Towards 2020—Future spectrum requirements for mobile broadband

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Executive summary

There is widespread recognition that mobile broadband services are an economic enabler within society and the provision of these services, technologies and applications in the wider community is in the public interest. The expectation of end users for access to services exhibiting increased speed and data allowance puts pressure on network operators in meeting demand and leads to requests from operators for access to greater amounts of spectrum.

Making spectrum available to meet the future requirements of mobile broadband services is complex as prime spectrum for mobile broadband services is also heavily utilised by other services and is a scarce resource. Communications regulators must consider the impact on existing spectrum management arrangements and incumbent users when making further spectrum available. Some of the issues to be taken into account include:

> determining when the effect of making spectrum available for mobile broadband services is no longer the highest value use as this may preclude other uses of the spectrum with inherent public benefit
> considering whether greater spectral efficiency can be achieved by network operators in existing spectrum holdings
> considering whether the needs of incumbent users of spectrum can be balanced with the future spectrum requirements for mobile broadband services.

International regulators are looking to ensure that sufficient harmonised spectrum is made available for mobile broadband services. Some international communications regulators have determined that up to 500 MHz of spectrum beyond that already available may be required to meet the demand for mobile broadband services by 2015. While the ACMA is not able to release all bands recognised internationally due to different domestic use, it has continued to plan and release additional spectrum to meet the demands for mobile broadband services as the need arises in the Australian context taking into account the need to harmonise arrangements at the regional and global level where possible.

The ACMA began its dialogue with stakeholders on future spectrum requirements in Australia in its consultation process on wireless access services (WAS) in 2006. The consultation process was completed in 2008 and identified the 2.5 GHz and 3.6 GHz as bands that could be made available for WAS in the short to medium term. The WAS consultation process also considered the dividend that would become available as a result of the transition to digital television; however, analysis and planning for the 700 MHz band was undertaken separately.

As indicated in the Five-year spectrum outlook 2011–2015, a key ACMA spectrum management priority is the mobile broadband project. The project is intended to continue a dialogue with stakeholders on issues including the future spectrum requirements for mobile broadband services and the needs of incumbent spectrum users.

Analysis undertaken by the ACMA and presented at the RadComms2010 conference identified a shortfall of approximately 150 MHz of spectrum which will be required to meet demand for mobile broadband services out to 2015; however, any estimation of spectrum requirements beyond this timeframe is notional.
The ACMA expects that the demand for spectrum to support mobile broadband services will increase over time in response to the increased proliferation of machine to machine (M2M) interactions but that the level of spectrum demand from portable screens will flatten or plateau. Significant and continuing advances in the spectrum efficiency offered by mobile broadband technologies, that is its capacity to carry data, have occurred since 2005 and these advances are expected to continue until at least 2020. The ACMA also expects industry to deploy infrastructure more extensively in order to ease the pressure on spectrum.

The ACMA has undertaken further analysis of spectrum demand out to 2020. The assumptions for this analysis were complex, looking at a combination of coding efficiencies, additional infrastructure and fixed-to-mobile convergence whereby data is offloaded from the mobile network using very small ‘WiFi’ like cells.

From this analysis, the ACMA estimates that an additional 150 MHz of spectrum will be required by 2020. This estimate takes into account the 800 MHz of spectrum already dedicated for operation by mobile communications services; and includes the 150 MHz previously identified by the ACMA as being required by 2015.

Delivering on this estimation would ensure that approximately 1100 MHz of spectrum is available in the Australian communications environment to support mobile broadband services by 2020. However, it is the issue of identifying which frequency bands and how the spectrum may be made available for use by future mobile broadband services that will take time and careful consideration. This is particularly the case where possible frequency bands have other, important existing uses or users. It is also important for mobile operators to consider what techniques could be deployed in their existing and proposed network architecture to achieve greater spectral efficiencies.

This paper details the existing mobile broadband environment in Australia and the ACMA’s analysis of the quantum of spectrum required to meet that demand. The paper looks at those bands and services below 6 GHz that could be made available for mobile broadband and invites interested stakeholders to comment on these. The paper also invites stakeholders to consider options for mobile broadband beyond 6 GHz and the potential for these bands to be used for in-home and personal communications services.

Concurrently released with this paper is a second paper, The 900 MHz Band: Exploring new opportunities, that examines options to replan the 820–960 MHz band (known as the 900 MHz band) to improve its utility and potentially make additional spectrum available in the medium term for mobile broadband services. The paper considers possible re-planning activities for the band including ‘refarming’ the digital cellular mobile telephony service segments (890–915 MHz paired with 935–960 MHz), currently planned for GSM technologies, to better facilitate 3G and 4G technologies and provides analysis on the potential for the 850 MHz ‘expansion’ band to be made available for future mobile broadband services. Given the concurrent release of this paper, the 900 MHz band is not considered in this paper. This is also the case for those frequency bands already under review or development including the 2.5 GHz and 700 MHz bands.

The submissions and comments received from stakeholders in relation to the issues raised in this paper will assist the ACMA in developing a forward work plan that will focus on particular frequency bands and associated planning and regulatory issues. The ACMA will consult on the proposed work plan at a later date.

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1. Introduction

Since the introduction of the analogue mobile phone service in Australia in the late 1980s, the Australian Communications and Media Authority (the ACMA) has continued to make spectrum available for mobile communications services as the demand for these services increases. As mobile services evolved to digital standards in the mid-1990s to include packet data services, the use of mobile technologies has broadened to include a range of other services and applications, including data.

In February 2006, the ACMA began a dialogue with stakeholders in its consultation process on wireless access services (WAS). The purpose of the first paper was to stimulate discussion and solicit information from stakeholders that would allow the ACMA to gauge the demand for future WAS and the associated spectrum support requirements. In December 2006, the ACMA released the second discussion paper titled Strategies for wireless access services: Spectrum access options. The purpose of this paper was to identify bands that the ACMA believed were the most suitable candidates for WAS in the short, medium and long term and seek comments on the identified bands, including some high-level options for band segmentation and licensing.

In 2007, there was up to 380 MHz of spectrum in use in some geographic areas capable of providing telephony services; much of this spectrum also offered the ability to support mobile broadband applications. The available bands included the 850/900 MHz, 1800 MHz and 2 GHz bands that had been apparatus or spectrum licensed up to this time. The WAS consultation process identified a need for more spectrum, and as a result, the 2.5 GHz and 3.6 GHz were identified as bands that could be made available for WAS in the short to medium term.

The WAS consultation process also considered the dividend that would become available as a result of the transition to digital television; however, at the time of the release of the paper, the government had not decided if or when a dividend would be released. The government subsequently announced that 126 MHz of the 520–820 MHz UHF broadcasting band would be made available for delivering wireless communications services, including mobile broadband. The ACMA has commenced a review of the use of the digital dividend releasing a discussion paper providing both a roadmap setting out the ACMA’s planned process for reallocation of the digital dividend and the key issues that will shape the configuration and allocation of the band.

Stakeholder demand for access to spectrum is increasing as the level of government, business and consumer access to ubiquitous high speed information gains greater momentum at both the domestic and international level. The demand and need for spectrum to support evolving International Mobile Telecommunications (IMT) services up to the year 2020 has been forecast by a number of organisations, including the International Telecommunication Union Radiocommunications sector (ITU-R). The demand for spectrum is based on the trend for new and emerging technologies to provide greater data capability for mobile broadband and similar services. This trend

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has subsequent implications for how spectrum is planned and utilised at the national level. New and emerging technologies offer improved data rates and spectral efficiency; however, the success of these new and emerging technologies will largely depend on the availability of spectrum.

Spectrum capacity is also under pressure from the rapid expansion of mobile data applications. Smartphones and tablets have been a significant catalyst for this change, with applications becoming increasingly prevalent. For example, Telstra released a statement claiming that consumer use of smartphones and tablets to access social networking sites accounts for a significant portion of mobile data activity. Telstra’s analysis of consumer behaviour over a 12 month period found that the number of consumers accessing Facebook on their mobile devices increased by 390 per cent. The number of people accessing Twitter grew 450 per cent, and visits to MySpace increased by 230 per cent in the 12 month period analysed.

A range of other ubiquitous multimedia devices including e-book readers, tablet devices, game consoles, mp3 players, cameras and remote healthcare monitoring devices are placing additional demands on spectrum capacity in the medium to long term. However, the future applications that will derive their data from mobile services are unknown, but it is likely that this pressure will continue to increase as new technologies appear over time. Therefore, it is important to consider the context in which the demand for mobile broadband is occurring.

There are a number of national projects underway that focus on building and extending national infrastructure, including the National Broadband Network (NBN) and initiatives associated with smart infrastructure. Systems such as the NBN will be capable of providing significant data capacity and will mostly likely increase the demand and use of new data intensive services and applications. It has been argued by some that the NBN will reduce the need for mobile broadband services; however, the use of fibre and wireless platforms for the delivery of broadband should be considered complementary with each suitable for different circumstances and addressing different user requirements.

The main differences between the NBN and mobile broadband platforms are the bandwidth and mobility that can be provided to the end users. A fibre network is capable of delivering very high data rates or bandwidth intensive services while wireless can provide high mobility but at potentially lower data rates depending on network loads. In addition, it is likely that the NBN will assist in the provision of wireless broadband services by enabling high bandwidth backhaul connectivity within the fibre footprint in areas which may previously have been underserved.

