The [Australian Civil Space Strategy 2019–2028](#) is an Australian Government strategy to deliver a globally responsible and respected space sector that lifts the broader economy, and inspires and improves the lives of Australians. It contains a number of [priority areas](#) that may influence development and deployment of satellite services in the 2 GHz band.

#### **Other relevant advice**

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 the ACMA for authorising access to spectrum: spectrum, apparatus and class licences. These approaches influence how spectrum replanning 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<sup>7</sup> and do not 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).

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<sup>7</sup> Technical conditions include maximum power, frequency range, out-of-band emissions limits, and geographical licence area.

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](#) for apparatus licences, which cover our costs and give people incentive to use spectrum efficiently.

The ACMA recently created a new apparatus licence type—the [area-wide apparatus licence](#). This authorises the operation of one or more radiocommunications devices within a defined geographic area within frequencies specified in the licence, subject to the conditions included on the issued licence. The licence type is proposed to be scalable, enabling its use for authorising different-sized geographic areas and bandwidths. Unlike existing apparatus licence types—which typically align with specific uses and purposes—the area-wide apparatus licence will be capable of authorising a variety of services, uses, applications and technologies.

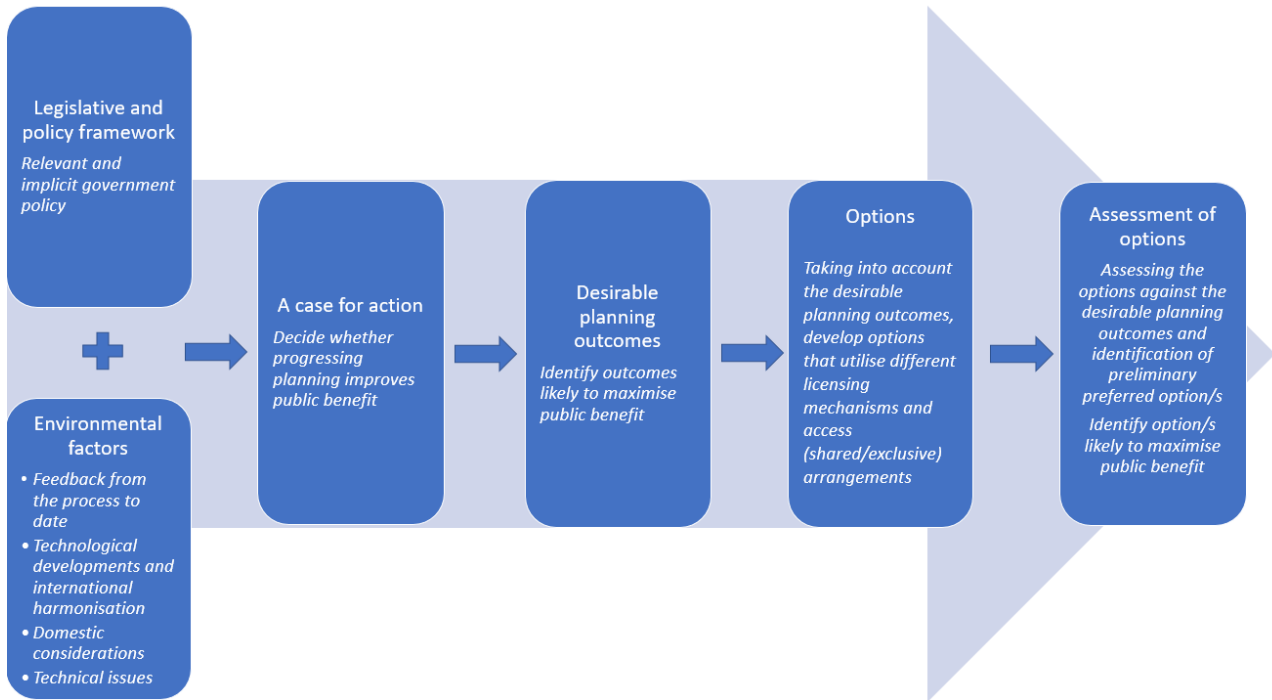
Class licences are a standing authorisation to access spectrum without the need to apply to the ACMA for an individual licence (hence no fees are paid), subject to the conditions of the relevant class licence. These conditions include technical and geographic matters and/or pertain to the type of use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

### **Spectrum planning options development**

We are guided in our spectrum management functions by [the object of the Radiocommunications Act 1992](#), set out in section 3 of the Act. A balanced application of regulatory and market mechanisms is often necessary in order to achieve key elements of the object of the Act, in particular maximising the overall public benefit from the efficient allocation and use of the radiofrequency spectrum and meeting the government's policy objectives.

Figure 1 below describes the approach the ACMA has used in developing and assessing preliminary replanning options for the 2 GHz band. The ACMA will continue to apply this general approach as it considers the responses to this paper and decides on replanning outcomes for the 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 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 [Five-year spectrum outlook](#). Interested parties are invited to provide their views on apparatus licence taxes in the 2 GHz band as part of those 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 this paper where relevant to aid discussion.

### ***Engagement in international activities***

The scope of this paper does not extend to Australian strategies or positions on matters under consideration in international spectrum management forums, such as the International Telecommunication Union or Asia-Pacific Telecommunity. These matters are dealt with separately through relevant preparatory processes led by the ACMA and/or the Department of Infrastructure, Transport, Regional Development and Communications. Stakeholders interested in these processes can find more information from the [ACMA website](#) or by contacting either the ACMA's International Radiocommunications Section ([irs@acma.gov.au](mailto:irs@acma.gov.au)) or the Department's International Radiocommunications Section ([wrc@communications.gov.au](mailto:wrc@communications.gov.au)).

## Next steps

This paper represents the public consultation phase of preliminary replanning, which is the third stage in the ACMA's band replanning process. The table below shows the subsequent activities and estimated timing that will follow release of this paper.

Completion of these activities is contingent on a variety of factors including feedback received from stakeholders and consideration by the ACMA Authority.

**Table 1: Indicative timeline for replanning the 2 GHz band**

Stage	Milestone	Date
<b>Stage 3— Preliminary replanning</b>	Release <i>Replanning the 2 GHz band: options paper</i>	22 July 2020
	Submissions due to options paper	2 September 2020
	Release <i>Replanning the 2 GHz band: outcomes paper</i>	No earlier than Q4 2020
<b>Stage 4— Replanning</b>	Commencement of replanning stage, if applicable	No earlier than Q1 2021

As noted above, a decision on whether the 2 GHz band will be progressed to the replanning stage will be made at the earliest in the fourth quarter of 2020.

The actions taken in the replanning stage will depend on the replanning option chosen. In the event the ACMA concludes the preferred replanning option does not involve re-allocating the band for the issue of spectrum licences, we will commence development of any necessary technical frameworks and/or allocation instruments for the release of the spectrum by an administrative allocation of apparatus licences.

If a replanning decision is made that would involve the issue of spectrum licences, a separate statutory process will be undertaken involving the Minister for Communications, Cyber Safety and Arts, as set out in section 153 of the *Radiocommunications Act 1992*.

# The process to date

## Consultation

In August 2019, the ACMA released a discussion paper titled [Planning of the 2 GHz band](#). The paper examined current use of the band, domestic demand and international trends. It also sought industry views on potential future uses of the band.

The 2019 discussion paper provided an overview of usage of the 2 GHz band at the national level and an overview of international developments. It identified incumbent and new interests in the 2 GHz band for the following spectrum applications or service uses:

- > Television outside broadcast.
- > Mobile-satellite services (MSS) with or without complementary ground component, including satellite IoT.
- > Wide-area wireless broadband applications, which we define as those providing wireless broadband services generally using network deployments over large, often contiguous, geographical areas such as those traditionally undertaken by mobile network operators or some fixed telecommunication providers such as NBN Co. Wide-area wireless broadband users benefit from the certainty provided by long-term largely exclusive access to spectrum, often (but not exclusively) through spectrum licences.
- > Local-area wireless broadband applications, which we define as those providing wireless broadband services (often fixed) over smaller, local geographical areas to subscriber or private networks. These include services such as those provided by wireless internet service providers (WISPs), miners, local governments and utilities etc. Local-area wireless broadband 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.
- > Direct-air-to-ground communications for the provision of inflight broadband services to aircraft.

## Summary of submissions

The ACMA received 18 submissions to the discussion paper—these are available on the [ACMA website](#). This chapter provides an overview of the issues raised in submissions and the outcomes of the consultation. Further detail on the consultation submissions is at [Appendix A: Responses to the discussion paper](#).

Two key themes emerged from submissions to the consultation. Firstly, there were divergent views between the various industry sectors seeking access to the band, and secondly, the stated level of demand for 2 GHz spectrum significantly exceeds the available supply. These key themes and sectoral interests are discussed below:

- > **Divergent views**—respondents were generally divided on the future planning of the 2 GHz band. Views on optimal future use were aligned with each respondent's industry sector. Support was provided for all potential service types including TOB, MSS (including some supporting a complementary ground component), terrestrial wireless broadband and direct air-to-ground communications.

- > **Television outside broadcast**—all submissions from organisations connected with this service advocated retaining the band for TOB services. They argued this would provide ongoing certainty for the industry and avoid costs associated with relocation to another band. Some respondents indicated sharing the band under geographic separation arrangements may be feasible, with TOB in metro areas and MSS in regional areas. This would be acceptable to these operators if temporary access to spectrum could be granted when major broadcasting events are held in regional areas.
- > **Mobile-satellite services**—respondents from the satellite industry provided strong support for phasing out TOB services and reallocating the band to MSS, including satellite-based IoT services. In addition to MSS, most mobile-satellite respondents<sup>8</sup> supported inclusion of a complementary ground component<sup>9</sup> to augment satellite services in high population areas where satellite connectivity may be unreliable. Complementary ground component is a terrestrial network that provides additional flexibility for operators to deploy solutions that are optimised for geography (terrain and built environment), coverage goals, user density, and service-level requirements including throughput and latency. Most respondents argued it would not be feasible to share the band with another service, either by sub-dividing the band or geographically separating services. Several operators asserted there is currently not enough spectrum available for mobile-satellite operators to support new demand, including IoT applications.
- > **Terrestrial wireless broadband**—respondents generally had divergent views on the optimal future use of the band including wide-area wireless broadband, local-area wireless broadband, and direct air-to-ground communications (see below). Some respondents indicated the band could be shared with other services via geographic or frequency separation. Replanning of the 2 GHz band was not considered a priority for mobile network operators, an exception being a respondent looking to provide services in metropolitan areas.
- > **Direct air-to-ground communications**—two respondents advocated for direct air-to-ground communications. Some respondents from other sectors questioned the viability and efficiency of dedicating the 2 GHz band to a direct air-to-ground communications service in Australia where flight paths cross only a small fraction of the landmass. This was contrasted with Europe which has a much higher density of flight paths and volume of air traffic.
- > **Demand exceeds supply**—the combined quantity of spectrum desired by proponents seeking access to the band exceeds the available bandwidth. Most respondents want exclusive access to the band for a single type of service, arguing that spectral or geographic separation between services is not feasible.

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<sup>8</sup> Four respondents supported mobile-satellite service with a complementary ground component.

<sup>9</sup> Complementary ground component and ancillary terrestrial component are different terms describing essentially the same system: the use of a terrestrial wireless broadband network to supplement mobile-satellite coverage. In this paper, we will primarily refer to such a system as a 'complementary ground component', however the two terms are considered interchangeable.



# Case for action

We have observed an increasing interest in the use of 2 GHz for a range of new services and applications, as well as preserving existing arrangements for TOB. Submissions to the 2019 paper confirmed significant interest in both preserving existing arrangements and alternative uses for the band. Changes to arrangements are likely to be necessary to ensure maximum public benefit is derived from its use, even if only to provide ongoing certainty to the current interim TOB arrangements.

Identifying 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.

## **Technology developments and international harmonisation**

International spectrum harmonisation and technology standardisation have the potential to offer benefits in Australia including access to equipment produced under economies of scale and technical standards, market accessibility to new international service providers and, depending on the application, global roaming.

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 (in the case of the 2 GHz band relevant to both terrestrial and satellite applications), often drive these changes and are important in enabling economies of scale to be developed.

International spectrum harmonisation decisions of the International Telecommunication Union 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.

Internationally, as noted in the 2019 paper, wireless broadband and MSS (including for complementary ground component) are supported or being considered in the 2 GHz band, with use varying by country and/or region.

Since the release of the 2019 discussion paper, the World Radiocommunication Conference 2019 (WRC-19) considered agenda item 9.1.1 related to the 2 GHz band. The outcome was a minor change to Resolution 212 encouraging administrations to take technical and operational measures to facilitate coexistence and compatibility between terrestrial and satellite components of International Mobile Telecommunications in the 2 GHz band. This outcome has no material bearing on domestic planning considerations.

In the European Union, the band is planned for MSS, including the complementary ground component<sup>10</sup> with licences issued to two operators.<sup>11</sup> Administrations in the Asia-Pacific Telecommunity are at different stages of planning or implementing the band for mobile broadband, fixed and/or MSS. In the United States, the band is allocated on a co-primary basis for mobile-satellite services and terrestrial fixed and mobile services. In Canada, the 2 GHz band is allocated to the mobile-satellite service with a requirement for concomitant deployment of an ancillary terrestrial component. This is due to a low population density covering a large landmass where many areas are not easily covered by other technologies.

These international trends and developments indicate widespread allocation of the band to MSS and terrestrial wireless broadband services. International circumstances are an important consideration in the Australian domestic context, where significant benefits can be gained from aligning spectrum allocations with major international economies.

International harmonisation efforts have largely focussed on use of the 2 GHz band by two services: wireless broadband (sometimes referred to as IMT) and the mobile-satellite service. Activity within this band in the ITU in recent years has focused on sharing studies between IMT and the mobile-satellite service with WRC-19 work undertaken on this matter being carried over into the regular ITU work programs outside of the next World Radiocommunication Conference cycle.

The 2 GHz band was added to the 3GPP<sup>12</sup> mobile broadband standards as part of release 16 (TS 38.101-1)<sup>13</sup> as band n65 for use in 5G New Radio services. 3GPP conducted studies and released a report<sup>14</sup> regarding 5G satellite services including the use of the 2 GHz band. Further work performed by 3GPP includes stating the required specifications for satellite environments.<sup>15</sup>

The Global Mobile Suppliers Association equipment database indicates limited equipment availability for terrestrial or satellite mobile equipment operating in the n65 band for 4G.<sup>16</sup> Further, information on 5G equipment for the 2 GHz band is not yet available, even though it is a recognised 5G band.

Finally, international support for TOB services in the 2 GHz band is negligible. While some countries previously supported TOB in the 2 GHz band, the ACMA is not aware of any ongoing use for this purpose outside of Australia.<sup>17</sup>

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<sup>10</sup> [ECC Decision ECC/DEC/\(06\)09](#): ECC Decision of 1 December 2006 on the designation of the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile-Satellite Service, including those supplemented by a complementary ground component.

<sup>11</sup> Inmarsat and EchoStar Mobile Limited (formerly Solaris Mobile Limited) see [2009/449/EC](#): Commission Decision of 13 May 2009 on the selection of operators of pan-European systems providing mobile-satellite services (MSS).

<sup>12</sup> The 3rd Generation Partnership Project (3GPP) is an umbrella for a number of international standards organisations which develop protocols for mobile telecommunications.

<sup>13</sup> 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone (Release 16) <https://www.3gpp.org/DynaReport/38101-1.htm>.

<sup>14</sup> 3GPP TR 38.811 Study on New Radio (NR) to support non terrestrial networks [http://www.3gpp.org/ftp/Specs/archive/38\\_series/38.811/38811-f20.zip](http://www.3gpp.org/ftp/Specs/archive/38_series/38.811/38811-f20.zip).

<sup>15</sup> 3GPP TR 38.821 Technical Specification Group Radio Access Network; Solutions for NR to support non-terrestrial networks (NTN) [http://www.3gpp.org/ftp/Specs/archive/38\\_series/38.821/38821-q00.zip](http://www.3gpp.org/ftp/Specs/archive/38_series/38.821/38821-q00.zip).

<sup>16</sup> See [gsacom.com](#).

<sup>17</sup> See, for example, report [ITU-R BT.2069-7](#), International Telecommunication Union, 2017.

Consequently, the trend internationally is not to use the band for TOB. Rather, MSS (with or without a ground component) and, in some cases, wireless broadband and direct air-to-ground communications are gaining prominence.

## Domestic considerations

Domestic considerations include the current and planned availability of spectrum for each use identified, incumbency considerations and the demand case for each use. This will often include consideration of the spectrum environment beyond the band being immediately considered.

The range of potential future uses of the 2 GHz band indicates that:

- > Considering TOB spectrum usage in the vicinity of 2 GHz, the current spectrum available for TOB under RALI FX21: Television outside broadcasting services in the bands 1980–2110 MHz and 2170–2300 MHz (without considering the 2 GHz band) and [2.5 GHz \(2570–2620 MHz\) mid-band gap](#) spectrum licences totals 250 MHz. A greater amount of spectrum than that previously available in the 2.5 GHz (2500–2690 MHz) prior to the digital dividend (not withstanding that there are some compatibility requirements that limit utility for TOB at some band edges).
- > Due to the small number of TOB licences currently in the 2 GHz band, the ACMA is of the view that the majority of these services could be accommodated in the 7.2 GHz (7100–7425 MHz) band or possibly in the 8.3 GHz (8275–8400 MHz)<sup>18</sup> bands both of which support TOB services.<sup>19</sup> Both these bands have channels supporting shared non-exclusive usage similar to the arrangements of the 2 GHz band. The ACMA notes that current arrangements in 7.2 and 8.3 GHz are intended to support analog technologies and seeks industry views as to whether there is need to update channel arrangements to reflect current digital technologies used.
- > There already exists considerable availability for wireless broadband in comparable mid-band frequencies between 1 and 6 GHz such that the availability of the 2 GHz for wireless broadband would constitute only a 6 per cent increase. Other bands potentially more suitable for new wireless broadband (especially 5G) are under consideration as part of the concurrent review of the 3.7–4.2 GHz band and the optimisation of the 3.4 GHz band. We acknowledge that many of the current arrangements for wireless broadband in the mid bands are better suited for wide-area rather than local-area wireless broadband uses, however the 3.7–4.2 GHz band review is also considering additional options for local-area wireless broadband.
- > While reasonable opportunities already exist for MSS in comparable frequency ranges between 1 and 2.5 GHz (over 110 MHz), there are currently only modest possible additional future opportunities for these services beyond the 2 GHz band. In addition, the 2 GHz band would represent up to a 50 per cent (or greater) increase in spectrum availability for MSS.

On balance, domestically there appears to be a stronger case for additional spectrum arrangements suitable for MSS applications than for TOB and wireless broadband (especially wide-area).

In light of these observations, it appears that the mix of uses that are likely to maximise the overall public benefit in the band is changing to include mobile-satellite applications more so than for TOB and wireless broadband (especially wide-area).

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<sup>18</sup> The ACMA understanding is that equipment availability for the 8.3 GHz band is limited, as such 8.3 GHz is seen as a more of a long-term option supporting future growth.

<sup>19</sup> Refer channel arrangements for these bands in [RALI FX3](#): Microwave fixed services.

Further analysis of domestic considerations is presented at [Appendix B](#).

## Conclusion

In the previous discussion paper, we noted that some form of planning in the 2 GHz band would be necessary, if only to establish arrangements that permit TOB services to continue using the band with ongoing certainty.

The ACMA considers that preliminary replanning of the band now is important to provide certainty to existing and prospective service providers, as well as to examine potential replanning scenarios that may enable higher value uses. Accordingly, the ACMA considers it appropriate to progress the band to the preliminary replanning stage, so that a range of potential replanning options can be considered for consultation. These reasons include:

- > strong interest from service providers seeking access to the band for deployment of new services
- > claimed bandwidth requirements reported by access seekers significantly exceeds the available supply
- > widespread international allocation of the band by advanced industrial countries to MSS and/or terrestrial wireless broadband services
- > continued growth in demand for downstream wireless services by consumers and businesses
- > desire for ongoing certainty of spectrum arrangements by the TOB industry
- > more broadly, the potential for improvement of Australia's communications services in regional and remote areas.

# Desirable planning outcomes

The ACMA has identified several desirable planning outcomes for the 2 GHz band, taking into account the legislative and policy environment, technological developments, international harmonisation issues, relevant domestic considerations and feedback from submissions to the 2019 discussion paper.

Existing and new uses identified for the 2 GHz band present potentially competing demands for access to the same spectrum. This is particularly the case in areas of high demand such as capital cities and other large population centres. The reason is that deployment of one service may deny access to the spectrum for another service seeking to operate in the same or nearby area. While sharing scenarios are generally contemplated in the ACMA's band replanning activities, these need to be weighed against the potential reduction in utility and access to spectrum they could cause to both existing and new services. In some cases, exclusive access and licensing arrangements may be the most appropriate approach.

We acknowledge that any changes in spectrum management arrangements may impact existing licensees operating in the 2 GHz band. In assessing options, we have identified impacts on existing users and uses and, where possible, considered options for sharing or alternative arrangements that could enable the continued provision of these services. If an option involves loss of spectrum access for incumbent licensees, the ACMA typically considers an appropriate transition period to allow sufficient time for affected licensees to adjust to the new arrangements.

The desirable planning outcomes for the review of the 2 GHz band are outlined below with the linkage back to the legislative and policy environment identified:

1. Support new uses of the band consistent with international harmonisation and domestic considerations which includes some mix of MSS uses (including for IoT) and possible wireless broadband uses, including MSS complementary ground component usage.
2. Resolve the interim nature of arrangements in the band to provide increased certainty for future uses of the band.
3. Ensure coexistence with adjacent band services is addressed. These include wireless broadband services operating below 1980 and 2170 MHz, and TOB / space research / space operations operating above 2010 and 2200 MHz.

These desirable planning outcomes are consistent with the legislative and policy framework outlined in the first chapter of this paper, including:

- > Maximising the overall public benefit from using the spectrum (object 3(a) of the *Radiocommunications Act 1992*).
- > Providing a responsive and flexible approach to meeting the needs of spectrum users (object 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 (object 3(d) of the Act).
- > Supporting the communications policy objectives of the Commonwealth Government (object 3(e) of the Act).

# Replanning options

In the 2019 discussion paper, the ACMA sought views on four possible approaches (scenarios) for future planning of the 2 GHz band:

- > optimised arrangements across the majority of the band for a single type of service or application
- > supporting all services with dedicated exclusive spectrum
- > geographical separation of services
- > a combination or hybrid approach of the above.

Respondents to the consultation provided no support for the scenario of supporting all services with dedicated spectrum. The claimed quantity of spectrum required by respondents for each of the services under consideration would make segmentation challenging. With that understanding, we have refined the options to focus on three options, each differentiated by its support for a single service type (TOB, wireless broadband or MSS).

Even within these options there is a degree of optionality and the ACMA is seeking views on the quantity of spectrum required and boundaries between services. For simplicity, frequencies are identified for each option to aid explanation and to illustrate possible implementation parameters.

In summary, the three options under consideration are:

- > **Option 1: Television outside broadcast**—convert interim arrangements for TOB into an ongoing arrangement.
- > **Option 2: Wireless broadband**—introduction of wireless broadband services via both spectrum and apparatus licensing. No support for TOB services.
- > **Option 3: Mobile-satellite services**—introduction of MSS. No support for TOB.

The table at the end of this chapter provides a summary of options for comparison.

When reading this section, note that:

- > The geographic area terms 'metro centres', 'regional areas' and 'remote areas' are defined in [Appendix F: Geographical area descriptions](#). These definitions are the same as in the [2 GHz spectrum licensing band](#) and while indicative of the ACMA's thinking, may vary as a result of information provided in submissions to this paper.
- > Breakpoints between frequency segments are indicative only. The appropriate values for any option depend upon several factors including feedback to this paper, the demand for specific applications, and service compatibility, such as with the adjacent-band TOB services.
- > In all options where a restricted band (guard band) is necessary to protect adjacent-band services, use of the restricted band by low-powered, low-duty-cycle satellite IoT services is proposed, subject to development of appropriate requirements to protect adjacent band services. This would enable more efficient use of the band and assist in meeting demand for satellite IoT spectrum,<sup>20</sup> regardless of which replanning option is eventually selected.

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<sup>20</sup> Most respondents from the satellite industry to the 2019 discussion paper advocated future use of the 2 GHz band to include satellite-based IoT services.

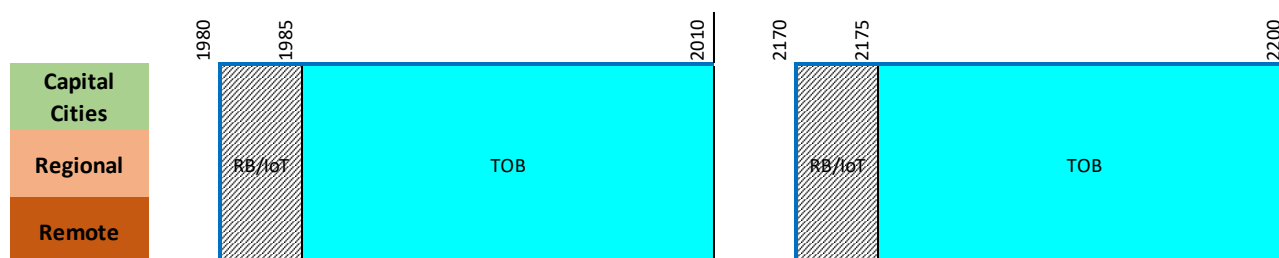
- > Existing arrangements to protect the Australian Radio Quiet Zone Western Australia will be maintained. Where required, references to those protection requirements will be included in documents developed to implement the outcomes of the 2 GHz process.
- > Existing arrangements for radiodetermination transmitters detailed in the [Radiocommunications \(Low Interference Potential Devices\) Class Licence 2015](#) (the LIPD Class Licence) will be preserved.
- > We consider that the small number of legacy fixed point-to-point links in regional and remote areas should not impact deployment of services under any of the options presented in this paper and that there is no compelling case for the clearance of these links. Hence in all options presented, options to preserve existing fixed point-to-point links (which are all in remote areas) are explored. As is the case now, no new links would be supported.<sup>21</sup>
- > Relevant technical coexistence considerations are analysed at [Appendix C: Technical issues](#).

## Option 1: Television outside broadcast

This option maintains access to the 2 GHz band for TOB services with planning arrangements revised to remove the caveat about interim TOB access.

The current restricted band (1980–1985 MHz and 2170–2175 MHz) necessary for coexistence between TOB and adjacent band wireless broadband (2 GHz spectrum licensing) would be considered for use by Australia-wide satellite IoT applications on a shared basis exploiting the low-duty-cycle, low-power nature of such systems.

Figure 2: Illustration of Option 1



### 1985–2010 MHz and 2175–2200 MHz (TOB)

Australia wide:

- > Retain existing access by TOB services.
- > At a minimum this would require updating RALI FX 21. Whether changes are also required to the TOB band and embargo 23 would require further consideration.

### 1980–1985 MHz and 2170–2175 MHz (satellite IoT)

Australia wide:

- > Low-powered, low-duty-cycle satellite IoT service where parameters developed to ensure compatibility with adjacent band TOB services.
- > Supported as a shared satellite IoT band under class licensing arrangements through inclusion in the Communications with Space Objects Class Licence with requirement for space/space receive apparatus licences.

<sup>21</sup> Under the [Television Outside Broadcast \(1980–2110 MHz and 2170-2300 MHz\) Frequency Band Plan 2012](#) no new fixed point-to-point links are allowed.

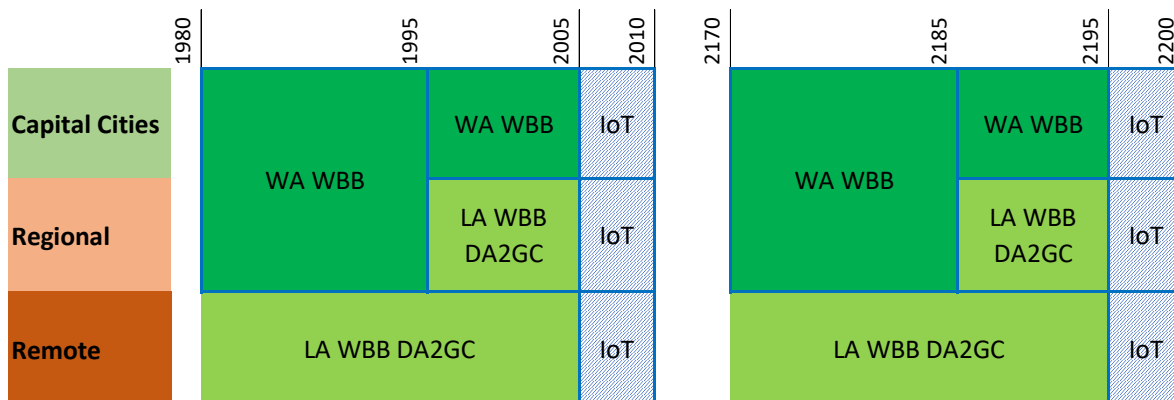
- > No coordination requirements with other licensees in the band (that is, licensees to self-coordinate).
- > Minimal regulatory assessment of satellite filing to ensure proposed operation is consistent with ITU filing similar to those of ACMA procedures for submission and processing of applications for [space and space receive apparatus licences](#).

## Option 2: Wireless broadband

This option is intended to accommodate new wireless broadband uses (both wide-area and local-area) including direct air-to-ground communications services. It also provides that the restricted band (2005–2010/2195–2200 MHz) currently used to protect adjacent-band TOB services be considered for use by Australia-wide satellite IoT systems on a shared basis exploiting the low-duty-cycle, low-power nature of such systems, subject to development of appropriate alternative requirements to protect adjacent TOB services. Frequency arrangements have been chosen so that wide-area wireless broadband will be adjacent to the 2 GHz spectrum licensing band (1920–1980/2110–2170 MHz).

For simplicity to aid explanation of the options and to illustrate possible implementation, particular frequencies ranges have been assumed for services. Feedback is sought on the quantum of spectrum for each service and frequency boundaries.

**Figure 3: Illustration of Option 2**



### 1980–1995 and 2170–2185 MHz

#### Wide-area wireless broadband and direct air-to-ground communications

Capital city and regional areas:

- > Re-allocation of the frequency range for the issue of spectrum licences or area-wide apparatus licence (AWL) with a technical framework optimised to wide-area wireless broadband services. In circumstances where demand is likely to exceed supply, a price-based allocation method (auction) is often used by the ACMA.
- > For direct air-to-ground communications, we propose to consider appropriate coordination arrangements with adjacent-band services during development of technical frameworks. This approach would provide a licensee with the option of providing wireless broadband or direct air-to-ground communications services, or both.

Remote areas:

- > Local-area wireless broadband and direct air-to-ground communications under apparatus licensing on a coordinated basis. AWL licensing would be considered where appropriate.



## 1995–2005 and 2185–2195 MHz

### Wide-area / local-area wireless broadband and direct air-to-ground communications

Capital city areas:

- > Re-allocation of the frequency range for the issue of spectrum licences or AWL with a technical framework optimised to wide-area wireless broadband services.
- > For direct air-to-ground communications, we propose to consider appropriate coordination arrangements with adjacent-band services during development of technical frameworks. This approach would provide a licensee with the option of providing wireless broadband or direct air-to-ground communications services, or both.
- > Capital city areas are based on 2 GHz spectrum licensing areas.

Regional and remote areas:

- > Local-area wireless broadband and direct air-to-ground communications under apparatus licensing on a coordinated basis.

## 2005–2010 and 2195–2200 MHz

### Satellite IoT

Australia wide:

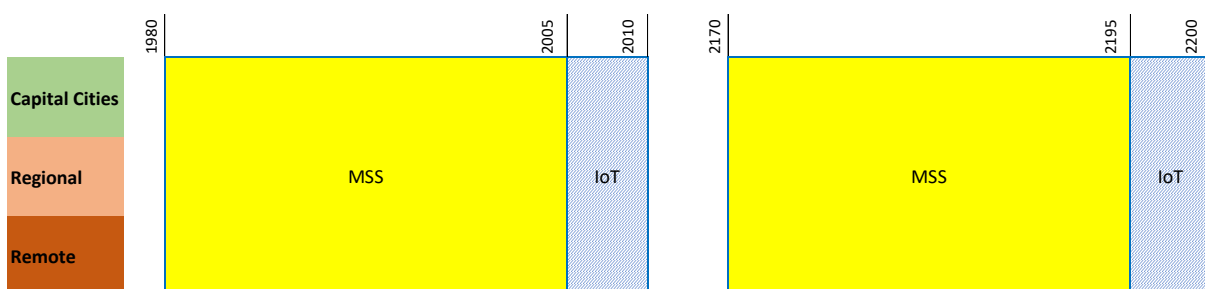
- > Low-powered, low-duty-cycle satellite IoT service where parameters developed to ensure compatibility with adjacent band TOB services.
- > Supported as a shared satellite IoT band under class licensing arrangements through inclusion in the Communications with Space Objects Class Licence with requirement for space/space receive apparatus licences.
- > No coordination requirements with other licensees in the band (that is, licensees to self-coordinate).
- > Minimal regulatory assessment of satellite filing to ensure proposed operation is consistent with ITU filing similar to those of ACMA procedures for submission and processing of applications for [space and space receive apparatus licences](#).

## Option 3: Mobile-satellite service including complementary ground component

This option provides for accommodation of new MSS (including satellite IoT and complementary ground component) and spectrum dedicated for satellite IoT services Australia-wide in the restricted band (guard band) protecting adjacent band TOB services. Existing point-to-point links would be grandfathered.

Subject to further submissions, the ACMA's preliminary view would be to divide the band in paired channels of 2 x 15 MHz, 2 x 10 MHz and 2 x 5 MHz.

Figure 4: Illustration of Option 3



### **1980–2005 and 2170–2195 MHz (MSS including satellite IoT and complementary ground component)**

- > Establishment of regulatory arrangements supporting Australia wide operation of mobile-satellite service, potentially through space/space receive apparatus licences and associated class licensing arrangements. Given the demand expressed in the consultation process for MSS and the challenges in coexistence between different MSS systems, a mechanism to resolve any competing demand, such as a price-based allocation method (an auction), may need to be considered in this case. The auction of spectrum for satellite services is a rare activity, the last time being in 2001.<sup>22</sup>
- > Option for complementary ground component services at the discretion of the MSS licensee with development of appropriate coordination arrangements with adjacent band services.
- > Authorisation arrangements for the complementary ground component will need to be considered further once a decision on the licensing approach for MSS is determined. This will include the need, or otherwise, for an MSS service to be provided in order for the licence to be used to provide complementary ground component.
- > Requirement to have an ITU satellite filing that supports operation of a mobile-satellite service in Australia
- > Requirement to undertake international and coordination regulatory checks as currently outlined in ACMA procedures for [Submission and processing of applications for space and space receive apparatus licences](#).
- > Support for TOB services removed from [Television Outside Broadcast \(1980–2110 MHz and 2170-2300 MHz\) Frequency Band Plan 2012](#) and associated RALI FX 21.
- > Given regulatory arrangements for space-based communication systems, licence allocation matters are likely to require consideration of:
  - > update of the [Radiocommunications \(Communication with Space Object\) Class Licence 2015](#) to include the 2 GHz band
  - > updates to the [Radiocommunications \(Foreign Space Objects\) Determination 2014](#) and the [Radiocommunications \(Australian Space Objects\) Determination 2014](#) to support potential/successful licence applicants in any price-based allocation process
  - > revisions to embargo 23 to align with licence allocation timelines.

### **2005–2010 and 2195–2200 MHz (satellite IoT)**

Australia-wide:

- > Low powered, low duty cycle satellite IoT service where parameters developed to ensure compatibility with adjacent band TOB services.
- > Supported as a shared satellite IoT band under class licensing arrangements through inclusion in the Communications with Space Objects Class Licence with requirement for space/space receive apparatus licences.
- > No coordination requirements with other licensees in the band (that is licensees to self-coordinate).
- > Minimal regulatory assessment of satellite filing to ensure proposed operation is consistent with ITU filing similar to those of ACMA procedures for [Submission and processing of applications for space and space receive apparatus licences](#).

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<sup>22</sup> Refer list of [spectrum auctions](#) on the ACMA website and the 2001 auction of 11.7–12.2 GHz for Space Licences - Apparatus licences.

## Possible option variations

Given interest in local-area wireless broadband, a possible variant of Option 3 is to provide for local-area wireless broadband in regional and remote areas in part of the band (for example, 1980–1990 and 2170–2180 MHz (2 x 10 MHz)). Mobile-satellite services could continue to operate in this segment on a no-protection basis, however a complementary ground component would not be supported. Interference between mobile satellite and local-area wireless broadband is expected to be self-managing with mobile-satellite use expected to be limited in areas of local-area wireless broadband operation.

Another variation of Option 3 is to grandfather existing TOB usage in capital cities. This would require coordination with MSS complementary ground component services. As outlined in the analysis at [Appendix E: Television outside broadcast and wireless broadband sharing study](#), separation distances up to 20 km would be required, resulting in spectrum denial in large parts of capital city areas. The ACMA considers this level of spectrum denial is likely to be too high, as it would preclude the operation of new services across substantial areas of high-density population centres.

## Implementation considerations

Consideration needs to be given to the duration of the transition period for any new arrangements in the 2 GHz band. Consideration of an appropriate reallocation period for any geographical area and frequency segment that may be subject to spectrum licence reallocation will be important (under Option 2). Similarly, appropriate implementation timeframes for changes to frequency band plans are relevant considerations under Option 3.

For Option 2, supporting MSS, the requirements outlined in the section Mobile-satellite spectrum considerations in [Appendix B: Domestic considerations](#) would need to be considered further in the context of a possible price-based allocation process.

For the proposal for a shared satellite IoT band under class licensing arrangements, the ACMA would consider the feasibility of implementation of this option independently of other elements so to not unnecessarily delay access to spectrum for satellite IoT systems. A key consideration in this regard is whether sufficient information is available to assess adjacent band interference matters.