There is also increased recognition from government agencies for spectrum to be allocated to meet the national mobile data requirements of police and other emergency services, whether on dedicated or existing commercial networks. What these projects have in common is the need for spectrum; however, the availability and quantum of spectrum remain unresolved.

This puts the ACMA in a complex position; despite the use of improved spectrum utilisation techniques or new technologies, it is likely that more spectrum will need to be made available to meet increasing demand for mobile broadband. This demand will also need to take into account the spectrum requirements of emerging technologies and applications; and also fulfil the legislative expectation to ensure that spectrum is allocated to its highest value use and is used efficiently. To this end, the ACMA is continuously reviewing spectrum trends to ensure that spectrum use delivers

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maximum benefits to industry and the community. Examples of this type of activity are evident in a number of spectrum management initiatives outlined in the recent edition of the *Five-year spectrum outlook 2011–2015*.\(^7\)

Some of the recent work undertaken by the ACMA that has the potential to realise significant public benefit include:

- The review of frequency bands to ensure that existing services are able to migrate to new technologies as they become available. In particular, the ACMA has commenced a review of the 820–960 MHz band (known as the 900 MHz band) and released a discussion paper parallel with this paper.\(^8\)
- The development of a radio quiet zone (RQZ) for deep space research activities in a remote area of Western Australia.
- The ongoing review of existing regulatory and technical arrangements to support the introduction of emerging and new technologies, and other services, such as mobile broadband.

It is not expected that the complex issues surrounding access to spectrum for mobile broadband and emerging technologies, combined with the need to provide certainty to incumbent services, will be identified and resolved by responses to this discussion paper.

It is expected that this paper will facilitate continued dialogue with stakeholders focused on identifying spectrum for mobile broadband, and satisfying the needs of incumbent users. This paper is anticipated to be the first in a series of papers underpinning the ACMA’s project, *Future spectrum requirements for mobile broadband*, flagged at item 4.2.4 in the ACMA’s *Five-year spectrum outlook 2011–2015*.\(^9\)

### 1.1 Purpose

A key purpose of this paper is to identify the baseline spectrum requirements for future mobile broadband services; to consider the needs of incumbent services and to consider strategies that could be deployed to reduce the pressure on other bands. Establishing the baseline for spectrum demand is the focus of Chapter 3, while Chapter 4 focuses on the strategies that could be deployed by network operators to achieve greater efficiencies within existing spectrum holdings.

Where spectrum utilisation strategies have been deployed by operators, yet the level of demand is still unmet, the ACMA will need to consider possible frequency bands that could be made available for future mobile broadband services. Chapter 5 provides an overview of all frequency bands under 6 GHz that have been identified by international regulatory agencies as possible bands for future mobile broadband services. This section also considers options for mobile broadband beyond 6 GHz and the potential for these bands to be used for in-home and personal communications services. The ACMA also has an objective to ensure that the needs of incumbent services operating in any of the possible bands are taken into account.

It is important to note that the ACMA has not made any decisions nor developed any planning arrangements regarding any of the bands included for analysis in Chapter 5.

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The ACMA expects that the submissions to this paper will assist in developing the ACMA’s future spectrum management strategy with particular focus on emerging technologies and mobile broadband services.

A second objective of this paper is to obtain information from stakeholders regarding the impact of emerging technologies and the associated benefits that they offer to the communications environment. The ACMA’s consideration of emerging technologies is not limited by definition. For example, the ACMA intends to consider the benefits offered by cognitive and ultra wide-band technologies, alongside those benefits offered by the use of femtocells and WiFi hotspots in high density areas. These technologies have the potential to offload data capacity in small localised environments thus improving data capacity in existing network architecture, as well as having other as yet unforeseen benefits for future services.

The remainder of this paper looks at a broad range of options to meet the longer term needs of the mobile broadband industry. The ACMA seeks stakeholder comment on any other issues not addressed in this paper that stakeholders believe should be considered in the ACMA’s analysis of future spectrum requirements for mobile broadband services out to 2020.

1. Are there any other issues not addressed in this paper that the ACMA should consider in the context of its analysis of future spectrum requirements for mobile broadband services out to 2020?

1.2 Overview of the mobile broadband project

The ACMA is currently in an information gathering stage and intends to use information collected in this process to inform a spectrum management strategy for mobile broadband, as well as assisting in the consideration of other spectrum management issues generally. The ACMA anticipates that the information will assist the ACMA in developing its future spectrum management policy agenda for mobile broadband issues. To this end, this paper focuses on obtaining information from industry in relation to spectrum planning issues such as:

- the future spectrum requirements of mobile broadband providers
- the identification of potential spectrum bands that could be made available for mobile broadband services
- the potential impact that the introduction of mobile broadband services may have on existing users
- consideration of emerging or new technology and network architecture options that may encourage greater efficiency and spectrum utilisation.

It is likely that information regarding emerging technologies will assist the ACMA in considering issues regarding spectrum utilisation and efficiency generally. Also, similar to the outcomes of the WAS project, it is likely that the submissions that the ACMA receives in response to this paper will assist in determining which frequency bands the ACMA will focus its spectrum planning, policy and allocation activities towards. It is important to recognise that at this point in time, the ACMA has not made any decisions regarding which frequency bands may be included in the forward work plan.

The ACMA will announce and seek comment on its proposed forward work plan via a response to submissions paper early in 2012. The work plan will also be included in future editions of the five-year spectrum outlook. The phases of the mobile broadband project are provided in Figure 1.1. The current status of the project is highlighted by the bold text in the first blue coloured section.
The time frames indicated in Figure 1.1 have had contingency built in to account for ongoing work conducted by the ACMA in relation to other major projects, such as the allocation of the 700 MHz and 2.5 GHz bands, along with considerations of the expiring spectrum licence process. Stakeholders should be aware that the implementation phase could also take some time and, as a result, there is limited interaction between this project and any upcoming spectrum auctions.

**Figure 1.1 Overview of the phases of the mobile broadband project**

- **Information gathering phase (2011)**
  - Release of initial consultation paper (Q2, 2011)
  - Review of submissions (Q3/Q4, 2011)

- **Planning phase (2012)**
  - Develop forward work plan (Q4, 2011)
  - Consult on forward work plan (Q1/2, 2012)
  - Review of submissions (Q3/Q4, 2012)

- **Implementation phase (2013)**
  - Finalise and publish forward work plan (Q1, 2013)
  - Beginning of review process for candidate frequency bands

It should be noted that the information provided in the submissions alone will not determine the ACMA’s view on which frequency bands will be reviewed, and in which timeframe. The ACMA will continue to consider a number of other variables, including the international communications environment, the supply and demand for available spectrum, and the evolution of technology and service developments. These broad considerations are consistent with the spectrum management decision framework that informs the priorities applied to projects detailed in the spectrum outlook. A diagram demonstrating how evidence informs the activities in the five-year spectrum outlook is provided in Figure 1.2.
Figure 1.2 How evidence informs the five-year spectrum outlook and spectrum management activities
The issues discussed in this paper are consistent with the objects of the Radiocommunications Act 1992 (the Act) and informed by analysis against a total welfare standard (TWS) and the Principles for Spectrum Management. The analysis in this paper is based on the premise that considerable public benefit could be derived from the introduction of new technologies, such as those associated with mobile broadband and its many applications.

1.3 Object of the Radiocommunications Act

The Australian Communications and Media Authority Act 2005 (the ACMA Act) sets out the spectrum management functions of the ACMA including:

- to manage the radiofrequency spectrum in accordance with the Radiocommunications Act 1992 (the Radiocommunications Act)
- to advise and assist the radiocommunications community.

Consistent with the spectrum management functions set out in the ACMA Act, the object of the Radiocommunications Act is to manage the radiofrequency spectrum in order to, among other things:

A. maximise, by ensuring the efficient allocation and use of the spectrum, the overall public benefit derived from using the radiofrequency spectrum

...  

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

D. encourage the use of efficient radiocommunications technologies so that a wide range of services of an adequate quality can be provided

...  

The analysis in this paper considers the public benefit that could be derived from increased proliferation of mobile broadband services and applications; and, in light of the objects of the Radiocommunications Act, considers that the identification of potential frequency bands that could be made available for future services, which harmonise with the bands identified in the international environment, will serve Australia’s national interests.

1.4 The Total Welfare Standard (TWS)

The ACMA’s analysis against a total welfare standard (TWS) includes an assessment of the impact that a regulatory proposal may have on the public interest. This assessment is measured as the sum of the effects on consumers, producers, government and the broader social impacts on the community. The application of a TWS requires that, to the fullest extent possible:

- all significant benefits and costs arising from the regulatory proposal will be given the same weight regardless of the identity of the recipient
- the approach expected to generate the greatest net benefit is the preferred approach.

Assessment against a TWS will continue to be an important consideration for the forward work plan that will be identified and developed for the mobile broadband project resulting from the outcomes of submissions to this discussion paper. The ACMA is not making any regulatory decisions or proposals in this paper; however is seeking information and comment from stakeholders on the potential for making spectrum available for future mobile broadband services, including the consideration of appropriate sharing arrangements between services and the benefits offered by new or emerging technologies. Feedback to this paper, particularly regarding costs and benefits, will form an important part of the TWS analysis.
The ACMA acknowledges that in certain situations, there may be a cost to operators where different services are required to share spectrum, where this previously was not the case. However, it is the ACMA’s view that the overall benefits to the Australian economy and community from the increased availability of mobile broadband services and applications such as machine to machine (M2M) interactions, e-health applications and other new or innovative services are considerable. The basis for this view is explained by considering the Principles for Spectrum Management.