## Summary of options by service type

Table 2: Summary of options by service type

Option	Television outside broadcast	Wide-area wireless broadband	Local-area wireless broadband	Direct air-to-ground communications	Mobile-satellite service (Australia-wide)
1	No change	Not supported	Not supported	Not supported	<b>IoT only:</b> 1980–1985 and 2170–2175 MHz
2	Clear existing services	<p><b>Capitals:</b> 1980–2005 and 2170–2195 MHz</p> <p><b>Regional:</b> 1980–1995 and 2170–2185 MHz</p> <p><b>Remote:</b> Not supported</p>	<p><b>Capitals:</b> Not supported</p> <p><b>Regional:</b> 1995–2005 and 2185–2195 MHz on a coordinated basis with direct air-to-ground communications</p> <p><b>Remote:</b> 1980–2005 and 2170–2195 MHz on a coordinated basis with direct air-to-ground communications</p>	<p><b>Capitals:</b> 1980–2005 and 2170–2195 MHz*</p> <p><b>Regional:</b> 1995–2005 and 2185–2195 MHz^</p> <p><b>Remote:</b> 1980–2005 and 2170–2195 MHz^</p>	<b>IoT only:</b> 2005–2010 and 2195–2200 MHz
3	Clear existing services	Not supported	Not supported	Not supported	1980–2005 and 2170–2195 MHz  <b>IoT only:</b> 2005–2010 and 2195–2200 MHz

\* considered in development of technical framework for wide-area wireless broadband

^ on a coordinated basis with local-area wireless broadband

# Assessment of options

## Introduction

The ACMA has undertaken a preliminary assessment of the options against the desirable planning outcomes for the 2 GHz band, informed by a preliminary quantitative cost-benefit analysis:

1. Support new uses of the band consistent with international harmonisation and domestic considerations which includes some mix of MSS uses (including for IoT) and possible wireless broadband uses, including MSS complementary ground component usage.
2. Resolve the interim nature of arrangements in the band, in order to provide increased certainty for future uses of the band.
3. Ensure coexistence with adjacent band services is addressed. This includes wireless broadband operating below 1980 and 2170 MHz, and television outside broadcast / space research / space operations operating above 2010 and 2200 MHz.

The assessment of each option 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.

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

## Assessment against desirable planning outcomes

### Desirable planning Outcome 1

*Support new uses of the band consistent with international harmonisation and domestic considerations.*

- > **Option 1: Television outside broadcast**—New services are not supported by this option, with the exception of satellite-based IoT services in the guard band. Since this is included in all options, it is not considered as a benefit of Option 1 in comparison with the other options.

Current international activity does not indicate a trend towards increased use or adoption of the 2 GHz band for TOB services. The ACMA is not aware of any other use cases internationally, and as such, use of the band for TOB is expected to remain a niche or unique application in Australia.

Use of the spectrum by TOB operators is inherently intermittent with a small user base. Intensity of use is an important factor impacting the value that can be derived from a band. Over recent years, TOB services have used the 2 GHz band intermittently and in limited geographical areas. This indicates a low intensity of spectrum use by incumbent licensees. This option does not support desirable planning Outcome 1.

- > **Option 2: Wireless broadband including direct air-to-ground communications**—International allocation and use of the 2 GHz band is trending towards terrestrial wireless broadband services and/or MSS. In terms of harmonisation efforts for wireless broadband use, the band has recently received designation in 3GPP standards (known as band n65), although equipment availability is limited. The band has also been subject to a global identification for international mobile telecommunications by the ITU since 1992.

Domestically, this option provides only a minor incremental increase in the availability of mid-band spectrum for wireless broadband services. The ACMA is currently focusing its efforts on addressing the availability of mid-band spectrum for 5G services in other bands, including 3.4 GHz and 3.7–4.2 GHz, where much larger gains may be possible. This option would also provide a licensee with the option of deploying a direct air-to-ground communications system either in isolation or in conjunction with a wireless broadband system. This option better addresses planning Outcome 1 than the first option.

- > **Option 3: Mobile-satellite service including complementary ground component**—The 2 GHz band is allocated globally by the ITU to the mobile-satellite service on a co-primary basis (together with fixed and mobile services). MSS is one of two major international trends in allocation and use of the 2 GHz band.

Respondents to the 2019 discussion indicated that suitable satellite modems and related equipment are currently available for use in the 2 GHz band. Several respondents also described aspirational business models ready for deployment using the 2 GHz band. These are based on anticipated demand in the emerging IoT market for large-scale, Australia-wide connectivity of devices and assets. This option best meets desirable planning Outcome 1.

## **Desirable planning Outcome 2**

*Resolve the interim nature of arrangements in the band to provide increased certainty for future uses of the band.*

- > **Option 1**—Converting the current interim planning arrangements to ongoing tenure for TOB licensees would satisfy their requests for long-term certainty in the band. However, this would preclude new access seekers and create ongoing uncertainty for deployment of commercial-ready services in the absence of viable alternative spectrum bands.

Viable alternative spectrum in the 7.2 GHz band may provide the longer-term certainty sought by TOB operators. Retaining existing arrangements will likely expose the band to continued requests for access that are likely to intensify as demand for alternative uses continues to grow. Thus, we consider that this option provides the lowest level of certainty for ongoing future uses.

- > **Option 2**—Potential wide-area wireless broadband licensees include mobile network operators that are likely to have capacity to extend existing networks to utilise the additional incremental spectrum that this band would provide to complement existing holdings. However, two of Australia's three mobile network operators stated in submissions to the 2019 discussion paper that the 2 GHz band is not an immediate priority in their spectrum roadmaps. For the local-area wireless broadband service, introducing spectrum arrangements for operators to use the band is likely to assist in the delivery of these use cases.

Regarding direct air-to-ground communications, there is a high level of uncertainty surrounding the potential benefits of these services as their potential future uptake and viability is unclear. The same functionality can also be provided by satellite systems, which are already in operation providing gate-to-gate connectivity to commercial airlines in the Ku and Ka bands. We consider this option provides a medium level of certainty for future uses of the band.

- > **Option 3**—A number of satellite operators are seeking access to the band that have MSS operating internationally and/or are planning services for the Australian market. Three operators have obtained scientific licences to operate temporarily for test and demonstration purposes. The ACMA considers that there are no readily

available substitute bands for ongoing deployment of these services. Support for a complementary ground component provides additional flexibility for operators to deploy solutions that are optimised for geography (terrain and built environment), coverage goals, user density, and service-level requirements including throughput and latency.

We consider this option provides a high level of certainty for future uses of the band and is the least likely to come under pressure in the medium term for alternative uses.

### **Desirable planning Outcome 3**

*Manage coexistence with adjacent band services.*

Each option addresses this desirable planning outcome effectively in the same way through the implementation of necessary restricted/guard bands and other technical planning arrangements. Hence this outcome offers no scope for differentiation between options and is therefore not discussed further.

## **Quantitative cost-benefit analysis**

Where evidence is available, a quantitative analysis is also undertaken by the ACMA as part of its band replanning activities, to better inform the overall planning decisions for the band.

The quantitative analysis, when undertaken, reflects a cost-benefit analysis of the proposed options. This analysis is detailed in [Appendix G: 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 for relocation to an alternative band. This quantitative cost benefit analysis is generally based on a constant output case and 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, we acknowledge 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 (such as future private and market valuations of the spectrum), or unable to obtain in practice (such as exact knowledge of equipment-related costs and business planning decisions).

The preliminary cost-benefit analysis concludes that the option with the highest net benefit is Option 3 and the lowest is Option 1.

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 2 GHz band.

## **Conclusion**

Our assessment against the desirable planning outcomes has identified Option 3 as most likely to maximise the overall public benefit and is therefore the ACMA's preliminary preferred replanning option for the 2 GHz band. We consider this option would:

- > maximise—by ensuring the efficient allocation and use of the spectrum—the overall public benefit derived from using the radiofrequency spectrum
- > provide a responsive and flexible approach to meeting the needs of spectrum users
- > encourage the use of efficient radiocommunication technologies and a wider range of services of an adequate quality by introducing new service types into the 2 GHz band
- > support the communications policy objectives of the Australian Government by providing spectrum that can be utilised for 5G and satellite technologies.

Option 3 meets the desirable planning outcomes as follows:

- > It supports new uses in the 2 GHz band, including MSS, IoT, and to some extent, terrestrial wireless broadband, consistent with international harmonisation trends and domestic demand drivers.
- > Support for a complementary ground component would enable deployment of terrestrial wireless broadband infrastructure (including 4G/5G services) where an operator considers this appropriate.
- > Ongoing certainty would be provided to users of the band, supporting services that are likely to retain a high level of domestic and international support at least into the medium term.
- > Coexistence with adjacent band services could be enabled via the development of appropriate technical conditions.



# Invitation to comment

## Making a submission

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

- > [Online submissions](#) can be made by uploading a document. Submissions in PDF, Microsoft Word or Rich Text Format are preferred.
- > Submissions by post can be sent to:
  - The Manager
  - Space Systems
  - 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](mailto: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***

View information about our policy on the [publication of submissions](#), including collection of personal information during consultation and how we handle that information.

Information on the *Privacy Act 1988*, how to access or correct personal information, how to make a privacy complaint and how we will deal with the complaint, is available in our [privacy policy](#).

# Appendix A: Responses to the discussion paper

## Overview

The ACMA released a consultation titled [Planning of the 2 GHz band](#) on 13 August 2019. The consultation period closed on 13 September 2019. Eighteen submissions were received from the following organisations:

- > Australian Broadcasting Corporation (ABC)
- > Australian Mobile Telecommunications Association (AMTA)
- > Australian Subscription Television and Radio Association (ASTRA)
- > Communications Alliance Satellite Services Working Group (CA SSWG)
- > Free TV Australia
- > Gearhouse Broadcast Pty Ltd
- > Inmarsat
- > Kepler Communications Inc.
- > NEP Australia
- > Nokia
- > Omnispace
- > Optus
- > Pivotel
- > Sirion Global
- > Telstra
- > Thoroughbred Racing Productions
- > Vodafone Hutchison Australia (VHA)
- > Wireless Internet Service Provider Association of Australia Inc. (WISPAU)

Submissions are published at the ACMA's [2 GHz consultation](#) page.

## Consultation questions

The discussion paper invited comment on the following questions:

1. What TOB services use the 2 GHz band under current arrangements? Is demand for TOB in this band growing or decreasing?
2. What interest do you have in making further use of the 2 GHz band?
3. Given the points raised in this discussion paper:
  - a. How much spectrum is required to provide the service?
  - b. Is there a clear geographical delineation—for example, metropolitan or regional—for the service?
  - c. Is there, or will there be, readily available equipment for the service?

## Summary of responses

Respondent views were generally divided on future planning of the 2 GHz band, with views on future use aligned with each respondent's industry type. Thus, we received submissions supporting all of the use case scenarios: TOB, MSS (with or without a

complementary ground component), terrestrial mobile broadband services and direct air-to-ground communications.

Responses are summarised into groups below according to the type of service that each respondent supported. Respondents advocating direct air-to-ground communication services are considered in the wireless broadband group, as these services are essentially a subclass of wireless broadband applications. Some responses addressed or supported multiple service types and in such cases comments from these respondents are distributed across the relevant sections below.

### **Television outside broadcasting**

Responses from organisations associated with the TOB industry were received from: ABC, ASTRA, Free TV, Gearhouse Broadcast, NEP Australia and Thoroughbred Racing Productions.

With the exception of the ABC and Free TV, each of these respondents advocated retaining the band for TOB services. They argued this would provide ongoing certainty for the industry and avoid costs associated with relocation to another band.

Submissions noted the 2 GHz band was used extensively as part of the Gold Coast Commonwealth Games. Parts of the band are used on special events such as F1 Grand Prix, MotoGP, V8 Supercars, Golf, G20 conference, horse racing, AFL and NRL Grand Finals and X-Games. While most major events occurred in metropolitan areas, some events such as the Tour Down Under and a large number of motor racing events (MotoGP and V8 Supercars) occur in regional areas. Submissions also indicated that support for production of Australian content for streaming services is an emerging demand.

While submissions indicated that the entire 2 GHz band is required to support existing and expected future service arrangements, such usage is not reflected in current licensing statistics which indicate a relatively low utilisation of the 2 GHz band as a whole.

The submission from ASTRA noted that member Fox Sports Australia uses the 2 GHz band for TOB either directly or through footage supplied by third parties. ASTRA considers that the band should not progress to preliminary replanning until the WRC-19 process is complete and the international position on the band is settled.

Gearhouse Broadcast noted that the 2 GHz band provides an essential resource enabling the use of wireless camera links for televised and streamed events around Australia. Limitation of this use or allowing shared use of the band by alternative services would severely limit the ability to achieve current outcomes and dramatically reduce the ability for future Australian content to be produced.

NEP Australia advised that the 2 GHz band is used extensively for special events including large sporting events. Reallocation to alternative services would have a significant negative impact on its operations. However, a future geographic split with TOB in metropolitan areas and MSS elsewhere may be acceptable if spectrum can be reassigned to TOB services when major events are held in regional areas.

Thoroughbred Racing Productions (TRP) noted its requirement to continue utilising the full 30 MHz bandwidth available in the 2 GHz band. As with NEP, TRP indicated that geographic separation may be feasible with an alternative service operating in regional areas. However, costs of up to \$0.5 million could be incurred if required to move all operations to the 7 GHz band in regional Victoria.

The submissions from ABC and Free TV did not address options for future use of the 2 GHz band. Rather, they advocated retention of existing interference protection arrangements for their operations in adjacent bands.

### **Wireless broadband**

Responses from the wireless broadband industry were received from AMTA, Nokia, Optus, Pivotal, Telstra, VHA and WISPAU.

Respondents generally had divergent views on the optimal future use of the band including wide-area wireless broadband, local-area wireless broadband, and direct air-to-ground communications. Some respondents suggested the band could be shared with other services via geographic or frequency separation.

AMTA, Optus and Telstra indicated that replanning the 2 GHz band is not considered an immediate priority. However, both AMTA and Telstra signalled their support for the band to progress to the next stage of the replanning process. Optus noted that any changes to arrangements in the 2 GHz band must retain the existing protection of guard bands for adjacent 2.1 GHz spectrum licence holders.

VHA indicated its interest in using the 2 GHz band to deploy mobile broadband services in metropolitan areas (consistent with a wide-area wireless broadband use). However, this is dependent on this use of band gaining further support internationally. By allocating 2 GHz to mobile broadband, the ACMA will help build momentum to support the band's allocation to mobile broadband internationally and encourage device manufacturers to develop equipment that will utilise the band.

Pivotal indicated a focus on serving regional areas, advocating that part of the 2 GHz band (2 x 10 MHz) be allocated to apparatus-licensed terrestrial mobile services and the remaining 2 x 20 MHz to MSS, terrestrial mobile services or a combination with MSS as primary. Pivotal indicated this approach would provide 10 MHz of FDD spectrum access for innovative 'place-based' LTE solutions outside of the traditional bands allocated on a spectrum-licensing basis, while also providing opportunities for potential future MSS services, particularly those targeting satellite-based IoT solutions. Pivotal also suggested that the band should be self-managed by licensees to manage potential interference, thereby increasing the overall utilisation of the spectrum.

In contrast, WISPAU advocated that the band be planned for fixed or mobile broadband purposes (consistent with a local-area wireless broadband use) via a dynamic spectrum licensing management system. This would allow existing licensees to continue to operate as well as enable the spectrum to be efficiently utilised by alternative services. WISPAU indicated that the 2 GHz band could accommodate smaller carriers displaced by replanning of the 3.6 GHz band in 2016.

### **Direct air-to-ground communications**

Telstra and Nokia advocated that the band be allocated to direct air-to-ground communications, based on IMT technology. Telstra considers the 2 GHz band provides the best opportunity to introduce this service in Australia, recommending that the entire 30 MHz paired spectrum be allocated to this purpose Australia-wide (thus providing sufficient bandwidth to enable deployment of competing services).

Telstra also noted growing interest from emergency services for connectivity to helicopters and their other low altitude aircraft. Telstra advised that they are participating in a trial in Melbourne with Uber to evaluate the connectivity requirements for a future connected aviation transport system in an urban environment. They consider that direct air-to-ground systems are a potentially useful connectivity option for this type of future transport service.

Nokia responded with similar views while diverging on the quantity of spectrum required. Nokia indicated that 15 MHz of paired spectrum in the lower half of the band should be granted to the direct air-to-ground communication service on an exclusive basis, in the same spectrum range used by the European Aviation Network. This would enable existing air-worthiness-certified equipment to be used in an Australian deployment.

## **Satellite**

Responses from the satellite industry were received from CA SSWG, Inmarsat, Kepler, Omnispace, Pivotal and Sirion Global. Submissions generally advocated for:

- > progression of the band to the preliminary replanning stage of the replanning process
- > phasing out TOB services
- > reallocating the band to MSS, including satellite-based IoT services.

Respondents indicated readiness to deploy a range of mobile-satellite applications including inflight broadband, satellite IoT, remote communication services serving mining and agricultural industries, emergency and public safety communications, as well as S-band satellite telemetry, tracking and command.

Interest in deploying satellite-based IoT services was indicated by Omnispace, Pivotal, Sirion and Kepler. These submissions indicated the expected large growth in IoT markets including areas such as agriculture and mining sectors as well as a vast range of tracking applications requiring national coverage.

Most respondents argued that it would not be feasible to share the band with another service, either by sub-dividing the band or geographically separating services. Several operators asserted there is currently not enough spectrum available for MSS operators to support new demand, including IoT applications.

The CA SSWG further suggested that spectrum embargo 23 stands in the way of market progress and urged the timely introduction of important new MSS for the entire 2 x 30 MHz available in the 2 GHz band. Consideration should be given to arrangements that facilitate deployment of a ground component to support satellite services in high population areas where the built environment may reduce satellite visibility.

Inmarsat indicated interest in using the 2 GHz band for a service similar to the European Aviation Network. This provides inflight broadband service for airline passengers and utilises a mix of satellite and a complementary ground component to meet coverage and capacity demands. Inmarsat advocated for the whole band to be allocated to nationwide MSS with no more than 2 x 15 MHz available to a single operator. Should terrestrial mobile broadband or direct air-to-ground communications systems gain access to the band, then Inmarsat considers it would be necessary to establish emission limits to protect MSS systems serving other countries, as these are visible from Australia.

Kepler considers the maximum public benefit is attained when the band is aligned with the international community and dedicated on a majority or near-majority use to the MSS. Kepler suggested that if the band is not re-allocated to the MSS there will not be enough spectrum available for MSS operators to support new demand. In terms of spectrum requirements, a 2 x 6 MHz allocation would greatly support the facilitation of Kepler's own IoT service as presently envisioned. Kepler further stated that the 2 GHz band had distinct advantages including small-form, omni-directional antennas used by portable equipment, and international use of the band for satellite services provided an existing market for commercial-off-the-shelf components.

Omnispace urged the ACMA to allow the deployment of global services such as MSS in the 2 GHz band, while allowing TOB operators to share or transition to other spectrum that may have more global economies of scale for their equipment. Omnispace sought Australia-wide access to 2 x 15 MHz in the 2 GHz band for MSS, complementary ground component and S-band telecommand and telemetry services. Additionally, Omnispace did not support sub-dividing or geographic separation in the band, nor did it support satellite IoT only in guard bands between services, rather satellite IoT must be able to access same spectrum as an MSS network.

As mentioned previously, Pivotal advocated for part of the 2 GHz band (2 x 10 MHz) to be allocated to apparatus-licensed terrestrial mobile services and the remaining 2 x 20 MHz to MSS, terrestrial mobile services or a combination with MSS as primary. Pivotal indicated this approach would provide 10 MHz of FDD spectrum access for innovative 'place-based' LTE solutions outside of the traditional bands allocated on a spectrum-licensing basis, while also providing opportunities for potential future MSS services, particularly those targeting satellite-based IoT solutions. Pivotal further suggested that the replanned 2 GHz band should be self-managed amongst licensees sharing the band.

Sirion Global indicated that 2 GHz is the cornerstone of Sirion's planned service. Sirion sought a single licence allocation of the entire band, Australia-wide for MSS with a terrestrial component. Sirion indicated readiness to deploy a non-geostationary orbit (NGSO) MSS network with a terrestrial component to augment capacity and coverage. It planned to utilise the system to provide services in the IoT market.

Finally, interest in deploying MSS in conjunction with terrestrial mobile broadband services (as a complementary ground component or ancillary terrestrial component) was reported by several respondents including Inmarsat, Omnispace, Pivotal and Sirion Global. These satellite operators indicated that a satellite system augmented with a terrestrial component would enable them to increase coverage and capacity where required and make the most efficient use of the 2 GHz spectrum.

# Appendix B: Domestic considerations

This appendix examines relevant domestic considerations that could influence the assessment of the best use of the 2 GHz band. This includes:

- > current spectrum arrangements and demand for services
- > regulatory and licences issues associated with MSS
- > possible options for licensing of direct air-to-ground communications
- > deployment considerations for complementary ground component and similarities with wireless broadband
- > possible options for licensing of complementary ground component
- > standards and likely channel bandwidths.

## History and current arrangements

In Australia, the segments of the 2 GHz band under consideration in this paper were originally part of a larger band known as the 2.1 GHz band, spanning 1900–2300 MHz. The 2.1 GHz band was planned for fixed point-to-point links. In the early 2000s, fixed links were cleared from the band to support the introduction of MSS and 2.1 GHz spectrum licences. While the majority of fixed point-to-point links were cleared from the band, the anticipated mobile-satellite service did not eventuate.

As a result, the 2 GHz band remained relatively underutilised until 2010, when the ACMA decided to make the 2 GHz band available for TOB services on an interim basis, pending a future review of long-term arrangements for the band. Interim arrangements were intended to assist in the transition of TOB services to new arrangements following changes resulting from the digital dividend process.

To support the TOB transition and retain flexibility for future replanning activities, the ACMA established a policy to restrict all services in the 2 GHz band except for TOB until the future use of the band was considered.<sup>23</sup>

Regulatory and policy arrangements established by the ACMA currently support the following uses of the 2 GHz band:

- > interim TOB services<sup>24</sup>
- > fixed point-to-point services that were licensed prior to the TOB band plan coming into effect
- > short-term technology demonstrations or other short-term applications, authorised on a case-by-case basis.

Regulatory arrangements also protect the Australian Radio Quiet Zone Western Australia (near Boolardy Station). These requirements are specified in the [Radiocommunications \(Mid-West Radio Quiet Zone\) Frequency Band Plan 2011](#), RALI [MS 32](#) on the coordination of apparatus licensed services within the Australian

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<sup>23</sup> Refer [spectrum embargo 23](#).

<sup>24</sup> Refer [RALI FX21](#): Television outside broadcasting services in the bands 1980–2110 MHz and 2170–2300 MHz.

Radio Quiet Zone Western Australia, and spectrum [embargo 41](#), which covers the 70 MHz–25.25 GHz band, and therefore applies to the 2 GHz band.

The main use of the band is for TOB services. With the exception of a handful of legacy fixed links in remote locations and occasional short-term use, the TOB industry has largely enjoyed exclusive use of the 2 GHz band since interim arrangements were established.

Current TOB use is sporadic and limited in both duration and geography, with irregular peaks for major events. The majority of regular use occurs in capital city areas, while use in regional areas is typically associated with occasional major events.

Responses to the discussion paper indicated that potential future bandwidth requirements for both existing TOB operators and new access seekers exceeds the available spectrum (2 x 30 MHz) in the 2 GHz band. This was particularly the case for the MSS, with five respondents interested in providing services with expected minimum bandwidth requirements in the order of 2 x 15 MHz. The only exception to this scenario is Kepler Communications, which indicated interest in satellite IoT applications, proposing an allocation of 2 x 6 MHz for each operator.

## Television outside broadcast spectrum considerations

### Current use

Television outside broadcast refers to wireless applications used as part of news gathering, special events or media production. The 2 GHz band is used mainly for transmitting video using either a wireless camera over a short distance or point-to-point link from an outside broadcast van to a central capture point, typically permanently located in a high point.

The 2019 discussion paper presented a snapshot of TOB licences of a point in time which showed limited usage with 22 licensed services. Submissions to the discussion paper suggested a higher level of usage than that presented. With the itinerant and irregular nature of TOB a more detailed analysis of TOB usage over the five-year period (2015–19) has been undertaken looking at usage throughout the year rather than an individual point in time. Results are presented in the table below. A more detailed analysis by licensee is at [Appendix D: Spectrum arrangements and licensing statistics](#).

Analysis of licences issued in this timeframe showed licence duration varied from a minimum duration to cover a single event (one to two weeks) to a maximum duration of one year. In 2019, the 14 licences at fixed locations in capital cities supported services at six locations, three in Melbourne, and one each in Adelaide, Perth and Sydney. This suggests that use of the 2 GHz band by TOB is limited in both time and geographical coverage.

**Table 3: 2 GHz TOB licences 2015–2019**

Location	2015	2016	2017	2018	2019
Australia-wide	7	1			
State-wide	3	4	4	8	14
Fixed location—capitals	55	7	16	12	14
Fixed location—regional	20	2	2	2	2
<b>Total</b>	<b>85</b>	<b>14</b>	<b>22</b>	<b>22</b>	<b>30</b>

These licence assignments and usage patterns indicate a relatively low utilisation of the 2 GHz band.



## Other planning arrangements supporting TOB

In addition to the 2 GHz band, there are arrangements supporting TOB services in the bands:

- > 2010–2110 MHz and 2200–2300 MHz under RALI FX 21
- > 2570–2620 MHz under [2.5 GHz mid-band gap](#) spectrum licences
- > 7100–7425 MHz, 8275–8400 MHz, 12.75–13.25 GHz and 21.2–23.6 GHz under RALI FX 3.

These TOB bands are either allocated to broadcasters<sup>25</sup> or for shared use. The 2 GHz band is a shared use band that supports a range of users such as small-scale production houses, sporting venues and other short-term use. The existing bands that also support shared use include the 7.2 GHz (7100–7425 MHz) and 8.3 GHz (8275–8400 MHz) bands.

A summary of arrangements in these bands is at [Appendix D: Spectrum arrangements and licensing statistics](#).<sup>26</sup>

Of those bands, ACMA understands that wireless cameras typically operate in the bands 2010–2110 MHz, 2200–2300 MHz, 2570–2620 MHz and 7100–7425 MHz with the other bands more likely to be used for temporary point-to-point links for distribution purposes. Based on licensing data, usage of the 8275–8400 MHz band appears to be limited, possibly due to limited equipment availability.

When looking at the shared users of the 7100–7425 MHz band, some of the 2 GHz band licensees also utilise this band including a production house and horse racing group. Utilisation of the 7100–7425 MHz band also appears to be low with the band only having a couple of shared users.

Considering TOB spectrum usage in the vicinity of 2 GHz, prior to the digital dividend process TOB services had access to 190 MHz of spectrum in the band 2.5–2.69 GHz. Post those arrangements there is access to 250 MHz (2010–2110 MHz, 2200–2300 MHz, 2570–2620 MHz) with the additional spectrum in the 2 GHz band available on an interim basis. While there are compatibility requirements limiting utility at band edges with adjacent band spectrum licensing services,<sup>27</sup> and restrictions in regional areas due to sharing with earth stations, fixed point-to-point links and defence aeronautical telemetry services, the available spectrum is greater than prior to the digital dividend even without consideration of interim arrangements in the 2 GHz band.

For bands above 7 GHz that support shared use, channel arrangements were developed to support analog services with interleave channel arrangement. With TOB equipment now predominately digital, there may be a need to review those arrangements if usage of the band increases (for example if 2 GHz was no longer available). To date, it has not been a matter raised by industry with the ACMA.

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<sup>25</sup> Broadcasters included in ACMA's RALI FX3 include ABC, Seven Network, Network Nine, Network Ten and Subscription Television (Foxtel).

<sup>26</sup> In addition to these arrangements wireless cameras can operate under provisions of the Low Interference Devices Class Licence in the 5725–5850 MHz band on a shared basis with other services such as wi-fi devices. However, given the shared nature of class licensing they are not considered comparable to the 2 GHz band for analysis purposes.

<sup>27</sup> Specifically [2 GHz spectrum licences](#) at 2110 and [2.3 GHz spectrum licences](#) at 2300 MHz.

## **Spectrum requirements and deployment scenarios**

Coverage of sporting events was the main use identified in submissions for TOB usage of the 2 GHz band. Considering video production quality requirements, submissions indicated that 8 MHz channels could support 1080i HD but larger bandwidths (17 MHz) were required to support 2160p 4K. Supporting 17 MHz channels in the 2 GHz Band would mean that only two 17 MHz channels and two 8 MHz channels would fit in the entire 2 GHz band.

NEP indicated that whilst other bands were available in the 6–7 GHz range for wireless cameras, the 2 GHz band had a coverage advantage and required fewer receivers. The 2 GHz band was well suited for covering outdoor events across a large area such as golf, motor sports and cycle road races. NEP did indicate that at large events they would use a combination of the adjacent band (2010–2110 and 2200–2300 MHz) under third-party arrangements as well as the 2 GHz band.

The ACMA understands that wireless cameras have an external RF module mounted on the camera which can be switched between bands by changing the module to the frequency band of operation, providing flexibility and minimising impact of band unavailability. Receiving points, however, might need to be configured with the appropriate RF module for the specific frequency band.

Regarding the use of wireless cameras, the ACMA understands that wireless cameras only contribute a small amount of the video with wired cameras providing the majority of the content when covering sporting events and major productions. Some exceptions exist in outdoor events which require the mobility to cover a large geographic area such as cycle road races or long-distance marathons.

Feedback from respondents indicated that reliable coverage was more difficult to obtain in the higher frequencies due to the propagation characteristics and that more receive points were required to achieve similar coverage. There is an increase in cost in operating at these higher bands due to the extra receive points required. The ACMA expects the majority of wireless camera links would cover short distances and have line of sight to the receiver, resulting in the TOB link performance of a 7 GHz system being similar to a 2 GHz system.

## **Mobile-satellite spectrum considerations**

### **Current planning arrangements supporting MSS**

In the context of the 2 GHz band, comparable bands in which MSS is supported in Australia are 1525–1559 MHz, 1610–1660.5 MHz, 1613.8–1626.5 MHz and 2483.5–2500 MHz. In total, this equates to 113.7 MHz of spectrum bandwidth.

These bands are used to provide voice and low data rate services (for example satellite IoT applications). Current licences are shown in the table below.

The 2 GHz band would increase the available spectrum for MSS by 52 per cent.

**Table 4: Mobile-satellite licensees in 2 GHz comparable bands**

Licensee	Licensed in Australia (MHz)	Mobile-satellite band (MHz)	Direction
Inmarsat Solutions (GSO)	1627.9–1660.1 <sup>†</sup> 1526.4–1558.6 <sup>†</sup>	1626.5–1660.5 <sup>^</sup> 1525–1559	Earth-to-space Space-to-earth
Thuraya Telecommunications Company (GSO)	1632.7–1660.5 <sup>†</sup> 1531.2–1559.0 <sup>†</sup>	1626.5–1660.5 <sup>^</sup> 1525–1559	Earth-to-space Space-to-earth
Iridium Australia (NGSO)	1617.78–1626.5 <sup>*</sup> 1617.78–1626.5	1610–1626.5 <sup>^</sup> 1613.8–1626.5	Earth-to-space Space-to-earth
Pivotal Group (GlobalStar NGSO)	1610.0–1621.185 <sup>*</sup> 2488.7–2500	1610–1626.5 <sup>^</sup> 2483.5–2500	Earth-to-space Space-to-earth

<sup>†</sup> Not the full band is licensed.

<sup>^</sup> GSO operators utilise 1626.5–1660.5 MHz and NGSO operators utilise 1610–1626.5 MHz based on L-band Memorandum of Understanding.<sup>28</sup>

<sup>\*</sup> Operate in parts of the band as this is shared with other mobile-satellite operators.

### Mobile-satellite service spectrum requirements and deployment scenarios

As discussed at [Appendix A: Responses to the discussion paper](#), mobile-satellite responses to the 2019 paper indicated interest to deploy a range of applications including inflight broadband, satellite IoT, remote communication services serving mining and agricultural industries, emergency and public safety communications, as well as S-band satellite telemetry, tracking and command.

Deployment models are based on Australia wide access with spectrum requirements varying from 2 x 6 MHz for IoT applications to 2 x 15 MHz for those looking to provide a full range of services.

Of the five respondents who indicated interest in deploying MSS, four supported a complementary ground component as a key requirement.

Submissions indicated the amount of spectrum required for the different MSS varied from 2 x 15 MHz for an inflight connectivity system to 2 x 5 MHz (or 2 x 6 MHz) for an IoT system. When considering spectrum requirements and five submissions expressing an interest in the band, it becomes clear that the 2 x 30 MHz available spectrum in the 2 GHz band would not be able to accommodate all the interest shown even if all the available spectrum is allocated for mobile-satellite purposes only.

The ACMA has observed from IoT mobile-satellite systems deployed in Australia in the VHF and UHF bands that they can operate in bands as small as 1 MHz on a shared basis between several operators. IoT MSS could be supported in several forms including a shared 5 MHz channel (class licensed), specific 5 MHz channels or sub-sections of the 5 MHz channels into lots of 1 MHz.

<sup>28</sup> L-Band MoU described in Annex 2 of CEPT / ECTRA Decision of 3 March 1999, on harmonisation of authorisation conditions in the field of satellite personal communications services (S-PCS) in Europe, operating within the bands 1525–1544/1545–1559 MHz, 1626.5–1645.5/1646.5–1660.5 MHz (ECTRA/DEC(99)01) <https://www.ecodocdb.dk/download/7415162b-af4b/ECTRADEC9901.PDF>.

## Wireless broadband

In the context of the 2 GHz band, comparable bands in which wireless broadband services are supported are considered those in the 1–6 GHz range, ‘mid-band 5G spectrum’. In summary, there is 808 MHz of spectrum in capital city areas, 758–833 MHz in regional areas and 688 MHz in remote areas, with 668 MHz of spectrum available Australia-wide. Licensing is under a mixture of apparatus and spectrum licensing.

In this context, the 2 GHz band would provide an additional six per cent<sup>29</sup> of spectrum in capital city areas.

Possible deployment scenarios cover site-based regional and remote area deployments suitable to site-based apparatus licensing, as well wide area deployments in capital sites more suitable to a spectrum licensing approach. In this context with the 2 GHz band adjacent to the 2 GHz spectrum licensing band, 2 GHz spectrum licensing areas are considered a reasonable starting point for any discussion of area definitions.

### Spectrum arrangements

For wireless broadband options, the ACMA is proposing to adopt spectrum arrangements based on 3GPP band 65 arrangements for the 2 GHz band, whereby base station receive operates in the 1980–2010 MHz range and base station transmit operates in the 2170–2200 MHz range.

Such arrangements are an extension of spectrum arrangements for the adjacent 2.1 GHz band which are based on the 3GPP band 1 arrangements (base station receivers in 1920–1980 MHz and base station transmitters in 2110–2170 MHz). This means that compatibility issues between wireless broadband providers can be expected to be very similar to existing 2.1 GHz band arrangements.

Spectrum arrangements based on band 65 could be used to support the frequency extension of 2.1 GHz wireless broadband networks providing additional capacity to those networks or support separate mobile networks that are integrated with mobile-satellite systems comprising a complementary ground component.

Responses from both wireless broadband and mobile-satellite operators saw the adoption of such spectrum arrangements supporting 3GPP band 65 as being beneficial.

When looking at the system bandwidths that could be deployed in the 2 GHz band, the current 3GPP standard<sup>30</sup> for NR 5G systems supports 5 MHz, 10 MHz and 20 MHz bandwidths. The implementation of an LTE 4G<sup>31</sup> system would support lower bandwidths including 1.4 MHz, 3 MHz as well as 5 MHz, 10 MHz and 20 MHz.

## Complementary ground component

The complementary ground component of a mobile-satellite service is in many respects similar to a wide area wireless broadband service. Both types of service

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<sup>29</sup> Assuming a 5 MHz guard band with adjacent television outside broadcast services leaving 2 x 25 MHz of spectrum for wireless broadband.

<sup>30</sup> [38.101-1 - NR; User Equipment \(UE\) radio transmission and reception; Part 1: Range 1 Standalone \(Rel 16.2.0\)](#).

<sup>31</sup> TR 36.101 Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception

involve deployment of base stations communicating with mobile terminals across a wide area. Accordingly, it is feasible that supporting MSS with a complementary ground component might result in the development of wide area wireless broadband networks in capital city areas.

In other jurisdictions where complementary ground component has been contemplated, the question of whether an obligation to provide an MSS service is necessary before the complementary ground component can be rolled out has been considered. The issue in question was the possibility of the MSS licensed use becoming a solely terrestrial wireless broadband network without the provision of an MSS service. In some cases, the provision of complementary ground component was conditional upon its being used to improve the MSS service availability.<sup>32</sup>

If a complementary ground component were to be considered in Australia these matters would also need to be considered. While these matters are most relevant to any future licence allocation work (after a decision is made on planned uses for the band), the ACMA is seeking industry views on the topic now to aid possible future considerations.

## **Direct air-to-ground communications spectrum considerations**

Direct air-to-ground communications is a technology that extends wireless broadband services to aircraft. Effectively, it provides a backhaul link between the ground and air to service Wi-Fi access points on an airplane. The same functionality can also be provided by satellite systems with in-flight connectivity provided by direct air-to-ground communications already provided by satellite services to commercial airlines in the Ku and Ka bands supporting gate-to-gate connectivity. For example, both Qantas and Virgin utilise satellite services to provide gate-to-gate inflight connectivity for passengers. For direct air-to-ground to provide the same coverage as current satellite services, an extensive network of ground stations would be required.