1.5 Principles for Spectrum Management
The ACMA developed a series of Principles for Spectrum Management (the Principles) to guide its decision-making on a range of significant spectrum management initiatives. The Principles are intended to guide the ACMA’s management of spectrum within its existing legislative responsibilities and government policy settings. The Principles aim to:

- promote consistency, predictability and transparency in the ACMA’s decision-making
- provide guidance for major planning and allocation decisions to be made over the next few years
- increase the ACMA’s ability to respond to challenges, including the impact of new technologies and increasing demand for spectrum for advanced services.

A key theme of the Principles is to optimise the use of market mechanisms with minimal regulatory intervention to maximise the public benefit. The Principles are:

- **Principle 1**—Allocate spectrum to the highest value use or uses.
- **Principle 2**—Enable and encourage spectrum to move to its highest value use or uses.
- **Principle 3**—Use the least cost and least restrictive approach to achieving policy objectives.
- **Principle 4**—To the extent possible, promote both certainty and flexibility.
- **Principle 5**—Balance the cost of interference and the benefits of greater spectrum utilisation.

The discussion in this paper is closely identified with principles 2, 4 and 5.

**Principle 2—Enable and encourage spectrum to move to its highest value use or uses**
The ACMA’s research reports indicate that increasing levels of consumer demand for mobile broadband services coupled with expanding volumes of data downloaded and accessed will require the ACMA to consider reviewing current and future spectrum allocations for mobile broadband services. The ACMA is monitoring spectrum management and planning activities that are occurring internationally with particular focus on the identification of frequency bands that could be made available for mobile broadband services in the future. Further discussion on increasing consumer demand for mobile broadband services is discussed in Chapter 3; and an overview of the frequency bands identified for IMT services is provided in Chapter 5.

All of the bands included for analysis in Chapter 5 are currently allocated for use by other services, including fixed, mobile, broadcasting, satellite and radiolocation services. However, what is not yet clear is whether these bands are currently allocated to their highest value use; or whether the ACMA could consider reviewing existing arrangements to facilitate spectrum to move to its highest value use. It is important to note that the review of a band to determine its highest value use may not require existing services to relocate; rather, the outcome of the review could mean that new or improved planning and sharing arrangements may need to be developed. It is obvious
that further analysis in this particular area will be required on a band by band and subsequent, case by case, basis.

This paper is not intended to review the frequency bands set out in Chapter 5 in detail. The purpose of the section is to provide an overview of the existing arrangements and incumbent services operating in the bands that have been identified as potential future bands for mobile broadband services at the international level. Where a frequency band is identified or recommended for further consideration, the particular band will be identified in the forward work plan that will be developed after analysis of the submissions to this paper. Any review will include comprehensive consultation processes.

Principle 4—To the extent possible, promote both certainty and flexibility
The information provided in submissions will assist the ACMA in considering how both Principles 4 and 5 can be addressed in any future arrangements. For example, the ACMA intends to provide certainty and flexibility for both incumbent and new operators in the development of new technical and regulatory arrangements. However, the way that this balance is to be achieved is yet to be considered or determined. The ACMA encourages stakeholders to provide comment in relation to how ‘certainty’ and ‘flexibility’ can be facilitated when considering the development of new arrangements to support mobile broadband and emerging technologies up to 2020.

Principle 5—Balance the cost of interference and the benefits of greater spectrum utilisation
A further example of where stakeholder information is required is how the ACMA could include new technologies that have the potential to provide greater spectrum efficiency and utilisation, such as femtocells or cognitive radio systems, in existing and new regulatory arrangements.

The ACMA encourages industry and licensees to consider the benefits that emerging technologies offer network architecture including a potential ability to increase capacity in hotspot areas. WiFi technologies have been noted as providing increased capacity to networks in congested areas, such as metropolitan areas or central business districts, and the prevalence of WiFi hotspots offered by retailers, such as fast food restaurants and cafes, is increasing.

Increasing infrastructure deployment and leveraging off of the capabilities offered by new technologies feature as characteristics that may assist in achieving greater utilisation of spectrum. Spectrum efficiency may also take into account the way in which a licensee or operator uses spectrum to meet its service requirements. It is noted that particular service requirements may have other considerations other than maximising the amount of data in the available bandwidth, such as services that have
safety of life implications, or networks required by emergency services organisations in
times of an emergency.\textsuperscript{10}

In the context of the mobile broadband project, the ACMA will continue to apply the
Principles in its consideration of whether spectrum efficiency is being achieved in any
particular band under review; taking into account both the technical considerations
offered by network architecture and evolution of technologies; and the particular
service requirements and characteristics of different networks.

1.6 Submissions
The ACMA invites comments on the issues set out in this discussion paper, or any
other issues relevant to the consideration of spectrum requirements for mobile
broadband in Australia. Submissions should be made:

By email: WAS-planning@acma.gov.au
By mail: Manager, Major Allocations Engineering Section
Spectrum Infrastructure Branch
Australian Communications and Media Authority
PO Box 78
Belconnen ACT 2616

The closing date for submissions is 1 July 2011.

Media enquiries should be directed to Emma Rossi on 02 9334 7719 or by email to
media@acma.gov.au.

Electronic submissions in Microsoft Word or Rich Text Format are preferred.

Effective consultation
The ACMA is working to enhance the effectiveness of its stakeholder consultation
processes, which are an important source of evidence for its regulatory development
activities. To assist stakeholders in formulating submissions to its formal, written
consultation processes, it has developed Effective consultation: A guide to making a
submission.\textsuperscript{11} This guide provides information about the ACMA’s formal, written, public
consultation processes and practical guidance on how to make a submission.

Publication of submissions
In general, the ACMA publishes all submissions it receives. However, the ACMA will
not publish submissions that it considers contain defamatory or irrelevant material.

The ACMA prefers to receive submissions which are not claimed to be confidential.
However, the ACMA accepts that a respondent may sometimes wish to provide
information in confidence. In these circumstances, respondents are asked to identify
the material over which confidentiality is claimed and provide a written explanation for
their confidentiality claims.

The ACMA will not automatically accept all claims of confidentiality. The ACMA will
consider each claim on a case-by-case basis.

\textsuperscript{10} The analysis provided in this paper does not address the complex issue of whether the business case for
government services, emergency organisations or utilities could consider the use of existing
telecommunications networks to supply non-critical communications.

When can the ACMA be required by law to release information?
The ACMA may be required to release submissions by law under the *Freedom of Information Act 1982* (Cth) or for other reasons including for the purpose of parliamentary processes or under court subpoena. The ACMA will seek to consult submitters of confidential information before that information is provided to another party, but the ACMA cannot guarantee that confidential information will not be released through these or other legal means.

Sharing of information
Under the *Australian Communications and Media Authority Act 2005*, the ACMA is able to disclose submissions to the Minister, the Department of Broadband, Communications and the Digital Economy, including authorised officials, Royal Commissions and certain Commonwealth authorities, such as the Australian Competition and Consumer Commission and Australian Securities and Investments Commission.

If information is accepted by the ACMA as confidential, the ACMA will seek to consult with the submitter of the information where the ACMA intends to share that information.

Status of this paper
This paper provides background information to assist people making comments to the ACMA. Nothing in this paper should be taken to bind the ACMA to any particular course of action in later processes.
2. Background

The ACMA recognises the importance of broadband as a key economic enabler and has made considerable progress in planning spectrum for mobile broadband. Over time, the ACMA has undertaken a number of initiatives to make spectrum available in regional and remote areas in order to meet local demand; as well as considering larger initiatives intended to deliver high value spectrum in metropolitan and regional areas.

This section discusses the ACMA’s progress on delivering spectrum options for mobile broadband and explains the need for greater spectral efficiency.

2.1 Defining mobile broadband

The term wireless access services (WAS) has been used extensively by the ACMA in its recent projects and initiatives and encompasses the variety of ways in which telecommunications service providers deliver a radio connection to an end-user from a core network, such as a public internet network. The term WAS covers a range of other terms, including:

- broadband wireless access (BWA)
- fixed wireless access (FWA)
- wireless local loop (WLL)
- multipoint distribution systems (MDS)
- radio local area network (RLAN).

For the purposes of this paper, mobile broadband is the term used to describe the various types of wireless high-speed internet access provided via a portable modem, telephone or other device. Consequently, the use of the term mobile broadband in this paper is inclusive of the following terms:

- wireless access services (WAS)
- mobile wireless access (MWA)
- nomadic wireless access (NWA).

The ACMA has undertaken a significant amount of work to make spectrum available for International Mobile Telecommunications (IMT) services and applications, including mobile broadband. This is evident in the outcomes of the extensive consultation process undertaken in 2006 and forward work plans that continue to deliver on the ACMA’s objective to release further spectrum for these services.