Direct air-to-ground communications is considered to have more in common with terrestrial services than satellite services, therefore for our analysis, direct air-to-ground will be considered as part of options supporting wireless broadband services. Two respondents to the 2019 discussion paper (Nokia and Telstra) advocated for direct air-to-ground communications use in the 2 GHz band. Telstra advised that such a system will require a minimum of 2 x 10 MHz, and that in Europe 2 x 15 MHz has been allocated for similar systems. Nokia noted that direct air-to-ground systems have the advantage of being able to be scaled to provide capacity where it is needed. Whilst direct air-to-ground systems are effectively a terrestrial wireless broadband system, Nokia advised that dedicated spectrum is required for each air-to-ground operator to sustain high-speed broadband services to users.

While the ACMA has not previously considered licensing arrangements to support direct air-to-ground communications networks, it is possible that such systems could be licensed via spectrum licensing (for example capital cities and regional areas) supporting coverage for areas of anticipated usage (major air traffic routes). Outside of these areas an apparatus licence approach of authorising each station in the network could be employed to facilitate usage by other services in areas where direct air-to-ground communications is not envisaged.

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<sup>32</sup> [ECC Decision ECC/DEC/\(06\)09](#): ECC Decision of 1 December 2006 on the designation of the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile-Satellite Service, including those supplemented by a complementary ground component.

Wide-area spectrum licensing would provide maximum flexibility for a licensee to deploy any technology in any configuration if it complies with the terms and conditions of the licence. The licensee would be responsible for managing interference between devices in the network. Under a spectrum licensing approach, the choice to deploy a terrestrial wireless broadband system or a direct air-to-ground communications systems would be a matter for the licensee.

Outside of spectrum licensing areas the deployment of individual direct air-to-ground devices under an apparatus licensing regime would more readily facilitate the deployment of one or more co-existing services, as these could be coordinated on a site-by-site basis. However, such an approach would mean expansion of a direct air-to-ground communications network would be dependent on spectrum availability in the desired area.

## Mobile-satellite service regulatory and licensing considerations

### International regulations

Before operating a satellite system<sup>33</sup> in Australia, the technical details of the network must be filed with the ITU<sup>34</sup> for inclusion in the Master International Frequency Register. Satellite systems may be filed through any national administration recognised by the ITU.

The ACMA's procedures for filing satellite systems with ITU are specified in [Australian procedures for the coordination and notification of satellite systems](#).

### Coordination between mobile-satellite systems

User terminals in mobile-satellite systems in the 2 GHz and L-band typically operating using omni-directional antennas. Meaning that user terminals can receive signals from other satellite systems operating on the same frequency. Similarly, satellite receivers can receive signals from user terminals transmitting in other satellite systems operating on the same frequency.

Consequently, coordination between mobile-satellite systems is largely concerned with band segmentation (segmenting the band between different operators). Division of spectrum between satellite operators is considered a licence allocation issue (refer to the section below "Licence allocation process").

An exception to this approach relates to satellite IoT systems where consistency is considered feasible due to the low-duty-cycle, low power, intermittency and modulation scheme, such that operation under a class licensing approach could be feasible. For example, terrestrial IoT systems are supported under class licence arrangements in the [Radiocommunications \(Low Interference Potential Devices\) Class Licence 2015](#). It is acknowledged that there could be an upper limit on the number of satellite IoT systems that could operate on such a basis and industry views are on this matter are sought.

### Licensing

As for all other types of radiocommunications, a satellite network may not be operated in Australia without a licence. To date, licensing of space systems has been under the apparatus licensing arrangements. However, if a spectrum licensing approach is

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<sup>33</sup> The ITU defines a satellite system as a space system using one or more artificial earth satellites. A space system is defined as any group of cooperating earth stations and/or space stations employing space radiocommunication for specific purposes.

<sup>34</sup> Refer ITU Radio Regulations Article 9 & 11, and ITU Rules of Procedures.

employed as a licence allocation process, exploration of whether the equivalent features are required and whether they could be included under spectrum licensing would require further consideration.

In general, there are two broad options for licensing of space systems in Australia.

The first option requires operators to obtain apparatus licences for each of their earth stations individually: an earth licence for the uplink and an earth receive licence for the downlink. Under this approach, a licence is not necessary for the space stations aboard a satellite. This method of licensing is typically used for fixed satellite services with a limited number of earth stations.

The second option involves a combination of apparatus and class licences. In certain bands specified in the [Radiocommunications \(Communication with Space Object\) Class Licence 2015](#) (the Space Object Class Licence), operators may licence the space stations aboard a satellite with a space licence for the downlink and a space receive licence for the uplink. Earth stations in the network are then automatically authorised collectively under the Space Object Class Licence. This approach is typically used for satellite systems with numerous or ubiquitous earth stations. It provides an efficient means of licensing a large number of earth stations, avoiding the need to obtain a licence for every earth station in a satellite system.

A mobile-satellite service operating in the 2 GHz band would be expected to require the second method of licensing, as it would likely involve deployment of an indeterminate and varying number of mobile user terminals or earth stations. Consequently, the ACMA would need to amend the Space Object Class Licence to facilitate use of the 2 GHz band and consider whether any revisions are required to the ACMA procedures for [Submission and processing of applications for space and space receive apparatus licences](#).

For an earth station to be authorised to operate under the Space Object Class Licence, the related space object must either be an Australian space object listed in the [Australian Space Objects Determination](#) or a foreign space object that is owned, controlled or operated by a company/entity listed in the [Foreign Space Objects Determination](#).

Before varying the Space Object Class Licence, the Australian Space Objects Determination or the Foreign Space Objects Determination, the ACMA would undertake consultation in accordance with the requirements of the *Legislation Act 2003*. This typically involves publication of a discussion paper with a period for submission of comments from interested parties.

### **Consultation with relevant government organisations**

Due to possible security issues associated with foreign ownership of aspects of space communications, applications for space-based communication systems may be subject to wider government consultation. Under current requirements<sup>35</sup> generally, the ACMA will consult with relevant organisations in the following situations:

- > new missions by existing ground stations that support (or suggest support) of foreign space systems, including the launch or early orbit phases
- > new foreign owned, or partly foreign owned, earth stations and space support equipment<sup>36</sup>

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<sup>35</sup> Refer [Submission and processing of applications for space and space receive apparatus licences](#)

<sup>36</sup> Space support equipment includes equipment that assists in the calibration of early orbit and on-orbit systems.

- > new Australian-owned earth stations that will provide support to foreign space systems including launch or early orbit phases, except where the foreign space system is used solely for commercial communications (for example, television broadcasting).

In the event that all or part of the 2 GHz band is allocated to the mobile-satellite service, the ACMA would need to consider how these requirements apply, including possible wider consultation within government.

### **Licence allocation process**

Like most apparatus licences, licences for space-based communication systems are typically granted by the ACMA on a first-in-time basis, subject to meeting requirements of the procedures for [Submission and processing of applications for space and space receive apparatus licences](#) and, if necessary, coordination with existing licensed services.

In the event that all or part of the 2 GHz band is allocated to the mobile-satellite service, a number of operators are likely to seek access to the spectrum. Indications of their spectrum requirements suggest that demand from satellite operators would significantly exceed the 2 x 30 MHz available in the band. Under such a scenario of demand exceeding supply, the ACMA generally considers whether to employ a price-based allocation system (section 106 of the Radiocommunications Act) or spectrum licensing; essentially allocation of licences using market mechanisms.

If such allocation arrangements are pursued, the ACMA will need to consider how and when to apply the usual regulatory pre-requisites for ITU filing and inclusion into the [Australian Space Objects Determination](#) or [Foreign Space Objects Determination](#) if required.

### **Mobile-satellite services with complementary ground component**

The ACMA has not previously considered the method for authorising the operation of the complementary ground component of a mobile-satellite service.

If spectrum licensed, the complementary ground component would be considered in the development of the associated technical framework.

Under apparatus licensing, an option would be to include as part of the framework supporting an Australia-wide area-wide apparatus licence both the mobile-satellite and complementary ground component under the one licence.

If the mobile-satellite service is authorised via a space / space receive apparatus licence, then possible options include supporting the complementary ground component under a separate apparatus licence type.

Will the ACMA has not explored the feasibility, a possible alternative approach is including a requirement to register complementary ground component stations under space and space receiver apparatus licences for the 2 GHz band. Such an approach would also require consideration as to the appropriateness of apparatus licence taxes and charges. That is, are they reflective of what would essentially be provision of a public telecommunications service.

Considering that the complementary ground component is technically similar to a local-area wireless broadband service, a similar approach is possibly more appropriate. This could be authorised via a public telecommunications service apparatus licence or an AWL. Such an approach would provide a licensee with optionality and means that licence taxes and charges associated with a public



telecommunications service are only incurred if such a service is provided. Further consideration is required as to whether, and under what mechanism, the issue of the public telecommunications service apparatus licence could be restricted to licensees of the space/space receive apparatus licence. Most likely this would be considered at the time of the development process for the legal instruments supporting the licence allocation process.

## **Consideration of spectrum options for other services in the 2 GHz band**

### **Low interference potential devices**

The LIPD Class Licence sets arrangements for the radiodetermination transmitters operating in the 30–12400 MHz range. These arrangements support ultra-wide band (UWB) devices with applications such as ground and wall penetrating radar aligning with international arrangements for UWB devices.

Operation of devices under the LIPD Class Licence is on a 'no interference and no protection' basis with other licensed services. The ACMA does not see a case to change the licensing arrangements for these devices.

### **Scientific apparatus licences**

Services operating under scientific apparatus licences, both assigned and non-assigned, are permitted to be licensed in the 2 GHz 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 in the licence) and non-assigned (the location and exact frequencies of operation are not recorded in 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 2 GHz band 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. For scientific non-assigned licences, the ACMA would propose to amend the Scientific LCD so that any frequency range subject to reallocation would be removed.

# Appendix C: Technical issues

Relevant technical coexistence considerations inform and guide the development of necessary planning and licensing frameworks.

As arrangements for multiple services are being considered in the 2 GHz band, the potential for issues associated with sharing<sup>37</sup> and compatibility<sup>38</sup> between these services and those in adjacent bands, needs to be considered when proposing and assessing possible future replanning options. This chapter outlines issues between services being considered in the 2 GHz band and, where relevant, existing co-ordination arrangements.

## Mobile-satellite and wireless broadband services

Here we consider the co-channel scenario between mobile-satellite and wireless broadband services (includes wide-area wireless broadband, local-area wireless broadband or the complementary ground component of an MSS). This discussion deals with cases where there are different licensees. Cases where the licensee is the same are not considered (for example, the scenario of a mobile-satellite operator utilising a complementary ground component).

Possible scenarios are shown in the figure below and include:

- > Integrated mobile-satellite system with complementary ground component where the user terminal is common to both networks (common user terminal). In this scenario, one licensee is responsible for the operation of the mobile-satellite system and the complementary ground component. Interference between the two elements of system is considered a matter for the licensee to manage.
- > Separate mobile-satellite and wireless broadband systems. In this scenario different licensees operate the mobile-satellite and wireless broadband systems. There are two possible variants of this scenario:
  - > the user terminal is configured to operate on both separate networks using a dual mode terminal (dual mode user terminal)
  - > the mobile-satellite user terminal is only configured to operate on the mobile-satellite system and does not operate when in the vicinity of the wireless broadband services (MSS-only user terminal).

These options effectively have the same infrastructure, but the compatibility issue focuses on the configuration and capability of the user terminal.

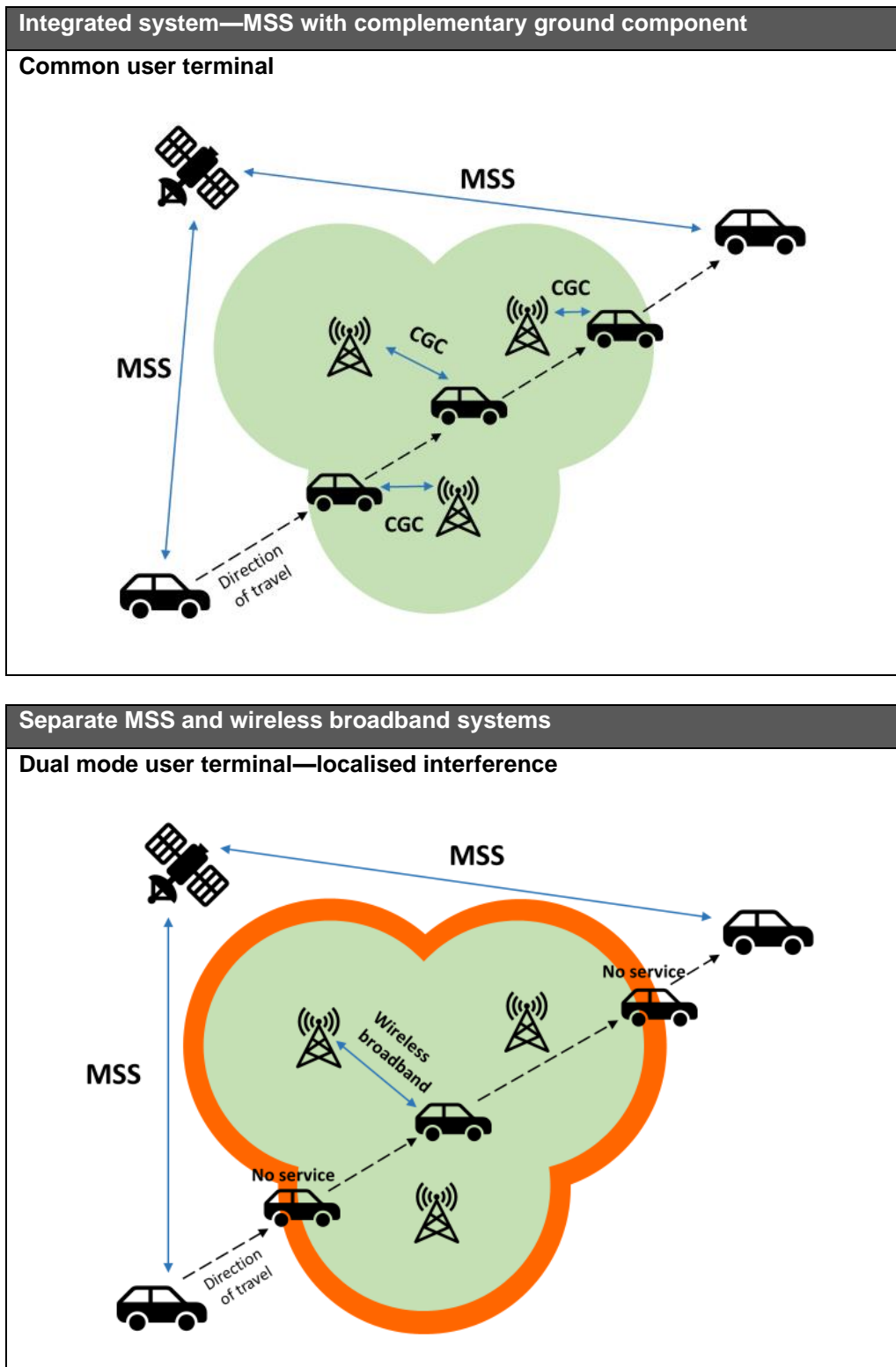
We have not considered the scenario whereby the MSS operator has arrangements in place to roam onto a terrestrial network in another band.

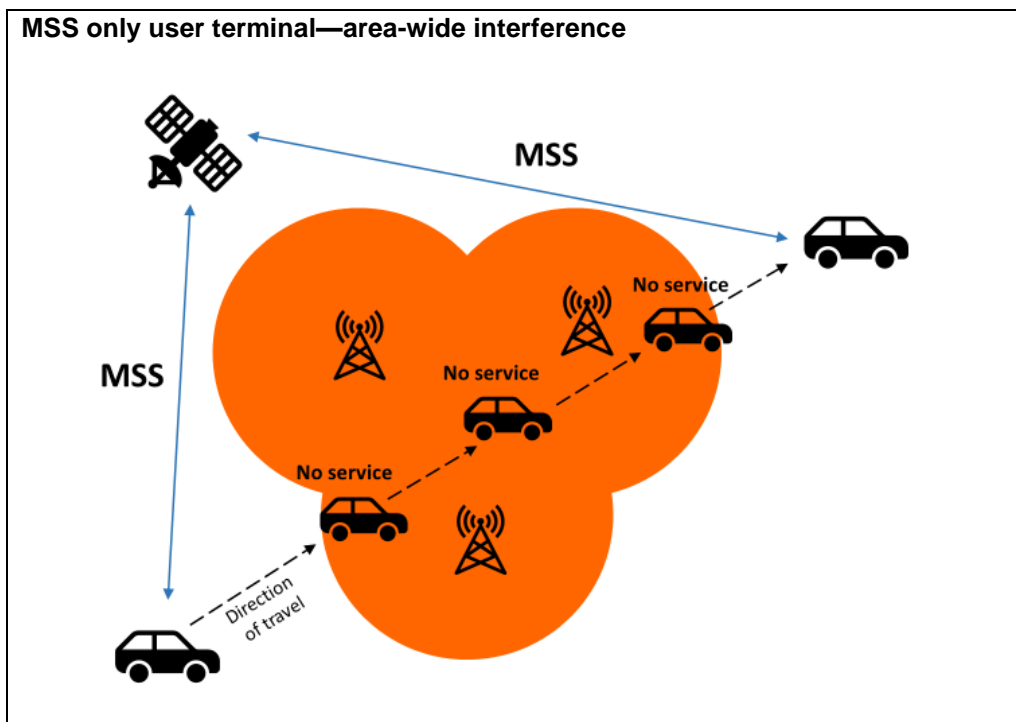
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<sup>37</sup> Sharing refers to the coexistence of services in the same band.

<sup>38</sup> Compatibility refers to the coexistence of services in adjacent or nearby bands.

Figure 5: Mobile-satellite and wireless broadband compatibility





### Mobile satellite and complementary ground component

A mobile-satellite system with complementary ground component effectively allows the terminal to seamlessly roam between systems effectively doing handovers as the system is integrated as one unit. Coexistence is achieved through the network configuration in a manner that is compatible for both satellite and terrestrial operation.

### Separate mobile-satellite and wireless broadband systems

Under this scenarios coexistence between separate mobile-satellite and wireless broadband systems is based on the capability of the user terminal. When there is a coverage overlap between mobile-satellite and wireless broadband systems, there is a transition zone when both systems interfere with one another and neither work. As the user terminal transitions through this zone and moves more into the coverage area of the wireless broadband service there is a point where this service is strong enough to overcome the interference from the mobile-satellite service and can then operate. As they are separate systems, then service only becomes available if the user terminal is a dual mode terminal and is registered on both systems. In the event that the user terminal only supports MSS, then it will have no service whilst in the coverage area of the wireless broadband service.

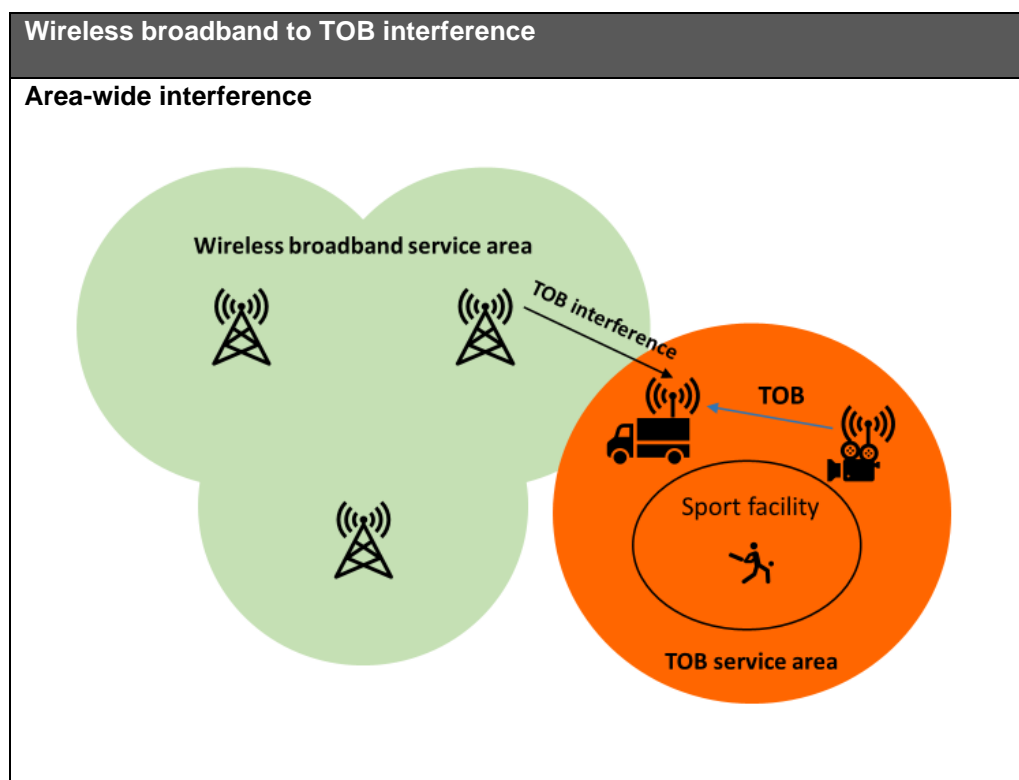
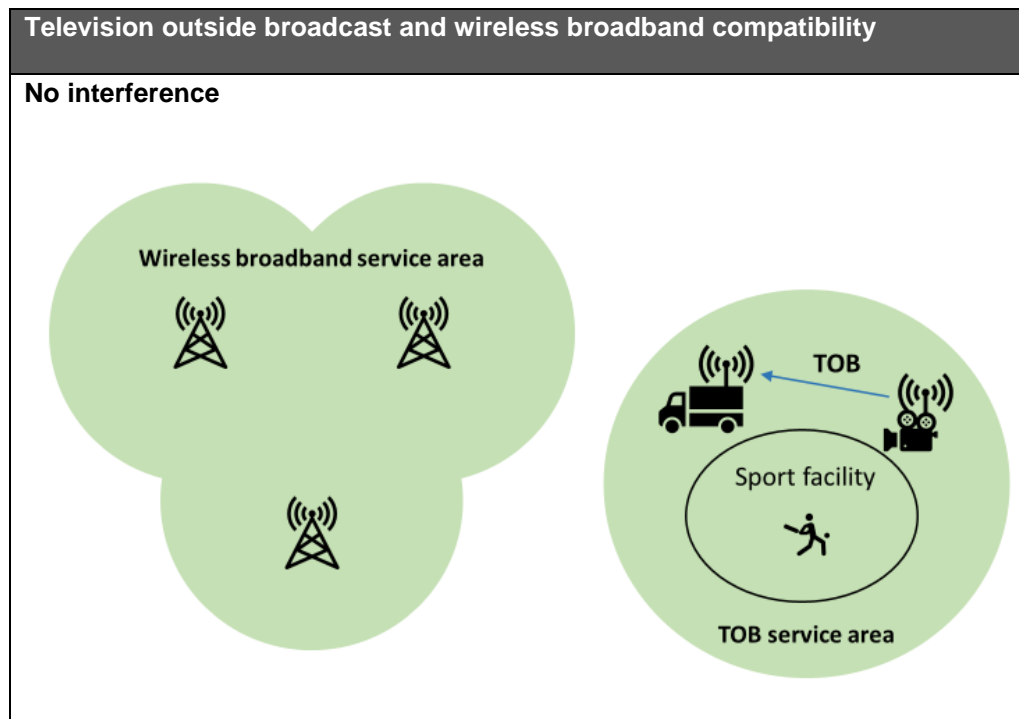
### ITU studies between mobile-satellite and wireless broadband services

Sharing studies between mobile-satellite and wireless broadband services were conducted by the ITU-R as part of WRC-19 agenda item 9.1.1. Further work is expected to continue within ITU-R Working Parties 4C and 5D regarding compatibility between services. These studies are of limited use in Australia as they are looking at the coordination of services between different countries. Any planning between services in Australia would need to consider the specific Australian environment and factor in the relevant parameters to maximise spectrum efficiency.

## Television outside broadcast and wireless broadband services

Here we consider a co-channel scenario between TOB and wireless broadband services (whether wide-area wireless broadband, local-area wireless broadband or the complementary ground component of an MSS).

Figure 6: Television outside broadcast and wireless broadband compatibility



A simple study was conducted using the TOB interference protection parameters specified in FX21 and utilising a clutter-based propagation model such as modified Hata model as detailed in the 2 GHz Technical Liaison Group (TLG)<sup>39</sup>. This study determined the required separation distance for a wireless broadband base station transmitter so that it does not cause interference to a TOB receiver. To utilise realistic EIRP values, the median value was selected from existing 2.1 GHz wireless broadband services in the adjacent band of 30 dBW/5 MHz which was considerably lower than the 47 dBW/ 5 MHz allowed under the 2.1 GHz spectrum licence.

The required separation distances of a wireless broadband base station so that it does not cause interference to a TOB are shown in the table below with ranges from 5 km to 20 km.

**Table 5: Separation distances between TOB receiver and wireless broadband base station**

Wireless broadband BS Tx EIRP	Separation distance (km)	
	TOB link 100 m	TOB link 200 m
Median 30 dBW / 5 MHz	12	18
Max 47 dBW / 5 MHz	31	39

The distances shown in this paper provide a good indication of the range of protection zone required but are not site specific as the modified Hata suburban model includes clutter but does not factor in site specific terrain. A more detailed study is included in [Appendix E: Television outside broadcast and wireless broadband sharing study](#), which shows the expected protection zones for existing TOB licences in Melbourne operating at AAMI Park or the Rod Laver Arena using a terrain-based propagation model.

## Adjacent band compatibility

The adjacent band compatibility between TOB and wireless broadband service needs to be considered to maintain current protection levels. Under the technical framework for the 2.5 GHz mid-band gap TOB spectrum licence, a 5 MHz restricted band is provided with respect to the adjacent 2.5 GHz spectrum licence band, with adjacent band coordination requirement to protect registered receivers in the 2.5 GHz mid band gap.<sup>40</sup>

Similarly, guard bands of 4 or 5 MHz are currently used between the TOB services and the 2.1 GHz mobile service. In particular, the mobile base transmit (2110–2170 MHz) channels can cause adjacent channel degradation to TOB services as the base station transmits at considerably higher power levels and can be located within close proximity of TOB receivers. If wireless broadband services are to be located within the 2 GHz band then they should be in the lower part to adjoin the 2.1 GHz band and consideration needs to be given to the upper section near 2200 MHz to ensure adequate protection is preserved for the TOB broadcaster's band (2200–2300 MHz).

<sup>39</sup> <https://www.acma.gov.au/publications/2016-01/report/2-ghz-tlg-package-2016>.

<sup>40</sup> For details of these requirements refer [Technical frameworks for spectrum licences](#).

In a submission received from NEP to the initial 2 GHz band consultation ([Planning of the 2 GHz band](#)) they indicated that they have invested heavily in filters to protect their TOB receivers from the existing 2.1 GHz mobile services and whilst these filters are tuneable, it would not be practical to have to be changing filter frequencies depending on the venue where they are televising from. The submission recommended that a 5 MHz guard band be maintained.

### **Other space services protection**

Also, the bands 2025–2110 MHz and 2200–2300 MHz are commonly used by earth stations to provide space operation services, earth exploration-satellite services and space research services. Implementation of any new service in the 2 GHz band would need to ensure adequate protections were in place to protect these other space services in the adjacent bands.

Currently under RALI FX 21 due to the sensitivity of earth station receivers operating in the adjacent band 2200–2300 MHz no airborne transmitters are supported and a minimum separation distance of 100 km is required between TOB transmitters operating in the band 2175-2200 MHz and earth station receivers in the band 2200–2300 MHz statement in RALI FX 21 (New Norcia, Mingenew and Tidbinbilla). These requirements would need to be preserved in the context of any new services in the 2 GHz band.

## **Coordination with other services**

### **Radio Quiet Zone protection**

Other issues that need to be considered include protecting the Australian Radio Quiet Zone Western Australia (near Boolardy Station). These requirements are specified in the [Radiocommunications \(Mid-West Radio Quiet Zone\) Frequency Band Plan 2011](#), RALI [MS 32](#) on the coordination of apparatus licensed services within the Australian Radio Quiet Zone Western Australia, and spectrum [embargo 41](#), which covers the frequency range 70 MHz–25.25 GHz, and therefore applies to the 2 GHz band.

Currently under arrangements for TOB stations airborne transmitters are not supported and no transmitters are to be operated within 150 km of the Mid-West Radio Quiet Zone. These requirements would need to be considered in the context of any new services in the 2 GHz band.

# Appendix D: Spectrum arrangements and licensing statistics

## 2 GHz TOB licensees

The table below shows breakdown of TOB licences from 2015–19. The year refers to the year the licence was issued.

Table 6: 2 GHz TOB licences 2015–19

Location type	2015	2016	2017	2018	2019
<b>Australia-wide</b>	<b>7</b>	<b>1</b>			
Broadcast Solutions (UK)	4				
The Trustee for Pinder Family Trust	3	1			
<b>State</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>8</b>	<b>14</b>
Racing New South Wales				2	2
Thoroughbred Racing Productions (Vic)	3	2	2	3	3
Integrated Video Technology Productions					2
The Technical Direction Company of Australia				2	2
Timothy Jarvis					1
Total Events Co.				1	2
Videocraft Australia		2	2		2
<b>Fixed location—metro</b>	<b>55</b>	<b>7</b>	<b>16</b>	<b>12</b>	<b>14</b>
Gearhouse Productions	54				
Mayo & Calder			6		
The Technical Direction Company of Australia				2	1
Videocraft Australia	1	1	4	4	4
F50 Australia					3
Kookaburra Systems				2	1
Sibesh Investments					1
Gearhouse Broadcast		6	6	4	4
<b>Fixed location—regional</b>	<b>20</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
Gearhouse Broadcast	18				
Crocmedia					2
Rapid TV	2	2	2	2	
<b>Total</b>	<b>85</b>	<b>14</b>	<b>22</b>	<b>22</b>	<b>30</b>



As of 14 July 2020, there were 18 TOB licences held by eight organisations in the 2 GHz band; Crocmedia (2), Kookaburra Systems (1), Racing New South Wales (2), Sibesh Investments (1), The Technical Direction Company of Australia (1), Thoroughbred Racing Productions (Vic) (3), Total Events Co. (2) and Videocraft Australia (6).

### **Current planning arrangements supporting TOB**

In addition to the 2 GHz band, there are arrangements supporting TOB services in the bands 2010–2110 MHz, 2200–2300 MHz, 2570–2620 MHz (2.5 GHz mid-band gap), 7100–7425 MHz, 8275–8400 MHz, 12.75–13.25 GHz, 21.2–23.6 GHz. An overview of the arrangements in each band follows.

#### **2010–2110 MHz and 2200–2300 MHz**

Arrangements in these bands are contained in RALI FX 21. Channel arrangements support usage by Australian Broadcasting Corporation (ABC), Channel Seven Sydney (Seven Network), Nine Network Australia (Nine Network), Network Ten and subscription television.

Planning arrangements also support usage by earth stations, fixed point-to-point links and Department of Defence airborne mobile telemetry operations. Coordination arrangements vary by frequency segment, geographical location and service with TOB operations having primary usage around capital city areas.

#### **7100–7425 MHz (7.2 GHz)**

TOB arrangements in these bands are contained in RALI FX 3. Channel arrangements support usage by the Seven Network, Nine Network Australia, Network Ten with channels also available on a shared basis for all other users.

TOB licensees in the band are Seven Network, Nine Network, Network Ten, Sky Channel, Australian Football League, Thoroughbred Racing Productions, KOJO Productions and Department of Parliamentary Services.

Part of the band (7250–7375 MHz) is designated for use by the Australian Defence Force and Department of Defence. The Department of Defence is to be consulted in considering non-defence use of this band.

This band is used for earth station receive by Airbus DS (SATCOM AUSTRALIA), Defence and Optus. There are 28 earth receive licences, with all of them being above 7249.683 MHz with the majority being above 7368 MHz.

Fixed point-to-point links have a small overlap into this band with the first channel of the 7.5 GHz band encroaching into the 7424.5–7425 MHz part of this band. As of the 14 July 2020 there were 68 fixed link assignments in this band across Australia.

Other services in this band also include Space Research (Earth-to-space) for which CSIRO have licences in Tidbinbilla and New Norcia. Universal Space Network Inc has a licence in this band in Mingenew.

#### **8275–8400 MHz (8.3 GHz)**

Arrangements in these bands are contained in RALI FX 3. Channel arrangements support usage by the ABC with channels also available on a shared basis for all other users. Besides the ABC there is no usage by other TOB organisations.

Services that share this band are detailed in Table 7, including the number of licences issued as of 14 July 2020.

**Table 7: Services that use the 8.3GHz band**

Use	Allocation	Licences*
Defence Receive		1
Earth station receivers	Earth Exploration space-to-Earth	8
Earth station transmitters	Fixed-Satellite	25
Point to Point	Fixed	16
Radiodetermination	Fixed	1
Television Outside Broadcast Network (ABC Only)	Fixed	4

\* At 14 July 2020

**12.75–13.25 GHz (13 GHz)**

Arrangements in these bands are contained in RALI FX 3. Channel arrangements support fixed point to point links, usage by the ABC, Seven Network, Nine Network Australia, and Network Ten with one channel available on a shared basis for all other users.

**21.2–23.6 GHz (22 GHz)**

Arrangements in these bands are contained in RALI FX 3. Many of the channel arrangements in these bands including the 7.2 GHz, 8.3 GHz and 13 GHz are developed to support analogue services with an interleave channel arrangement.

**Table 8: Television outside broadcast bands and licensees—at 14 July 2020**

Band	Licensees
1980–2010 and 2170– 2200 MHz	Crocmedia, Kookaburra Systems, Racing New South Wales, Sibesh Investments, The Technical Direction Company of Australia, Thoroughbred Racing Productions, Total Events Co. and Videocraft Australia.
2010–2110 and 2200–2300 MHz	ABC, Seven Network, Nine Network, Network Ten, FOX Sports
2.5 GHz mid-band gap	ABC, Seven Network, Nine Network, Network Ten
7.2 GHz	Seven Network, Nine Network, Network Ten, Sky Channel, Australian Football League, Thoroughbred Racing Productions, KOJO Productions, Department of Parliamentary Services
8.3 GHz	ABC
13 GHz	ABC, Seven Network, Nine Network, Network Ten, Racing and Wagering Western Australia
22 GHz	Nil

NEP indicated that whilst other bands were available in the 6-7 GHz range for wireless cameras, the 2 GHz band had a coverage advantage and required fewer receivers. The 2 GHz band was well suited for covering outdoor events across a large area such as golf, motor sports and cycle road races. NEP did indicate that at large events they would use a combination of the broadcaster's TOB licences as well as the 2 GHz band.

NEP also advised that wireless cameras mounted in moving vehicles such as racing cars or aeroplanes are affected by doppler shift. The higher TOB bands were more limited in the speeds they could support than the 2 GHz band due to doppler shifts.

These alternative bands are predominately designated for temporary TOB point-to-point links, but as technology advances, more wireless camera applications may appear in these bands.

Due to the low number of TOB ongoing licences, one strategy to minimise transition cost could be to grandfather existing licences and only allow new TOB services in the other TOB bands.

For major events, the cost impact would be minimal as equipment is normally hired for these events.

### Wireless broadband

Bands that support wireless broadband services in the mid-band range (1-6 GHz) are outlined in the table below.

**Table 9: Current mid-band (1-6 GHz) wireless broadband spectrum**

Band	Frequency range (MHz)	Total BW (MHz)	Metro BW (MHz)	Regional BW (MHz)	Remote BW (MHz)	Additional information
1800 MHz	1710–1785 paired with 1805–1880	150	150	150	150	Spectrum licensed metro and regional areas. Apparatus licensed remote areas.
1900 MHz	1900–1920 unpaired	20	0	20	20	Apparatus licenced in regional and remote areas. Access restricted in metro areas to preserve future planning options.
2.1 GHz	1920–1980 paired with 2110–2170	120	120	120	120	Spectrum licensed in metro areas and 2 x 20 MHz in regional areas. Apparatus licensed in regional and remote areas. (2 x 40 MHz regional, 2 x 60 MHz remote.)
2.3 GHz	2302–2400 unpaired	98	98	98	98	Spectrum licensed in capital cities and regional areas.
2.5 GHz	2500–2570 paired with 2620–2690	140	140	140	140	Spectrum licensed Australia-wide

Band	Frequency range (MHz)	Total BW (MHz)	Metro BW (MHz)	Regional BW (MHz)	Remote BW (MHz)	Additional information
3.4 GHz	3400–3700 unpaired	300	300	190-265	160	Spectrum licence: 225 MHz in capital cities and major regional centres, 190 MHz in regional areas.  Apparatus licence: 75 MHz in capital cities and some surrounding regional areas, 160 MHz in remote areas (See Note 1).
5.6 GHz	5600-5620 MHz and 5630–5650 MHz	40		40		
		868	808	758-833	688	

Note 1: This reflects current arrangements in the 3400-3700 MHz band. However, as stated in the paper [Optimising arrangements for the 3400-3575 MHz band—Planning decisions and preliminary views](#), the ACMA is working towards making the entire 3400-3700 MHz band available for WBB Australia-wide under a combination of spectrum and apparatus licence arrangements. This includes:

- > Metro: 300 MHz SL
- > Regional: 35–67.5 MHz AL, 232.5–265 MHz SL
- > Remote: 300 MHz AL.

# Appendix E: Television outside broadcast and wireless broadband sharing study

The aim of this study is to identify areas where wireless broadband service deployment could be restricted due to interference to existing licensed TOB services. It considers cochannel interference from a macro base station to TOB receive stations in Melbourne and is indicative of metropolitan areas with low TOB service incumbency.

## Study parameters

### Wireless broadband parameters

The wireless broadband parameters used in the analyses are based on [Report ITU-R M.2292](#) (M.2292) that contains information on parameters to use in sharing studies involving 4G systems. For the purposes of this study, 4G system characteristics and parameters in the 2.1 GHz range of M.2292 were assumed for the cochannel cases.

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) wireless broadband transmitter occupies the entire operational bandwidth of the TOB receiver.