2.2 Available spectrum for IMT services

The growth and increasing consumer demand for applications and services in the information and communication technology (ICT) sector led to consideration of additional spectrum being made available for future IMT services at the World Radiocommunications Conference in 2007 (WRC-07).

Agenda item 1.4 at WRC-07 identified the need for global harmonisation of spectrum for use by IMT technologies. Although there was no consensus reached on making all identified bands available for IMT at WRC-07, additional spectrum was identified in a range of new bands, including the UHF TV bands on a regional basis and extended.

12 The purpose of Agenda Item 1.4 is to consider frequency-related matters for the future development of IMT-2000 and systems beyond IMT-2000 taking into account the results of studies undertaken in accordance with Resolution 228.
C-band (3400–3600 MHz) on a multi-country basis. A summary of the bands considered at the global level are provided in Table 2.1.

Table 2.1 Additional spectrum allocations for IMT at WRC-07

<table>
<thead>
<tr>
<th>Frequency range (MHz)</th>
<th>Quantum (MHz)</th>
<th>Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>450–470</td>
<td>20</td>
<td>Worldwide</td>
</tr>
<tr>
<td>790–862</td>
<td>72</td>
<td>Europe and Asia</td>
</tr>
<tr>
<td>698–862</td>
<td>164</td>
<td>Americas and parts of Asia Pacific</td>
</tr>
<tr>
<td>2300–2400</td>
<td>100</td>
<td>Worldwide</td>
</tr>
<tr>
<td>3400–3600</td>
<td>200</td>
<td>No worldwide allocation but accepted by many countries</td>
</tr>
</tbody>
</table>

The ITU-R has identified a number of frequency bands that could be made available for IMT services and applications, many of which are available in Australia.\(^\text{13}\) Table 2.2 sets out the frequency bands that are, or soon will be, available for IMT services in Australia. These bands are available in the market either by participating in an allocation process or via a trade or third party authorisation (lease) arrangement.

### Table 2.2 Bands released (or are to be) for IMT services in Australia

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectrum</th>
<th>Type</th>
<th>Existing usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>694–820 MHz (Note 1)</td>
<td>2 x 45 MHz</td>
<td>Likely to be</td>
<td>Analogue/Digital TV to be cleared to realise digital dividend</td>
</tr>
<tr>
<td></td>
<td></td>
<td>spectrum licensed</td>
<td></td>
</tr>
<tr>
<td>825–845 and 870–890 MHz</td>
<td>2 x 20 MHz</td>
<td>Spectrum licence</td>
<td>Mobile telephony (3G—WCDMA/HSPA)</td>
</tr>
<tr>
<td>890–915 and 935–960 MHz</td>
<td>2 x 25 MHz</td>
<td>Apparatus</td>
<td>Mobile telephony (2G—GSM900 and 3G—WCDMA/HSPA)</td>
</tr>
<tr>
<td>1710–1785 and 1805–1880 MHz</td>
<td>2 x 75 MHz</td>
<td>Spectrum licence</td>
<td>Mobile telephony (GSM1800). Licensed for Australia-wide use (restricted to the lower 2x15 MHz in regional areas)</td>
</tr>
<tr>
<td>1900–1920 MHz</td>
<td>20 MHz</td>
<td>Spectrum licence</td>
<td>3G services—Licensed in capital cities only</td>
</tr>
<tr>
<td></td>
<td>20 MHz</td>
<td>Apparatus</td>
<td>Broadband. Licensed in regional and remote areas only</td>
</tr>
<tr>
<td>1920–1980 and 2110–2170 MHz</td>
<td>2 x 60 MHz</td>
<td>Spectrum licence</td>
<td>3G mobile telephony and broadband. Licensed in capital cities and regional areas (restricted to the upper 20 MHz)</td>
</tr>
<tr>
<td></td>
<td>2 x 40 MHz/2 x 60 MHz</td>
<td>Apparatus</td>
<td>3G mobile telephony and broadband. Licensed in regional (2 x 40 MHz) and remote areas (2 x 60 MHz)</td>
</tr>
<tr>
<td>2302–2400 MHz</td>
<td>98 MHz</td>
<td>Spectrum licence</td>
<td>Broadband. Licensed in capital cities and regional areas.</td>
</tr>
<tr>
<td>2500–2690 MHz (Note 2)</td>
<td>2 x 70 MHz</td>
<td>Spectrum licence</td>
<td>Band currently under review to allow for new services such as mobile telephony and wireless broadband in 2 x 70 MHz.</td>
</tr>
<tr>
<td></td>
<td>50 MHz</td>
<td>Spectrum licence</td>
<td>Technology flexible framework underpinning ENG operation in 50 MHz.</td>
</tr>
<tr>
<td>3425–3442.5 and 3475–3492.5 MHz</td>
<td>2 x 17.5 MHz</td>
<td>Spectrum licence</td>
<td>Fixed wireless access, broadband. Licensed in capital cities and major regional centres.</td>
</tr>
<tr>
<td>3442.5–3475 and 3542.5–3575 MHz</td>
<td>2 x 33.5 MHz</td>
<td>Spectrum licence</td>
<td>Broadband. Licensed in capital cities and regional areas.</td>
</tr>
<tr>
<td>3575–3700 MHz</td>
<td>Up to 30 MHz</td>
<td>Apparatus</td>
<td>Fixed wireless access, broadband to coordinate with fixed links and Earth stations. Licensed in regional and remote areas.</td>
</tr>
</tbody>
</table>

**Total bandwidth 890 MHz**

**Note 1:** This spectrum is commonly referred to as the digital dividend.

**Note 2:** This band is planned for FDD technologies to support IMT services. The mid-band gap will be converted to a spectrum licence for broadcasting purposes.
2.2.1 Consultation on wireless access services

The WAS consultation process began in February 2006 and culminated in the release of a paper in October 2008 identifying a forward work plan for the ACMA to make spectrum available for WAS. The digital dividend was identified as a band that could be made available for mobile broadband services early in the analysis, and the ACMA undertook work on this band independently of the consultation process on WAS. The forward work plan identified from the consultation outcomes was set out in a document titled Strategies for wireless access services: Spectrum access options—Consultation Outcomes. The WAS strategy identified 2.5 GHz and 3.6 GHz as bands that could be made available within one to four years to support WAS. The paper also included a summary of alternative bands that had been identified by respondents to the consultation process.

2.2.2 The 2.5 GHz band

The 2.5 GHz band was identified as a candidate band to address the emerging demand for broadband wireless access services in both the Australian and international contexts. The ACMA released a discussion paper titled Review of the 2.5 GHz band and long-term arrangements for ENG in January 2010 to review the pricing, planning and licensing arrangements for spectrum in the 2.5 GHz band.

2.2.3 The 3.6 GHz band

The ACMA released a discussion paper titled Release of the 3.6 GHz band for wireless access services in April 2009 that detailed licensing arrangements and allocation processes to allocate apparatus licences in regional and remote areas of Australia. As a result of the submissions received, the ACMA decided to allocate apparatus licences via either an administrative process or a price-based allocation process in accordance with section 100 and 106 of the Act.

2.2.4 Alternative bands for WAS

The respondents to the WAS consultation process also commented on a number of other issues and potential bands for WAS. The main suggestions are summarised below:

- existing but unused spectrum allocations should be investigated
- re-farming of existing WAS spectrum allocations should be considered
- there is a need to investigate other bands which either have or have not yet been identified for IMT, including bands above 6 GHz, which may be suited for nomadic applications
- the frequency range 45–70 MHz is already identified for fixed and mobile applications in Regions 2 and 3 and could be considered for WAS
- the 2700–2900 MHz band could be considered for rural/remote area WAS usage on a coordinated basis with aeronautical radar systems
- the standard C-band, 3700–4200 MHz, could be considered in the long term.

The band that attracted the most attention was the standard C-band. Fixed Satellite Service (FSS) operators that commented on this band strongly opposed any allocation in this segment of spectrum; while some WAS proponents argued that consideration

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should be given to its access for mobile broadband in the longer term.18 Issues associated with the standard C-band, and other alternative bands, are considered in Chapter 5.

2.3 International planning activities for mobile broadband

The consideration of possible frequency bands for future mobile broadband services is being undertaken on a worldwide basis by international regulatory agencies. Analysis of spectrum planning and allocation activities undertaken in the international environment shows that the current focus is on allocation of spectrum associated with the digital dividend provided in respective countries; and the re-allocation of spectrum to support the deployment of national broadband infrastructure. A number of regulatory authorities have released consultation papers and plans indicating that they will seek to make further spectrum available for mobile broadband after the allocation of the digital dividend. Some of the papers and plans include:

- EU—i2010, now a part of Europe 2020: A European Strategy for Smart, Sustainable and Inclusive Growth (‘A Digital Agenda for Europe’)
- UK—Digital Britain
- UK—Britain’s Superfast Broadband Future
- France—Francenumberique 2012
- Estonia—Estonian Information Society Strategy 2013
- Belgium—Belgium, Digital Heart of Europe 2010–2015
- USA—National Broadband Plan
- USA—Plan and Timetable to Make Available 500 MHz of Spectrum for Wireless Broadband
- USA—An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675–1710 MHz, 1755–1780 MHz, 3500–3650 MHz, and 4200–4220, 4380–4400 MHz bands
- Canada—Plan for a Digital Canada.

An analysis of the international environment is provided in Appendix A.