**Table 9: Wireless broadband cochannel study parameters**

Parameter	Unit	Value	Justification
Antenna height	m	25	From Rep. ITU-R M.2292
Channel bandwidth	MHz	5	From spectrum licence for the 2.1 GHz band
Max EIRP per Ch	dBW	47.2	From spectrum licence for the 2.1 GHz band
Max EIRP in 1 MHz	dBW/MHz	40.2	7 dB adjustment
Median EIRP per Ch	dBW	30	Median from 2.1 registrations
Median EIRP in 1 MHz	dBW/MHz	23	7 dB adjustment

### TOB receive station parameters

This study provides a representation only of the impact in a major metropolitan area and only looks at the 2 GHz band licences in Melbourne. The site specific information is included in Table 10: and due to the close proximity of the two sites only the AAMI Park site has been used.

**Table 10: TOB station study site parameters**

Location	Latitude	Longitude	Maximum gain (dBi)	Antenna height (m)
AAMI Park Olympic Boulevard South Melbourne	-37.825829	144.982219	0	10
Melbourne Exhibition Centre	-37.82433	144.954913	3	10*

\* Current licences have an antenna height of 0m and have used 10m for this study.

**Table 11: TOB receive station study generic parameters 200 m TOB Link**

Parameter	Value	Reference
Antenna pattern	Omni directional	RALI FX21
Wireless Camera EIRP	-10 dBW/ 8 MHz	RALI FX21
Path loss over 200 m	84.4	Calculated (Free Space Loss)
Antenna Gain (Rx)	3 dBi	RALI FX21
Minimum wanted signal level per Ch	-91.4 dBW/8 MHz	EIRP – Loss +Grx
Minimum wanted signal level per MHz	-100.4 dBW/ MHz	-9 dB adjustment
Protection ratio	26 dB	RALI FX21
Interference threshold	-126.4 dBW/MHz	EIRP – Loss +Grx - PR

**Table 12: TOB receive station study generic parameters 100 m TOB Link**

Parameter	Value	Reference
Antenna pattern	Omni directional	RALI FX21
Wireless Camera EIRP	-10 dBW/ 8 MHz	RALI FX21
Path loss over 100m	78.4	Calculated (Free Space Loss)
Antenna Gain (Rx)	3 dBi	RALI FX21
Minimum wanted signal level per Ch	-85.4 dBW/8 MHz	EIRP – Loss +Grx
Minimum wanted signal level per MHz	-94.4 dBW/ MHz	-9 dB adjustment
Protection Ratio	26 dB	RALI FX21
Interference Threshold	-120.4 dBW/MHz	EIRP – Loss +Grx - PR

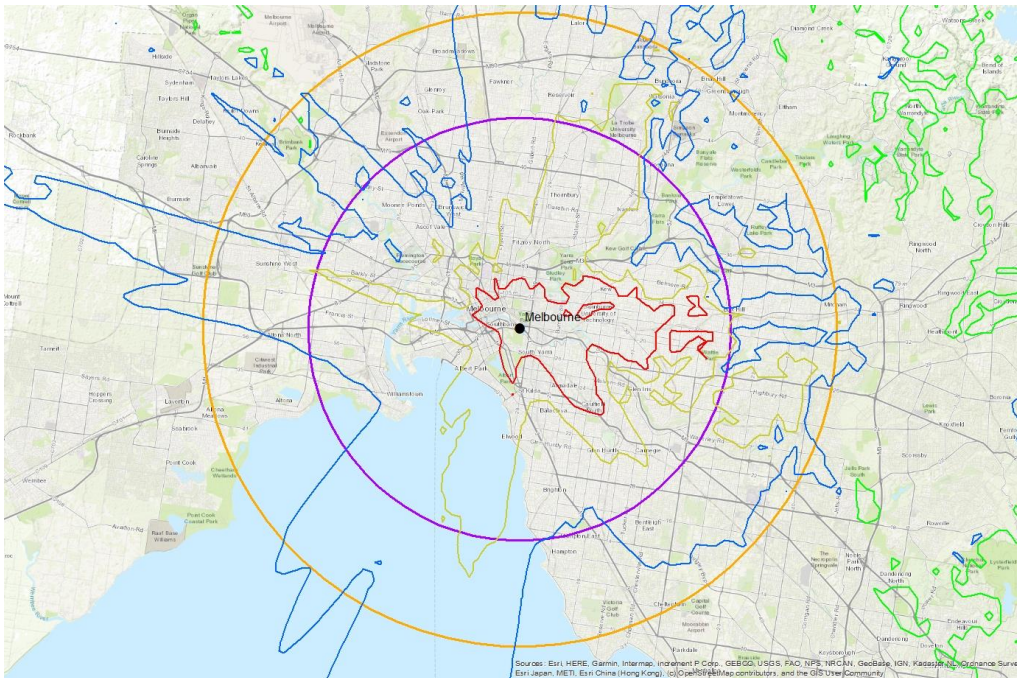
**Propagation model and terrain**

The study was completed using:

- > *Visualyse Professional 7.9.7.9* with three-second DEM from the Shuttle Radar Topography Mission (SRTM).
- > Propagation model ITU-R P.452-16 with long term protection criteria ( $p_0=50\%$ ).

While the use of detailed clutter information may also help to improve the accuracy of the impact between wireless broadband services and TOB receivers, the ACMA does not have access to reliable information to accurately model clutter. 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 mitigation measures (such as lower antenna height, increased antenna tilt, lower transmit power etc) contours have been included to model 20 dB of extra loss.

**Figure 7: Wireless broadband base station interference to TOB receivers**



**Table 13: Plot legend—threshold values shown in plot**

Threshold	Value	Colour
Interference threshold with 100 m link with 20 dB clutter	-100.4 dBW/MHz	Red
Interference threshold with 100 m link	-120.4 dBW/MHz	Yellow
Interference threshold with 200 m link	-126.4 dBW/MHz	Blue
Interference threshold	-147.3 dBW/MHz	Green
Circle 12 km – 100 m link – Median BS EIRP	Modified Hata	Purple
Circle 18 km – 200 m link – Median BS EIRP	Modified Hata	Orange

## Results

The wireless broadband base station transmit interference into TOB receivers is shown in Figure 7. Table 13 provides the legend describing the different contours and colours. The inner 12 km circle (purple) is the modified Hata impact area and is the best-case protection zone for a 100 m TOB link against a wireless broadband base station transmitter with a median EIRP (23dBW/MHz). The red contour is the predicted protection zone for the same TOB link scenario with 20 dB of clutter added. The yellow contour is the same scenario without any clutter loss. This analysis shows that a protection zone greater than 12 km is required around a TOB receiver from any wireless broadband base station transmitter with a median EIRP.

The required protection zone is most likely to lie between the yellow and blue contours around 15km. The Blue contour shown in Figure 7 outlines the protection zone for a 200 m TOB link when impacted by a wireless broadband base station transmitter with a median EIRP (23dBW/MHz). This contour comes close to the 18 km orange circle which identifies the protection zone required using the modified Hata model for a wireless broadband base station transmitter with a medium EIRP (23dBW/MHz).

This study shows that the required TOB protection zone is likely to be greater than 12 km in the Melbourne environment when looking at existing TOB licences.



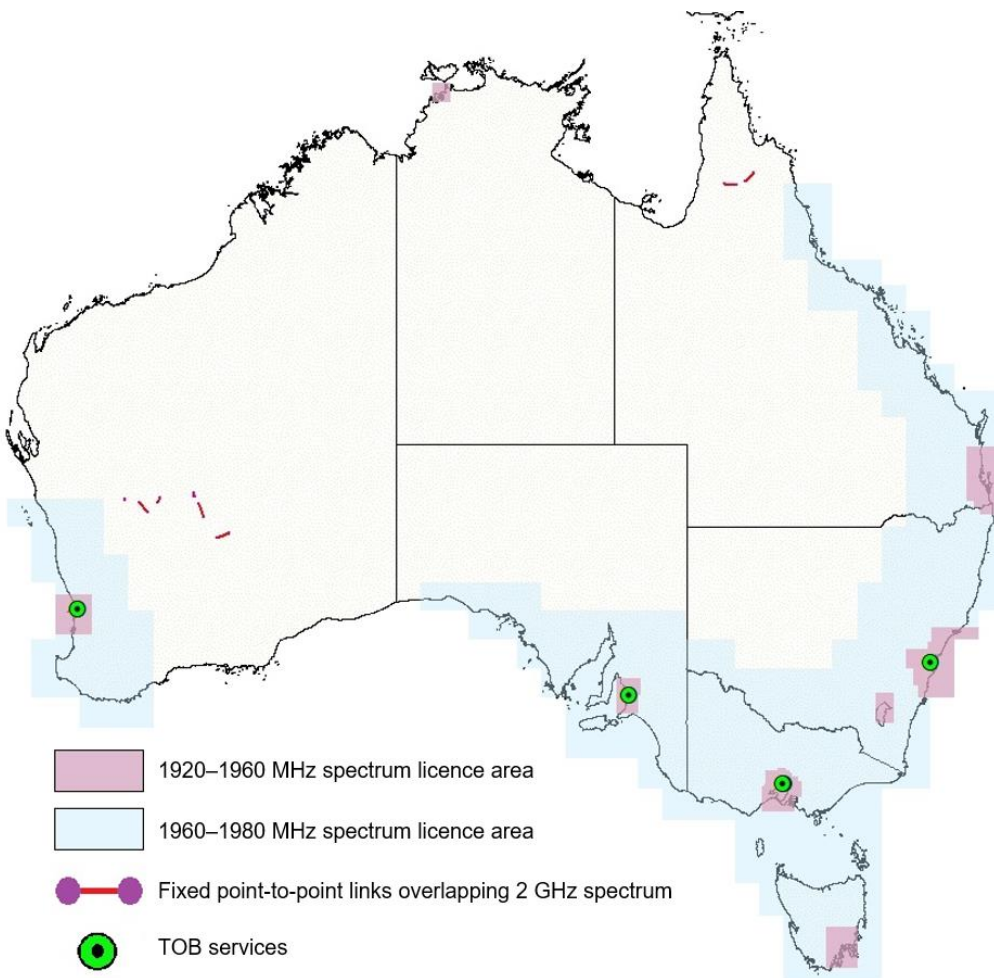
# Appendix F: Geographical area descriptions

The ACMA has defined geographical areas to assist in the analysis of replanning of the 2 GHz band. These areas are displayed below and show the following:

- > 1920–1980 MHz spectrum licence area (SLA) in capital cities.
- > 1960–1980 MHz SLA in regional areas.
- > Fixed point-to-point links for which part of the bandwidth overlaps the 2 GHz spectrum.
- > The location of TOB services, noting more than one TOB service may exist per point.

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](#).

**Figure 8: Geographical area descriptions**



The HCIS coordinates for the 1920 to 1960 MHz and 1960 to 1980 MHz SLA are listed in the table below and can be converted into a Placemark file (viewable in Google Earth) through a facility on the [ACMA website](#).

**Table 14: HCIS description of areas**

Spectrum licence area frequency range	Area name	HCIS
1920–1960 MHz	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, NT5G, NT5H, NT5K, NT5L, NT5O, NT5P, NT6E, NT6F, NT6G, NT6H, NT6I, NT6J, NT6K, NT6L, NT6M, NT6N, NT6O, NT6P, NT8C, NT8D, NT8G, NT8H, NT8K, NT8L, NT8O, NT8P, NU3A, NU3B, NU3C, NU3D, NU3F, NU3G, NU3H, NT5C4, NT5C5, NT5C6, NT5C7, NT5C8, NT5C9, NT5D4, NT5D5, NT5D6, NT5D7, NT5D8, NT5D9, NT6A4, NT6A5, NT6A6, NT6A7, NT6A8, NT6A9, NT6B4, NT6B5, NT6B6, NT6B7, NT6B8, NT6B9, NT6C4, NT6C5, NT6C6, NT6C7, NT6C8, NT6C9, NT6D4, NT6D5, NT6D6, NT6D7, NT6D8, NT6D9, 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
	Darwin	GO7C, GO7D, GO7G, GO7H, GO7K, GO7L, GO8A, GO8E, GO8I
	Hobart	LY8L, LY8P, LY9I, LY9J, LY9K, LY9L, LY9M, LY9N, LY9O, LY9P, LZ2D, LZ2H, LZ3A, LZ3B, LZ3C, LZ3D, LZ3E, LZ3F, LZ3G, LZ3H, LY8H4, LY8H5, LY8H6, LY8H7, LY8H8, LY8H9, LY9E4, LY9E5, LY9E6, LY9E7, LY9E8, LY9E9, LY9F4, LY9F5, LY9F6, LY9F7, LY9F8, LY9F9, LY9G4, LY9G5, LY9G6, LY9G7, LY9G8, LY9G9, LY9H4, LY9H5, LY9H6, LY9H7, LY9H8, LY9H9, LZ2L1, LZ2L2, LZ2L3, LZ3I1, LZ3I2, LZ3I3, LZ3J1, LZ3J2, LZ3J3, LZ3K1, LZ3K2, LZ3K3, LZ3L1, LZ3L2, LZ3L3
	Melbourne	KX3J, KX3K, KX3L, KX3N, KX3O, KX3P, KX6B, KX6C, KX6D, KX6F, KX6G, KX6H, KX6J, KX6K, KX6L, LX1I, LX1M, LX1N, LX1O, LX4A, LX4B, LX4C, LX4E, LX4I, KX3F7, KX3F8, KX3F9, KX3G7, KX3G8, KX3G9, KX3H4, KX3H5, KX3H6, KX3H7, KX3H8, KX3H9, KX3M6, KX3M8, KX3M9, KX6A2, KX6A3, KX6A5, KX6A6, KX6A8, KX6A9, KX6E2, KX6E3, KX6E5, KX6E6, KX6E8, KX6E9, KX6I2, KX6I3, KX6I5, KX6I6, KX6I8, KX6I9, 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

Spectrum licence area frequency range	Area name	HCIS
	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	NW1, MV9I, MV9J, MV9K, MV9L, MV9M, MV9N, MV9O, MV9P, MW3C, MW3D, MW3G, MW3H, MW3K, MW3L, MW3O, MW3P, NV4N, NV4O, NV4P, NV5M, NV5N, NV5O, NV5P, NV7B, NV7C, NV7D, NV7E, NV7F, NV7G, NV7H, NV7I, NV7J, NV7K, NV7L, NV7M, NV7N, NV7O, NV7P, 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, NV4I5, NV4I6, NV4I8, NV4I9, 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
1960-1980 MHz	West coast	BV, AU2, AU3, AU6, AU9, AV9, AW3, BU1, BU2, BU4, BU5, BU7, BU8, BU9, BW1, BW2, BW3, BW5, BW6, CV4, CV7, CW1, CW4
	South and east coast	IW, JW, KW, LW, LX, LY, MV, MW, NT, NU, GV1, GV2, GV3, GV6, HV1, HV2, HV4, HV5, HV6, HV8, HV9, HW3, IV4, IV5, IV6, IV7, IV8, IV9, JV4, JV5, JV7, JV8, JV9, JX1, JX2, JX3, JX5, JX6, KV7, KX1, KX2, KX3, KX4, KX5, KX6, KX8, KX9, KY2, KY3, KY6, LQ1, LQ2, LQ4, LQ5, LQ7, LQ8, LR2, LR3, LR5, LR6, LV9, LZ1, LZ2, LZ3, MR1, MR4, MR5, MR7, MR8, MR9, MS1, MS2, MS3, MS4, MS5, MS6, MS8, MS9, MT3, MT6, MT9, MU3, MU5, MU6, MU8, MU9, MX1, MX2, MX3, MX4, MX7, MY1, MY4, MY7, MZ1, NS4, NS7, NS8, NS9, NV1, NV2, NV3, NV4, NV5, NV7, NW1, GO7C, GO7D, GO7G, GO7H, GO7K, GO7L, GO8A, GO8E, GO8I

# Appendix G: Cost-benefit analysis

This cost-benefit analysis (CBA) identifies relevant cost and benefit inputs likely to arise under each 2 GHz 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 *Radiocommunications Act 1992* (the Act). Detail on the CBA methodology can be found in the [Cost-benefit analysis methodology](#) section at the end of this appendix.

There are three replanning options currently proposed for the 2 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 of the interim television outside broadcast (TOB) service arrangements, 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 cost estimates and methodology common across options assists in identifying the relative costs difference between options. The ACMA welcomes any information regarding cost or benefit inputs that may provide further insight for the analysis.

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: TOB with Internet of Things (IoT).
- > Option 2: Wireless broadband.
- > Option 3: Mobile-satellite service (MSS) complementary ground component and satellite IoT.

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

- > Option 1: expected to only generate a small net benefit compared with the status quo, resulting from access to satellite IoT in 2 x 5 MHz on a shared basis (as is the case under all options) and added certainty for TOB users.
- > Option 2: expected to be highly net beneficial as wide-area wireless broadband users have placed a strong demonstrated value on equivalent spectrum that significantly exceeds the costs of displacing TOB services, while there is also some spectrum made available to local-area wireless users in regional and remote areas.
- > Option 3: expected to be highly net beneficial as the utilisation of complementary ground component by MSS users could allow for the dual benefits of MSS and wireless broadband, with different services being deployed based on what is most economically beneficial in each geographic area. This is considered the option most likely to maximise net benefit as the market can determine whether MSS or wireless broadband use is most beneficial.

While this CBA has resulted in Option 3 being considered the option most likely to maximise net benefit, the CBA is only one element of a broader, integrated replanning analysis. Replanning decisions will involve consideration of the CBA alongside other elements of analysis identified within this options paper.

## Cost-benefit inputs for each option

The following analysis outlines all the potential cost or benefit inputs that would result under each proposed option. Each of the cost and benefit inputs are compared with current arrangements in the 2 GHz band—that is, the interim TOB band plan.

Following the discussion of cost and benefit inputs, the ‘Option comparison’ section provides an analysis comparing each option and determining the option that is most likely to maximise the net benefit associated with replanning.

The following factors should be considered for all options:

- > Legacy fixed links located in remote areas are not required to vacate the band under any option, as is the case under the current interim TOB band plan. As such, no costs associated with fixed links need to be considered in this analysis.
- > Low-powered, low-duty-cycle satellite IoT is supported on a shared basis in 2 x 5 MHz of restricted spectrum, although the frequency position of this spectrum changes depending on the option. While it is discussed in Option 1, it is available under all options and therefore not a point of comparison between different options.

### Option 1: TOB with Internet of Things (IoT)

Option 1 largely retains the status quo, converting the interim TOB arrangements into ongoing arrangements. This option provides an added benefit compared with the status quo, as the current restricted band (1980–1985/2170–2175 MHz) between TOB and adjacent band wireless broadband (2 GHz band spectrum licensing) would be considered for use by Australia-wide satellite Internet of Things (IoT) applications. IoT use would be on a shared basis, exploiting the low-duty-cycle, low-power nature of such systems.

#### **Option 1: Cost inputs**

There is no change to the arrangements for TOB, which are the only current users of the band. There are therefore no cost inputs for Option 1.

#### **Option 1: Benefit inputs**

The benefit inputs in Option 1 result from the introduction of Australia-wide IoT applications in 1980–1985/2170–2175 MHz (10 MHz in total) and added certainty of tenure for TOB licensees.

#### Satellite IoT

The key benefit of Option 1 comes from the introduction of Australia-wide IoT applications in 1980–1985/2170–2175 MHz (2 x 5 MHz or 10 MHz in total). It is noted that support for satellite IoT in 10 MHz of bandwidth on a shared basis is a constant among all available replanning options for the 2 GHz band, so the benefits of this use do not need to be assessed when comparing the options. However, the benefits – the level of which the ACMA considers highly uncertain and therefore has not attempted to quantify here – should still be noted as this IoT use represents a change from the status quo. The ACMA welcomes any information or evidence that could assist with quantifying these benefits.

## TOB

Under this option, TOB licensees will be provided longer term certainty in the band as the interim arrangements are converted into ongoing arrangements. The benefit of this option for TOB licensees is isolated to the benefits of additional certainty, as TOB use is otherwise a continuation of the status quo. This may lead to an increase in TOB services, though the ACMA does not expect that to be material. The ACMA welcomes any insight into whether greater certainty may increase TOB use in the band, and the potential economic benefits of this compared with the current interim TOB arrangements.

### **Option 1: Net benefit**

There are zero cost inputs under Option 1, which means the net benefit is equal to the benefit inputs. Due to these economic benefits being unquantifiable, the magnitude of the net benefit for Option 1 is unable to be determined.

**Table 15: Option 1 cost-benefit side-by-side comparison**

Costs	Benefits
N/A	Satellite IoT use on a shared basis in 1980–1985/2170–2175 MHz). This benefit is common to all options being considered.
	Additional certainty of tenure for TOB licensees.

### **Option 2: Wireless broadband**

Option 2 opens up the band for wide-area and local-area wireless broadband use (including direct air to ground communications services) and also provides spectrum for satellite IoT services in the restricted band (guard band) that would protect adjacent band TOB services at higher frequencies.

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

- > TOB would be required to vacate the band.
- > Wide-area wireless broadband services to be supported in capital cities in 1980–2005/2170–2195 MHz, and regional areas in 1980–1995/2170–2185 MHz. Direct air-to-ground communication services would be accommodated under the technical frameworks, leaving the choice of whether to deploy wide-area wireless broadband or direct air-to-ground communications or both to the licensee.
- > Local-area wireless broadband and direct air-to-ground communications supported in 1995–2005/2185–2195 MHz in regional areas and in 1980–2005/2170–2195 MHz in remote areas on a coordinated basis.
- > Low-power, low-duty-cycle satellite IoT supported on a shared basis in 2005–2010/2195–2200 MHz.

### **Option 2: Cost inputs**

The primary cost input under Option 2 is the cost associated with TOB services being cleared from the band. Licensing information indicates that there were 23 wireless camera licences operating in the 2 GHz band as at April 2020. While the band also hosts six short-term licences supporting test and demonstration applications (at April 2020), these are not considered due to the short term and non-renewable nature of the licences.

If equivalent TOB services are able to be maintained using alternative spectrum or alternative delivery means, clearing TOB services from the band would be considered a constant output case. Under this scenario, only the supply cost burden of maintaining service without continued access to the 2 GHz band needs to be considered as output remains equivalent. If TOB services are unable to be maintained in some or all instances, clearing TOB services from the band would be a variable output case as output would be reduced. In this case, the costs would include the impact on producer surplus, consumer surplus and broader social net benefits.

The ACMA has relatively limited information regarding TOB costs. However, it is expected that TOB services would be able to be maintained because there are alternative spectrum options available for TOB use. TOB services would therefore represent constant output cases as it is expected that services can be maintained.

While the ACMA has no current cost information on TOB equipment, we consider that replacing TOB infrastructure would be less expensive than the cost of replacing a fixed point to point link (for example, TOB is unlikely to have the costs associated with the two towers in a fixed point to point link).

In the 3.6 GHz replanning process, the average cost range for equipment replacement for a fixed link system was between \$85,000 and \$100,000.<sup>41</sup> If we consider equipment replacement costs for TOB services to be somewhere between \$50,000 to \$85,000, extrapolating this cost to all licences would result in overall costs between \$1.1m and \$1.9m for TOB to relocate to other bands. The ACMA notes that these costs are estimates, and we would appreciate industry feedback on these estimates.

While TOB services in the 2 GHz band are expected to be constant output cases, there is the potential for TOB services to represent variable output cases, which would occur if equivalent services are unable to be maintained without access to 2 GHz band spectrum. The economic costs of TOB services being unable to be maintained are highly uncertain and we have therefore not attempted to quantify them here. The ACMA welcomes any information that helps outline the economic costs (or forgone benefits) of TOB services being displaced from the band.

### ***Option 2: Benefit inputs***

The main benefit inputs under Option 2 come from the introduction of wireless broadband services (including both wide-area and local-area wireless broadband). While satellite IoT would be located in a different part of the band, the benefits derived from its introduction are considered the same as under Option 1 due to an equal amount of bandwidth being made available.

#### Wide-area wireless broadband

For wide-area wireless broadband in defined areas, the typical method to determine the economic benefits derived from the spectrum is to apply potential valuations of the spectrum (in \$/MHz/pop terms) as a proxy. Previous spectrum prices are often used as a guide in these circumstances, as they reflect a demonstrated willingness to pay that can be considered a baseline for economic benefits.

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<sup>41</sup> 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 point-to-point costs is on p41-43.

It should be noted that wide-area wireless broadband services already have access to the following amounts of bandwidth in similar spectrum:

- > **1800 MHz band:** 2 x 75 MHz (or 150 MHz) in metro and regional areas (note: 2 x 10 MHz or 2 x 15 MHz is used by rail services in the five major capital cities)
- > **2 GHz band:** 2 x 60 MHz (or 120 MHz) in metro areas and 2 x 20 MHz (or 40 MHz) in regional areas
- > **2.3 GHz band:** 98 MHz of unpaired spectrum in metro and regional areas, with some minor exceptions
- > **2.5 GHz band:** 2 x 70 MHz (or 140 MHz) Australia-wide.

In the context of the above wide-area wireless broadband holdings and further mid-band holdings in 3.4–3.7 GHz, the availability of an additional 2 x 25 MHz represents a minor incremental increase. The ACMA expects that there are likely to be diminishing returns to this additional equivalent spectrum, which would result in a lower value being placed on this 2 x 25 MHz than, for instance, what has previously been placed on the 2 x 60 MHz of adjacent spectrum in the 2 GHz band already available to wide-area wireless broadband.

Key reference points for the value of the spectrum to wide-area wireless broadband users are:

- > Reissue price for the abovementioned portion of the 2 GHz band (1920–1980/2110–2170 MHz, 2 x 60 MHz or 120 MHz in total) as part of the expiring spectrum licence (ESL) reissue process. Spectrum licences with a 15-year duration were reissued at a price of \$0.625/MHz/pop. The willingness of licensees to pay that amount indicates that the value of the spectrum is equivalent to that price at a minimum for the geographic areas in which these licences were located—typically in capital cities and broader regional areas, but not remote areas.
- > Digital dividend auction price for 2.5 GHz band (2500–2570/2620–2690 MHz, 2 x 70 MHz or 140 MHz in total) spectrum. While the combinatorial clock auction format used for this auction means exact prices for 2.5 GHz band are unable to be calculated, it is estimated the price paid for 2.5 GHz spectrum was only slightly greater than the reserve price of \$0.03/MHz/pop. This can be inferred as total revenue from the auction only marginally exceeded the revenue that would have been generated if all spectrum that was sold across the two available bands went at the respective reserve price of each band. This marginal additional revenue was the combined result of prices paid in the assignment stage and the 2.5 GHz band price slightly exceeding the \$0.03/MHz/pop reserve price.

Considering the 2 GHz band spectrum available for wide-area wireless broadband under this option is contiguous with the spectrum reissued for \$0.625/MHz/pop, this higher price is expected to be a closer estimate of its economic value than the Digital Dividend price for the 2.5 GHz band of just over \$0.03/MHz/pop. As previously stated, however, the additional spectrum only represents a marginal increase in spectrum availability for wide-area wireless broadband and there is a strong possibility that the incremental \$/MHz/pop value placed on this spectrum would be lower than the value of existing spectrum holdings.



**Table 16: Wide-area wireless broadband—estimated benefits for different \$/MHz/pop values**

Category	Affected population	\$/MHz/pop	Total benefit
Wide-area wireless broadband in metro areas (2 x 25 MHz)	19.2 million	\$0.03	\$28.7 million
		\$0.625	\$598.5 million
Wide-area wireless broadband in regional areas (2 x 15 MHz)	5.3 million	\$0.03	\$4.7 million
		\$0.625	\$98.0 million

*Note: The affected population includes forecasts for June 2020 based on the areas outlined in Appendix F: Geographical area descriptions. Metro areas refer to the 1920–1960 MHz SLA in Appendix F, while regional areas refer to the 1960–1980 MHz SLA with the metro areas excluded. The June 2020 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. Population and total benefit have been rounded to the nearest 100,000.*

Direct air-to-ground communications is also a possible complementary service under this option. However, the viability of this application is uncertain in Australia and the benefits of having this optionality are incorporated in the benefits of wide-area wireless broadband services. As such, it is not discussed in additional detail as a benefit input.

#### Local-area wireless broadband

Different reference points are required to help determine the economic benefits of reallocating the band for local-area wireless broadband in regional and remote areas. The ACMA considers the best example of a demonstrated willingness to pay for equivalent spectrum are ESL reissue prices for 2.3 GHz and 3.4 GHz spectrum licences. The reissue price for these licences was \$0.03/MHz/pop. Some of these spectrum licences were exclusively in regional and/or remote areas, and a common use case for these licences in regional and remote areas has been local-area wireless broadband. This price is therefore considered to represent an approximate floor on the willingness to pay for this spectrum for local-area wireless broadband.

This option provides access to local-area wireless broadband in 1995–2005/2185–2195 MHz (2 x 10 MHz or 20 MHz in total) in regional areas and in 1980–2005/2170–2195 MHz (2 x 25 MHz or 50 MHz in total) in remote areas. For simplicity, the valuation of \$0.03/MHz/pop has been applied to all available spectrum in the respective geographic area categories.

**Table 17: Local-area wireless broadband—estimated benefits under Option 2**

Category	Affected population	\$/MHz/pop	Total benefit
Local-area wireless broadband in regional areas (2 x 10 MHz)	5.3 million	\$0.03	\$3.1 million
Local-area wireless broadband in remote areas (2 x 25 MHz)	0.45 million	\$0.03	\$0.68 million

*Note: Similar to the previous table, the affected population includes forecasts for June 2020 based on the areas outlined in Appendix F: Geographical area descriptions. The affected population of remote areas refers to the total population of Australia residing outside of metro and regional areas, with the method of forecasting June 2020 population being the same as the previous table. Due to relatively small numbers, the remote area population and total benefit have been rounded to the nearest 10,000 for added detail.*

There are some uncertainties involved in applying a uniform \$/MHz/pop value to spectrum in regional and remote areas. The key issue is that local-area wireless broadband services are not as broad-based as wide-area wireless broadband by definition and therefore would not be covering the entirety of the population in these areas, which means a population measure may not be as appropriate for local-area wireless broadband. However, there may be a greater value placed on the population in geographic areas where local-area wireless broadband services actually operate, as they can target these areas and avoid other unprofitable areas. These contrasting effects mean that the ACMA considers \$0.03/MHz/pop can be used as a guide to the average value of the spectrum to potential local-area wireless broadband users but note there are significant uncertainties surrounding this valuation and how it would be distributed across the population.

**Option 2: Net benefit**

Option 2 is considered net beneficial as it is highly likely that the benefits associated with wide-area wireless broadband and local-area wireless broadband gaining access to the band will exceed the costs of TOB services losing access to the band – irrespective of whether TOB services represent a constant or variable output case. A summarised view of the cost and benefit inputs is outlined in the table below.

**Table 18: Option 2 cost-benefit side-by-side comparison**

Costs	Benefits
TOB services lose access to the band: <b>approximately \$1.1 million–\$1.9 million</b> , based on the uncertain cost range of \$50,000–\$85,000 per TOB licence.	Wide-area wireless broadband: <b>approximately \$33.4 million–\$696.5 million</b> , based on a valuation range of \$0.03/MHz/pop–\$0.625/MHz/pop.
	Local-area wireless broadband: <b>approximately \$3.8 million</b> , based on a value of \$0.03/MHz/pop in regional and remote areas.

### **Option 3: Mobile satellite (including complementary ground component and satellite IoT)**

Option 3 accommodates new MSS (including satellite IoT and complementary ground component) users and provides spectrum dedicated for satellite IoT services Australia-wide in the restricted band (guard band) protecting adjacent band TOB services.

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

- > TOB would be required to vacate the band.
- > MSS (including satellite IoT and complementary ground component) would gain exclusive access to the band in 1980–2005/2170–2195 MHz.
- > Low-power, low-duty-cycle satellite IoT supported on a shared basis in 2005–2010/2195–2200 MHz.

#### ***Option 3: Cost inputs***

The cost inputs for Option 3 are equivalent to Option 2, in that TOB services would be cleared from the band. Refer to 'Option 2: Cost inputs' for further detail.

#### ***Option 3: Benefit inputs***

The main benefit inputs under Option 3 come from the introduction of MSS (including satellite IoT and complementary ground component). The benefit from the introduction of IoT is considered the same as under Option 1.

#### **MSS (including satellite IoT and complementary ground component)**

The ACMA considers that the quantitative benefits of MSS (including the option of utilising complementary ground component) are highly uncertain and welcomes the submission of any information or data points that could help illustrate these quantitative benefits. This section therefore relies on a qualitative assessment of benefits for MSS (including complementary ground component) in comparison to wide-area wireless broadband use, as providing MSS operators with the option of utilising complementary ground component. In effect, this allows MSS to be supplemented by wide-area wireless broadband services in high-demand areas where greater capacity is required, such as capital cities.

The potential for users to deploy either MSS or complementary ground component (similar to wide-area wireless broadband) or both, depending on which is most suited in each geographic area, means that Option 3 may provide for a market-led determination of the most economically beneficial use in each geographic area. In geographic areas where wide-area wireless broadband is more beneficial than MSS, there is the potential for MSS operators to utilise complementary ground component services and derive similar economic benefits from the spectrum as Option 2. In addition, in geographic areas where MSS is more beneficial than wide-area wireless broadband (for example, remote areas), the same operators can deploy MSS and thus generate more economic benefits than Option 2.

It is noted that the actual benefits derived from the 2 GHz band by MSS use may depend on the licensing framework implemented following a replanning decision. In particular, we note that spectrum licensing may not be the optimal licensing framework for MSS use, and that this deviates from the basis for \$/MHz/pop benefit approximations in this CBA (under Option 2 for wide-area wireless broadband and logically under Option 3 where complementary ground component has been compared with wide-area wireless broadband). At this stage, the ACMA considers it to be prudent to assess the potential benefits of each option irrespective of the licensing framework that may be applied, so the impact of different licensing arrangements has not been analysed in this CBA.

**Option 3: Net benefit**

Option 3 is considered net beneficial as the economic benefits of providing MSS users access to the 2 GHz band are projected to be greater than the costs associated with clearance of TOB services. The position of Option 3 in comparison with Option 2 therefore hinges on whether MSS (including satellite IoT and complementary ground component) is more beneficial than a combination of wide-area and local-area wireless broadband. These comparisons will be considered further in the following *Option comparison* section of this CBA.

**Table 19: Option 3 cost-benefit side-by-side comparison**

Costs	Benefits
<p>TOB services lose access to the band: <b>approximately \$1.1 million–\$1.9 million</b>, based on the uncertain cost range of \$50,000–\$85,000 per TOB licence.</p>	<p>MSS (including complementary ground component) considered to potentially derive benefits greater than Option 2 wide-area wireless broadband benefits, as complementary ground component can provide similar benefits to wide-area wireless broadband in geographic areas where this use is most beneficial, while MSS can provide greater benefits than wide-area wireless broadband in other areas.</p>

**Option comparison**

Each replanning option for the 2 GHz band contains various unquantifiable cost-benefit inputs, and there is also uncertainty in the quantifiable inputs. This means that determining the optimal replanning option from a cost-benefit perspective is also partly uncertain, although there are some robust qualitative cases for particular options.

The only departures from the status quo for Option 1 in terms of cost and benefit inputs are access to 2 x 5 MHz for satellite IoT (which is available under all options so is not a point of difference in this comparison) and added certainty for TOB users. The ACMA considers that the minor net benefit exclusively available in Option 1 is likely to be exceeded by the net benefit of replanning the band for a new use, as occurs under Options 2 and 3.

With Option 1 removed from consideration as the option most likely to maximise net benefit, the key issue for comparing the remaining options is whether local-area or wide-area wireless broadband or MSS (including complementary ground component) will be more beneficial (that is, comparing Options 2 and 3). Resolving this issue, based on the CBA approach, will help determine the option likely to be most net beneficial after accounting for all cost and benefit inputs.

**Benefit comparison of wireless broadband and MSS**

The comparison between wireless broadband and MSS was outlined in the *Option 3: Benefit inputs* section. The optionality afforded by MSS in enabling MSS operators to deploy complementary ground component, which if implemented could be generally equivalent to a wide-area wireless broadband service, would allow for the market to determine whether wireless broadband or MSS would be able to derive greater economic benefit from the spectrum. This may vary between different geographic areas – while Option 2 would only allow for wide-area or local-area wireless broadband in different geographic areas, Option 3 could theoretically allow for MSS or wireless broadband depending on whether the geographic area suits either use.

The 2 x 25 MHz of spectrum is also likely to represent high marginal benefit if allocated to MSS (which has 113.7 MHz of spectrum between 1–6 GHz). The 2 x 25 MHz of spectrum may exhibit more acute diminishing marginal value for wide-area wireless broadband since there is a substantial amount of equivalent spectrum already available for wide-area wireless broadband between the 1800 MHz band and the 2.5 GHz band, as outlined under 'Option 2: Benefit inputs' in this appendix.

The ACMA therefore considers that Option 3 is more likely to maximise net benefit than Option 2, although it has been noted that the potential benefits derived may depend on the licensing framework imposed on the band.

## **Summary**

The above analysis results in the following summarised CBA results:

- > Option 1: expected to only generate a small net benefit compared with the status quo, resulting from access to satellite IoT in 2 x 5 MHz on a shared basis (as is the case under all options) and added certainty for TOB users.
- > Option 2: expected to be highly net beneficial as wide-area wireless broadband users have placed a strong demonstrated value on equivalent spectrum that significantly exceeds the costs of displacing TOB services, while there is also some spectrum made available to local-area wireless broadband users in regional and remote areas.
- > Option 3: expected to be highly net beneficial as the utilisation of complementary ground component by MSS users could allow for the dual benefits of MSS and wireless broadband, with different services being deployed based on what is most economically beneficial in each geographic area. This is considered the option most likely to maximise net benefit as the market can determine whether MSS or wireless broadband use is most beneficial.

## 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 by measuring 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 the 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 appendix 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.