2.4 Defining spectrum utilisation

Improved spectrum utilisation techniques could offer network providers greater efficiencies within existing spectrum holdings and could impact on the overall quantum of spectrum required in the future. For example, if greater technical efficiency is achieved, the total quantum of spectrum required for mobile broadband communications may be less than that currently speculated upon by industry and other regulatory agencies. The Federal Communications Commission (FCC) announced in 2010 that an additional 500 MHz of spectrum would be needed for mobile broadband technologies by 2020.19 This announcement was echoed by other countries, including the United Kingdom,20 however, while these announcements may reflect the spectrum requirements in these respective countries, what is not clear is the quantum of

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18 Further explanation and information on the justifications provided by FSS and WAS proponents are available in the WAS consultation papers available at www.acma.gov.au/WEB/STANDARD/pc=PC_100424#CurrentProjects.


20 The United Kingdom released a paper in December 2010 titled Britain’s Superfast Broadband Future that specified the quantum of spectrum required. The paper is available at: www.bis.gov.uk/assets/biscore/business-sectors/docs/b/10-1320-britains-superfast-broadband-future.pdf.
spectrum required in the Australian context. The ACMA examines the spectrum requirements for the Australian communications environment out to 2020 in Chapter 4.

Spectrum utilisation techniques include consideration of technology, infrastructure and economic factors designed to enhance the overall network architecture of a licensee’s service to achieve maximum use of the spectrum.21

Although the development of spectrum sharing arrangements between licensees may offer some efficiency for operators, this type of usage does not directly address the issue of technical efficiency. Further to this, it is noted that the deployment of a new technology, such as those defined as 4th Generation, for example, does not in itself ensure technical efficiency. The way in which the technology is deployed in the network, referred to as network architecture, and coupled with the use of other techniques, such as dynamic frequency and channel allocation for example, can help to ensure that a licensee is able to make maximum use of their spectrum asset.

Spectrum utilisation techniques are designed to ensure that maximum data rates are achieved, subject to noise, interference and bandwidth constraints. The discussion in Chapter 4 focuses on how consideration of the network architecture, including the deployment of complementary infrastructure such as picocells and femtocells in dense urban environments, decreases the size of the coverage areas required by individual macro and micro-cells and improves spectrum efficiency. The discussion also takes into account issues associated with the use of improved technologies, such as coding, to improve overall spectrum efficiency by operators.

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21 This view is similar to that of J.W. Burns who argues that factors to take into account when considering spectrum efficiency are technical, economic and functional constraints on the different services operating in the band. The ACMA view is more general than this, as it is believed that spectrum efficiency (at varying levels) can be achieved by all users of the spectrum, regardless of the end use of the service. Refer to J.W. Burns, Measuring Spectrum Efficiency – The Art of Spectrum Utilisation Metrics, Aegis Systems Ltd. Presented at IEE Conference ‘Getting the most out of the radio spectrum’, October 2002. A copy of the paper is available at www.aegis-systems.co.uk/library/article.html.
3. The baseline demand for mobile broadband spectrum in Australia

The ACMA released its annual Communications report 2008–09 in January 2010 summarising the telecommunication service adoption and take-up rates from information obtained by Australian telecommunications service providers.22 This information is provided by service providers in accordance with reporting obligations under section 105 of the Telecommunications Act 1997. One of the key issues highlighted in the report is the increasing level of consumer demand to be able to access broadband applications in fixed, nomadic and mobile environments. This trend is supported in the ACMA’s 2009–10 Communications report series23 showing the number of mobile phone services increased by 2.1 million from June 2008 to June 2009; while fixed-line services decreased by 600 thousand and a total decline of 8.5 per cent over the past five years. The report also noted that just over 40 per cent of phone users who had an internet-enabled device had accessed the internet with their mobile.

This section considers how the increased level of consumer demand for mobile broadband and its applications impacts on the demand for access to spectrum in the Australian and international context; establishing a baseline for spectrum into the future.

3.1 Pressure on spectrum from new technologies

The trend for new technologies to provide greater data capability will have implications for how spectrum is planned and utilised. New technologies offer improved data rates and spectral efficiency; however, the success of these new technologies will largely depend on the availability of spectrum.

Given the anticipated lifetime of access technologies is beyond 15–20 years (GSM was introduced in Australia in 1993), it is often difficult for carriers to refarm spectrum in order for it to be utilised to provide access to the new technologies because there is such a substantial commercial and consumer investment in technology that may or may not be considered out-of-date.

One way that this may be achieved is via a government policy mandating a move to a newer technology. For example, in 1992, the government mandated the phase-out of the analogue phone system in favour of digital technologies; eventually, the analogue network was switched off on 31 December 2000.

The other difficulty is that not all new access methods provide the same service types as those they are replacing. LTE and WiMAX are not inherently voice carriage technologies because they are not circuit switched technologies like those used in GSM and WCDMA. LTE does have a VOIP capability that has been trialled in some domestic environments and will eventually evolve into a voice carriage service.

Spectrum capacity is also under pressure from the rapid expansion of mobile data applications and the increasing volume of data that is downloaded. What is not known

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are the future applications that will derive their data from mobile services and therefore it is likely that this pressure will continue to increase as new technologies appear over time. Therefore, it is important to consider the context in which the demand for mobile broadband is occurring.

### 3.2 Demand for mobile broadband in Australia

Australia’s population size, density and distribution characteristics are very different to that of other countries of a similar or larger size. Australia’s population is concentrated on the east coast, with population densities greatest in the major cities of Brisbane, Sydney, Melbourne, Adelaide and Perth. The population density declines further away from the coasts, heading inland away from these metropolitan centres. The population density of Australia at 2009 is shown in Figure 3.1.

![Figure 3.1 Australia’s population density at June 2009](image)

Figure 3.1 Australia’s population density at June 2009

Therefore, if it is accepted that the amount of spectrum required for mobile broadband is linked to population density in a particular geographic area, then this suggests that the highest spectrum demand exists along the east coast and in the metropolitan cities; and that demand for spectrum is not now, nor will it in the future, be as great outside of these areas. This argument does not refute the need for access to spectrum in regional and remote areas. However, it is argued that if spectrum needs can be addressed in the metropolitan areas, or where the greatest population density resides, then the ACMA’s ability to address spectrum management issues outside of these areas may also be resolved.

In recent years, Australians have readily adopted fixed broadband solutions in substitution for dial-up services. According to the Australian Bureau of Statistics (ABS),

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mobile wireless (excluding mobile handset connections) was the fastest growing technology in internet access, increasing to 3.5 million services in June 2010.\footnote{ABS, 8153.0, Internet Activity, Australia, Dec 2010 www.abs.gov.au/ausstats/abs@.nsf/mf/8153.0/.


Figure 3.2 demonstrates the take up of internet services by technology type based on the Internet Activity Survey conducted by the ABS for December 2010.

![Figure 3.2 Internet services by technology type](image)

Figure 3.2 shows that digital subscriber line (4.458 million connections) is still used by the majority of consumers for their broadband connections; however, there is increased evidence of the take-up of fixed and mobile wireless technologies (4.254 million connections). With the rollout of the NBN, it is expected that fibre connectivity (24,000 connections) will also begin to take market share away from traditional access techniques including digital subscriber line and cable.

The ACMA’s report titled Australia in the digital economy: The shift to the online environment considers that while the use of mobile networks and devices to support triple play services such as voice, data and video is changing the dynamics of internet use by providing increased mobile flexibility; the use of mobile networks is viewed as complementary to fixed broadband services.\footnote{ACMA, 2009–10 Communications report series, Report 1—Australia in the digital economy: The shift to the online environment, available at www.acma.gov.au/WEB/STANDARD/pc=PC_311301.}

This trend may be attributed to the increasing volume of data downloaded by internet users in Australia.

During the June quarter in 2010, internet users were estimated to have downloaded 155,503 terabytes of data, compared to 99,249 terabytes in the June quarter of 2009. However, while mobile broadband has driven growth in the broadband subscription market, fixed networks appear to carry the bulk of the data downloaded from the internet at 91 per cent at June 2010.\footnote{ACMA, 2009–10 Communications report series, Report 1—Australia in the digital economy: The shift to the online environment, available at www.acma.gov.au/WEB/STANDARD/pc=PC_311301.}

This trend is demonstrated in Figure 3.3.
The telecommunications industry argues that demand for spectrum will significantly increase in the next five years. This increased demand is attributed to an overall increase in the volume of data downloaded as a result of greater consumer use and machine to machine interactions. There have been a number of figures quoted by industry proponents and regulatory authorities regarding the amount of spectrum that will be required by 2020. These figures range between 500 MHz to 1720 MHz of required spectrum.

For example, the FCC’s announcement in 2010 that an additional 500 MHz of spectrum would be needed for mobile broadband technologies by 2020 has led to a number of papers being released by the National Telecommunications and Information Administration (NTIA). These papers detail work programs identifying what activities are necessary to release spectrum in the relevant 10-year period. A number of the FCC’s initiatives will require either the relocation of incumbents or the development of sharing arrangements.

An ITU-R report released in 2007 claimed that anywhere between 1280 MHz and 1720 MHz of spectrum would be required to meet the demands of mobile broadband applications and services by 2020. The ITU-R report is made up of global information received from administrations and industry regarding the volume of data being downloaded by Australian internet users.

Note: ABS did not publish statistics on the volume of data downloaded by technology prior to December 2009. Previous reporting periods have been excluded due to ABS targeting ISPs with more than 10,000 subscribers only.

Revisions: Dec 09 figures were revised by ABS in June 2010. ABS reports that ‘download data presented should only be considered an indicative measure of internet activity during the reference period and therefore should be used with caution.’

Source: ABS, 8153.0–Internet Activity, Australia, June 2010.

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28 Figures have been quoted by the FCC, the United Kingdom’s Department for Business Innovation and the ITU-R. For further information refer to the Magic Mobile Future Report from UMTS Forum; the IPTS Study conducted by the European Commission; the WINNER Report from the Wireless World Initiative New Radio Group; and the Final Report for the Independent audit of spectrum holdings on spectrum demand for non-government services 2005-2020 prepared for Ofcom by Analysys Mason.

downloaded by consumers or citizens. These trends have then been entered as parameters to develop a proposed range of figures regarding spectrum demand that is not applicable to particular countries. The ITU-R report does not offer certainty or an easily applied methodology for particular administrations to apply to their individual country’s circumstances.

Figure 3.4 shows the spectrum demand forecast used by industry in 2010 that applies the ITU-R report as its baseline. According to the industry members who use the chart, it indicates that between 2014 and 2020, there may be a 160 MHz to 700 MHz shortfall in spectrum capacity for mobile broadband services and applications in Australia. It is important to note that the assumptions in the figure below regarding spectrum demand are not based on particular parameters relevant to the Australian spectrum management environment. Therefore, while the figure is interesting and provides additional information to feed into the process of determining future requirements, it is not a true representation of spectrum requirements for future broadband services in the Australian context.

Figure 3.4 Spectrum demand forecast for mobile broadband (2010–2020)

The indication that there may be up to a 700 MHz shortfall by 2020 does not take into account the ongoing spectrum planning activities undertaken by the ACMA, nor any further advancements in technology that may result in the intervening timeframe. The ACMA continually reviews bands and planning arrangements to determine whether the band is allocated to its highest value use, or whether technological advances allows for greater opportunities to share spectrum between different services.

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30 This spectrum demand chart has been used by Ericsson and the Australian Mobile Telecommunications Association (AMTA) in presentations in 2010.
31 Chart used by AMTA at the ACMA’s International Training Program 2010 in the presentation Mobile broadband: Industry requirements and regulatory inputs, 7 December 2010.
There are a number of examples where the ACMA is achieving this, including:

- the review of the 2.5 GHz band
- the release of the digital dividend
- the development of arrangements for public telecommunications services (PTS) apparatus licences to be issued in the 2.1 GHz and 1.8 GHz bands
- the release of the 3.6 GHz band for WA in regional and remote areas
- the review of existing arrangements the 900 MHz band.

In a number of these activities, the ACMA has reviewed the planning and regulatory arrangements in the bands and either amended or developed new arrangements.

Despite the fact that the ITU-R’s report does not fully reflect the Australian communications environment, the ACMA agrees that further spectrum may need to be made available to meet the needs for mobile broadband into the future, especially taking into account increased activity in data streaming and machine to machine interactions. However, the issue for the ACMA is to determine the quantum of spectrum required for future mobile broadband services in the Australian communications environment. This analysis will need to take into account the need for consistency with international trends; and the needs of incumbent users.

3.3 Developing the baseline for spectrum demand

Australia led the world in introducing market based spectrum allocations, nearly all of which were intended for mobile telephony and all except two bands now support some form of mobile broadband service. In order to continue to meet the demand for mobile broadband spectrum, the ACMA has conducted analysis to determine a baseline spectrum demand out to 2014. This baseline is then used in Section 4 to determine the baseline spectrum requirements out to 2020. The baseline assumes the following:

- that the demand for mobile broadband spectrum was met in 2007
- that technology and network architecture will improve over time
- that the quantum of spectrum required will plateau at some stage as a result of increased spectral efficiencies.

To determine the baseline, the ACMA took the average of three industry mobile broadband demand estimates that were based on data volume and traffic, and normalised these results to 2007. The ACMA was then able to produce an estimate for the amount of spectrum required by 2014 based on projected data volume and traffic. This analysis showed as much as thirty times (30x) the amount of spectrum available in 2007 would be required by 2014. The spectrum demand curve is detailed in Figure 3.5 for the period between 2007 and 2014.

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22 The 2.3 GHz band was originally spectrum licensed to support MDS services and was varied in 2009 to support the operation single frequency IMT services such as WiMAX. The 500 MHz and 20/30 GHz spectrum licences do not support mobile broadband services.
The spectrum demand curve in Figure 3.5 uses the spectrum available to the market in 2007 as a benchmark normalised to one. The demand curve demonstrates that a 30x increase in data demand occurs between 2007 and 2014. In other words, if demand for data was equivalent to spectrum demand, then this curve indicates that there is a near 30x increased need for spectrum if no other factors, such as technology evolution, are taken into consideration. It is evident that the 30x figure is a gross exaggeration; is clearly not achievable in such a short period; and unsustainable in the longer term, assuming even a linear increase in demand beyond 2014.

The ACMA analysis of this demand has concluded that only 2.5 times the spectrum in use in 2007 will be required by 2015, or approximately an additional 150 MHz.

6. Are the ACMA’s assumptions on establishing a baseline for demand correct?
7. Are there other strategies to establish spectrum demand that the ACMA has not thought of, or applied?
4. Strategies to address increased demand

This section is intended to set out a range of options that could be applied by network operators to achieve efficiencies in existing spectrum holdings. The options include:

> leveraging off of the benefits offered by advances in technologies, such as improved coding and system efficiencies
> reconsidering the trade off between spectrum and infrastructure in network architecture or topology
> the possibilities offered by the introduction of new or emerging technologies
> fixed-to-mobile convergence whereby data is ‘offloaded’ from the cell to WiFi like hotspots in the home or office connected to fibre.

If these options are adopted by network operators, it is only where they are shown not to fully address the demand needs for future mobile broadband services that the ACMA will need to consider whether other, possible frequency bands should be made available.

The use of these options by network operators may ameliorate the need for significantly large amounts of spectrum to be made available in the future. For example, ACMA analysis using the baseline demand figure provided in the previous section (near 30x increase in spectrum requirements to 2007) demonstrates that by applying some of the options outlined above, the amount of spectrum required for future mobile broadband services can be reduced, as in the 2015 case to an additional 150 MHz.

4.1 Considering advances in technologies

Evolution and advancements in technology offer improvements in spectral efficiency and this is an important consideration for spectrum planning into the future. For example, in cellular technology, the move to 3G and 4G technologies provides significant improvements in spectral efficiency and frequency re-use, especially compared with 2G technologies. In its 2010 analysis, the ACMA estimated that the spectral efficiency of pre 2007 networks was an average of 1.85 bit/Hz.

Initial research conducted by the ACMA shows that a fivefold (5x) increase may be possible by 2015, depending on the technology chosen. For example, LTE technology demonstrates a 5x increase compared with HSPA; however, a 3x improvement was applied after taking legacy communications systems into account, that is, an average of 5.6 bit/Hz. Although increases in bit/Hz cannot be relied upon in the longer term (as the Shannon limit will eventually be reached), improvements in spectral efficiency of three to five times may be achievable in the medium term. Both the ACMA and the ITU (in ITU-R M.2078) expect that by 2020, 15 bit/Hz will be achievable.

For the 2015 analysis, a 10x demand for spectrum is still a high number and probably not sustainable without moving many services currently using the radiofrequency spectrum onto the emerging NBN; noting that part of the NBN rollout includes a wireless access component. For many service providers and users, this would be a significant shift and may not be achievable within the next five years. If this is the case, then it follows that many service providers and users will seek to obtain the benefits offered by new technologies and need to reconsider and replan network architecture as a result.
4.2 Network architecture

A standard trade-off in industry is that between spectrum and infrastructure. Where insufficient spectrum is available yet demand is high, additional infrastructure is needed to reduce or spread the number of users per cell. Traditionally, the price of spectrum has allowed a fairly generous trade-off, however if that price is adjusted to account for the value of displaced incumbent services in some way, then a different balance could eventuate.

Assuming network operators move away from current network planning scenarios where macro-cells are used to provide coverage to wide areas, to a scenario where the density of cell sites has increased, particularly in metropolitan areas, further efficiencies could be gained. The increased density of cell sites would meet the anticipated future demand for mobile broadband services in the metropolitan areas and could be achieved using microcell, picocell or femtocell technologies. If the cell radius of existing wireless infrastructure was halved, the demand could reduce from the 10x figure to about 7.5x by 2014.

Although reducing the cell radius may be a high cost and imposition on existing communications service providers, the overall effect on spectrum demand is an improvement over the 30x demonstrated in the normalised demand curve at Figure 3.5. The ACMA anticipates that network architecture will develop over time in such a way as to ensure reasonably good use of sites and spectrum. For example, network operators may use one frequency band for macrocells, or wide area networks, and a different frequency band for the infrastructure providing higher capacity in the areas of high demand, such as femtocells in metropolitan areas.

It is recognised that there may be difficulties with enabling femtocell technologies to be used in the existing network architecture; however, the ACMA is open to considering how the use of femtocell or similar technologies can be incorporated in the future communications environment. There is potential for femtocells to operate in frequency bands outside of the bands currently identified for wide area networks. If this is the case, the higher frequency bands could be used for in-building coverage facilitated by femtocells. This scenario demonstrates further layering of the network architecture of the current mobile telecommunications environment from the wide area network, facilitated by macrocells, down to the microcell and femtocell levels.

8. What are some of the emerging technologies that providers may consider deploying in their respective network architecture in the next five- to 10-year period?

9. Should particular new or emerging technologies be considered a higher priority than others? Why is this the case?

10. The ACMA notes that some providers have indicated that there may be some constraints on using new technologies, such as femtocells, in current network architecture. What are the current constraints and what arrangements could the ACMA consider introducing that would facilitate their use?

4.3 Identifying a quantum of spectrum

If the existing network architecture was improved over time to include the two scenarios described above, that is, leveraging off of new technologies and deploying additional infrastructure to halve the cell radius, the spectrum demand figure only increases to approximately 2.5x above that used in 2007. This equates to an additional 150 MHz of spectrum being required by 2015.
The 2.5x figure, or an additional 150 MHz, is considered to be a more achievable outcome by the ACMA. However, making further spectrum available for mobile broadband will become inherently difficult over time as the bands nominated for review will require regulatory and technical arrangements to be considered or developed. This will become especially difficult in frequency bands that are currently allocated for use by services that have not previously been subject to sharing arrangements with other different services.

The difficulty for the ACMA in predicting the amount of spectrum that is required in 2020 is the uncertainty about future technology improvements; increases in infrastructure deployment; and the future levels of data volume and traffic.

It is possible to use a similar methodology to estimate the quantum of spectrum required for mobile broadband out to 2020. Assuming the same exponential rate of increase in data volume and traffic growth up to 2020, a 487x increase in data demand between 2007 and 2020 would result. The ACMA believes this is a reasonable estimation taking into account that consumer demand is expected to plateau as tablets and smart phones saturate the market, but machine to machine communications traffic grows.

4.3.1 Spectrum for 2015

Given the variability in means to determine the quantum of spectrum required within a long range timeframe, the use of estimates for deriving the baseline spectrum requirements to meet mobile broadband growth will be limited in the analysis below to the baseline identified above for 2015. The assumptions used to calculate the spectrum demand figure of approximately 2.5x in Figure 8 are considered to be reasonable predictions. These assumptions included:

> a 3x improvement in coding and system efficiency since 2007
> the deployment of additional infrastructure to half the cell radius of that used in 2007.

In 2007, there were a number of bands available in the Australian communications environment capable of delivering mobile broadband. These bands are outlined in Figure 4.2.

Figure 4.2 2007 mobile broadband spectrum allocations

Of the bands outlined above, only 10–20 MHz (depending on region) of the 850 MHz band was unused in 2007; as was 30 MHz (2 x 15 MHz) of the 1800 MHz band. In addition, approximately 10–15 MHz of the TDD segment of the 1900 MHz band was unused in 2007.33

Two of the bands most sought after for use for future mobile broadband services are the 700 MHz band, referred to as the ‘digital dividend’, and the 2.5 GHz band. There is approximately 300 MHz of realisable spectrum in these bands, shown in orange in the figure above. The 2.3 GHz band is also shown as a ‘future’ band in Figure 4.2, because although the band was available in 2007, it is only now starting to be used to provide wireless broadband services.

In 2007, there was approximately 380 MHz of spectrum ‘in use’ which is taken to have met the spectrum needs at this time. Therefore, after taking the ACMA’s projected demand figure into account, it is anticipated that approximately 930 MHz of spectrum will be needed by 2014 to meet demand. If the spectrum that was available but not yet used in 2007 (the 2.3 GHz band) is combined with that expected to be released in the next few years (the 700 MHz and 2.5 GHz bands), there will be a total of 776 MHz available, or about 800 MHz if smaller, unused lots are taken into account. This represents a shortfall of the anticipated 930 MHz figure of between 130–150 MHz.

Although identifying and making the 150 MHz of spectrum available still presents a challenge, many candidate bands are already being studied both in Australia and elsewhere: along with studies to see if re-planning or re-farming of bands, such as the 900 MHz and 1800 MHz ‘GSM bands’, could yield greater efficiencies. This could reduce the overall spectrum demand and thus the burden on incumbent services in potential new bands. Channel aggregation, particularly in the 1800 MHz band, would

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33 This spectrum may be used for cell broadcast, but the amount available depends on future IMB standard.
also achieve greater data capacity and the ACMA will work with all licensees to achieve this.

> The ACMA is currently undertaking its review into the 900 MHz band to determine the efficiencies that may be achieved by replanning to allow for use by new mobile telecommunications technologies. The outcomes of this review could be determined and implemented within the timeframe of the analysis above, that is, by 2014.34

> The 1800 MHz band is currently under review in the context of the expiring spectrum licences process. The ACMA anticipates that the planning arrangements for this band will encourage the transition from 2G to 3G+ and 4G technologies. It is likely that the new planning arrangements for this band will be implemented in 2013.

Section 5 of this paper, combined with the recently released paper on the 900 MHz review, identifies bands that will be able to support the need for an additional 150 MHz of spectrum to be made available leading up to 2015. In some cases, new spectrum is discussed; and specifically, in the review of the 900 MHz band, consideration is given to the re-farming of spectrum to improve efficiency.

As identified in Section 3, many administrations and the ITU have attempted to estimate the quantum of spectrum that will be required to meet the needs of a developed information society. ITU analysis in Report M.2078 demonstrated a potential shortfall in Australia of 900 MHz to the end of 2014 and as much as 1340 MHz by 2020. The ACMA’s ability to make further spectrum available however, is constrained by the international environment. Australia is a technology adopter and it is common for the ACMA to adopt planning and regulatory arrangements for bands that are being accepted and implemented in larger markets such as Europe, Asia and America.

### 4.3.2 Spectrum for 2020

The ACMA believes that the amount of spectrum forecast in M.2078 is both unnecessary and unsustainable, and would find it difficult to make this much spectrum available as it is often already heavily utilised. The ACMA has undertaken a further analysis of spectrum demand for 2020 and has found that an additional 150 MHz would be needed. This is because our analysis assumed increases in spectrum efficiency (to 15 bits/Hz) and infrastructure (smaller cells). Additionally, the ITU estimates do not assume migration from one technology to another; a view not supported by the ACMA. The ACMA expects carriers to make the best use of their spectrum and this would mean migration to new technologies as early as possible.

In Figure 4.3, the ACMA outlines its expectations for data and spectrum demands through to 2020. The blue bar chart represents data demand based on industry assumptions to 2015 and ACMA trending to 2020. The red curve is the ACMA’s anticipated level of spectrum demand to meet the needs of mobile broadband.

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Australia is a ‘mature’ user of mobile technology with a fast uptake of new services and the ACMA expects that data demand will increase exponentially as a result of this trend until about 2018. As demand begins to slow, the ACMA expects an increase in demand for machine-to-machine (M2M) applications to sustain the exponential nature of this demand curve through to 2020.

In determining the quantum of spectrum to meet the increasing data demand to 2020, a number of assumptions have been made. As previously discussed, the ACMA assumes that spectrum already allocated to mobile broadband is used in such a way as to maximise efficiency. The 1800 MHz band appears to be the first candidate band for the deployment of LTE in Australia, and in deriving our spectrum demand estimate, the ACMA assessed the data capacity of this band using LTE after 2015; assuming the band is aggregated into optimal channel lots.

The spectrum demand curve also takes into account a linear increase in coding efficiency to meet data demand which is anticipated to be 8x greater than that in 2007. This means that for 2020, we anticipate that each hertz of spectrum will be able to support 15 bits (in accordance with ITU Report M.2078). Some access technologies are already claiming to support 20 bits/Hz, and the ACMA expects industry to maximise spectrum efficiency where possible by migrating to technologies achieving greater spectral efficiency such as LTE.

Finally, while in its assumptions the ACMA has allowed for overlap of technologies, it has not allowed this indefinitely. The ACMA understands that legacy technologies need to be supported while there is a significant market penetration of handsets, but as this penetration decreases, the ACMA is also aware that there are mechanisms that encourage migration.
The ACMA will continue to review the use of spectrum, including an assessment of infrastructure and technology deployments by industry to ensure existing spectrum is used as efficiently as possible.

Beyond the bands identified to meet the 2015 shortfall, the ACMA intends to look to what it believes will be a peak spectrum demand year in 2020 where as much as 300 MHz of additional spectrum, above that available in 2007, will need to be identified and made available in peak demand areas.

Nearly all spectrum suitable for wide area mobile broadband has been identified. The ACMA believes that new bands need to be identified which may service hot-spots of extreme demand, but that these bands can be higher in frequency than those used for coverage. The ACMA acknowledges that the advice of equipment vendors will be valuable in considering the future of network and system architecture options.

The ACMA also believes that much of the spectrum used in higher frequency bands may be used to ‘offload’ data to/from a fibre node inside the home or office in a similar way that 802.11 technologies do today. Further consideration on the use of home or office networks, such as femtocells, connected to the fixed network are considered in Section 5.10.

11. What types of network or system architecture could be implemented by 2015 and beyond?
12. What frequency ranges of operation would these networks or systems require operating in?
5. Candidate bands for mobile broadband

Depending on outcomes in the international environment and the effect that greater spectrum utilisation techniques have on the use of spectrum, a combination of the frequency bands discussed may provide the ACMA with the ability to meet the 150 MHz shortfall to 2015 identified in the previous section. This section is intended to identify bands under 6 GHz for possible use by mobile broadband services.

At this early stage of the process, the ACMA wishes to consider all options available to it; however, has excluded the following bands from its analysis:

> **450–470 MHz**—the ACMA has recently concluded its review of the 400 MHz band and is now in its implementation phase. This segment of the 400 MHz band was considered in the context of the review.

> **2.5 GHz**—a significant amount of work is already underway with this band and further analysis in this paper is not required.

> **Digital dividend**—a significant amount of work is already underway with this band and further analysis in this paper is not required.

The ACMA is already undertaking work in relation to the bands identified above and this work is detailed further in the current edition of the five-year spectrum outlook. It is important to recognise that this paper represents a first pass approach to considering frequency bands. The ACMA understands that there are incumbent services operating in the frequency bands identified in the analysis that will be sensitive to their particular band of operation being highlighted as a possible band for future mobile broadband services.

In order for the ACMA to formulate the next stage of the mobile broadband process, the following questions are specific to each frequency band below, and the ACMA asks interested stakeholders to provide comment against each of these questions on each band they see necessary.

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. What interest is there in the identified band for access to provide mobile broadband services? Alternatively, if there is no interest, please indicate why.</td>
</tr>
<tr>
<td>14. What impact would the introduction of mobile broadband services have on the operation of existing services in the identified band in areas of high, medium and low density areas?</td>
</tr>
<tr>
<td>15. Is there interest in replanning the identified band to better align spectrum allocations with international standards to support mobile broadband, or more generally?</td>
</tr>
<tr>
<td>16. Could sharing arrangements be developed to support the coexistence of mobile broadband services with incumbent services?</td>
</tr>
<tr>
<td>17. What quantum of spectrum could be made available for mobile broadband services in the band? How much contiguous spectrum would be required (FDD, TDD or both)?</td>
</tr>
<tr>
<td>18. Is there interest in FDD, TDD or both access methods operating in the band?</td>
</tr>
</tbody>
</table>

For each of the bands in Chapter 5:
It is important to note that the ACMA has not made any decisions nor developed any planning arrangements regarding the relevant bands’ use for mobile broadband services. The bands are included because they have been highlighted in the international environment as having the potential for use by IMT technologies. The paper provides some context on how these bands are being used in the Australian communications environment.

5.1 Bands identified for possible IMT services

A number of frequency bands were initially identified at WRC-07 and more recently as part of sharing studies conducted by ITU-R Working Party 5D to support IMT-Advanced technologies.\textsuperscript{35} There are also a number of other frequency bands that have been identified for use with IMT-Advanced technologies by the 3GPP and IEEE standards bodies.\textsuperscript{36}

Table 5.1 highlights frequency bands that may be used by mobile broadband and other IMT-Advanced services subject to the development of co-existence and sharing arrangements in the future. The bands are consistent with those identified by the ITU-R, and 3GPP and IEEE standards bodies.

An analysis of the bands listed in Table 5.1 follows, taking into account factors such as the current use of the band as well as the current regulatory arrangements that may limit or affect how mobile broadband services could be introduced in the band.


\textsuperscript{36} 3GPP, Feasibility study for further advancements for E-Ultra (LTE-Advanced Release 9), September 2009 and ITU, Acknowledgement of candidate submission from IEEE under step 3 of the IMT-Advanced process, 15 October 2009, IMT-ADV/4-E.
Table 5.1 Bands identified for possible IMT services

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Duplex method</th>
<th>Available bandwidth</th>
<th>Current use</th>
<th>Current mobile and fixed allocations (from the ARSP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>815–825 MHz and 860–870 MHz</td>
<td>FDD</td>
<td>20 MHz (2 x 10 MHz)</td>
<td>Fixed/Mobile</td>
<td>520–820 MHz Fixed and mobile (secondary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>820–890 MHz Fixed and mobile (primary)</td>
</tr>
<tr>
<td>1427.9–1462.9 MHz and 1475.9–1510.9 MHz</td>
<td>FDD</td>
<td>70 MHz (2 x 35 MHz)</td>
<td>Fixed/Mobile/Broadcast satellite</td>
<td>Fixed (primary) Mobile (primary)³⁷</td>
</tr>
<tr>
<td>1518–1559 MHz and 1610–1660.5 MHz³⁸</td>
<td>FDD</td>
<td>DL: 41 MHz UL: 50.5 MHz</td>
<td>Mobile satellite service</td>
<td>1668–1668.4 MHz Fixed and mobile (secondary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1668.4–1675 MHz Fixed and mobile (primary)</td>
</tr>
<tr>
<td>1668–1675 MHz³⁹</td>
<td>TDD</td>
<td>7 MHz</td>
<td>Mobile satellite service</td>
<td>1675–1690 MHz and 1700–1710 MHz Fixed and mobile (primary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1690–1700 MHz Fixed and mobile (secondary)⁴¹</td>
</tr>
<tr>
<td>1675–1710 MHz⁴⁰</td>
<td>TDD</td>
<td>35 MHz</td>
<td>Meteorological satellite service</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980–2010 MHz and 2170–2200 MHz</td>
<td>FDD</td>
<td>60 MHz (2 x 30 MHz)</td>
<td>Mobile satellite service</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2483.5–2500 MHz</td>
<td>TDD</td>
<td>16.5 MHz</td>
<td>Mobile satellite service</td>
<td></td>
</tr>
</tbody>
</table>

³⁷ In the band 1435–1535 MHz under footnote AUS3, the aeronautical mobile service for telemetry has priority over other uses by the mobile service.
³⁸ Australia is party to the Memorandum Of Understanding - Regions 1 And 3 Multilateral GSO/MSS Intersystem Co-Ordination For The Frequency Bands 1525–1544/1545–1559 MHz 1626.5–1645.5/1646.5–1660.5 MHz.
³⁹ The band 1668–1668.4 MHz (secondary) and 1668.4–1670 MHz (primary) is allocated to mobile except aeronautical mobile services.
⁴⁰ The only allocation to mobile services for Region 3 in the frequency range 1690–1700 is via a footnote (381), which only covers a few countries (and not Australia).
⁴¹ These services are listed in the ARSP as secondary, although there is no Australian or Region 3 allocation to these services.
<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Mode</th>
<th>Bandwidth</th>
<th>Service</th>
<th>Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3300–3400 MHz</td>
<td>TDD/FDD</td>
<td>100 MHz</td>
<td>Radiolocation</td>
<td>Fixed (secondary) Mobile (secondary)</td>
</tr>
<tr>
<td>3400–3425 MHz</td>
<td>TDD/FDD</td>
<td>25 MHz</td>
<td>Fixed/Radiolocation</td>
<td>Fixed (primary) Mobile (secondary)</td>
</tr>
<tr>
<td>3492.5–3542.5 MHz</td>
<td>TDD/FDD</td>
<td>50 MHz</td>
<td>Fixed/Radiolocation</td>
<td>Fixed (primary) Mobile (secondary) 3492.5–3500 MHz Mobile (primary) 3500–3542.5 MHz</td>
</tr>
<tr>
<td>3575–3600 MHz</td>
<td>TDD/FDD</td>
<td>25 MHz</td>
<td>Fixed/Radiolocation</td>
<td>Fixed (primary) Mobile (primary above 3600 MHz)</td>
</tr>
<tr>
<td>3600–3800 MHz</td>
<td>TDD/FDD</td>
<td>200 MHz</td>
<td>Fixed/Fixed satellite service</td>
<td>Fixed and mobile (primary)</td>
</tr>
<tr>
<td>3800–4200 MHz</td>
<td>TDD/FDD</td>
<td>400 MHz</td>
<td>Fixed/Fixed satellite</td>
<td>Fixed and mobile (primary)</td>
</tr>
</tbody>
</table>

42 In this band there is no primary allocation to the mobile service, and a secondary allocation only in Region 2.
43 These services have an AUS 11 footnote (service is intended to be used principally for the purposes of defence).
44 In the band 3400–3500 MHz, the mobile service is allocated in Region 3 on a secondary basis.
45 The ARSP lists mobile as a secondary service, although the Region 3 allocation is primary service.
5.2 The 850 MHz ‘expansion’ band

The frequency range considered in this section is the paired frequencies 815–825 MHz and 860–870 MHz. This section of the band is currently referred to as the 850 MHz ‘expansion’ band.

The 850 MHz expansion band is mainly used to support a variety of apparatus-licensed services including:

- cordless telephone systems
- fixed point-to-point services
- land mobile services.

Table 5.2 provides a summary of services allocated in the 850 MHz expansion band. The service allocations are identified in accordance with Australian allocations in the Australian Radiofrequency Spectrum Plan (ARSP). The services listed in italics are secondary allocations in the band.

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>520–820 MHz</td>
<td>Broadcasting Fixed Mobile</td>
<td>149, 306, 311A, 320</td>
</tr>
<tr>
<td>820–850 MHz</td>
<td>Fixed Mobile 317A</td>
<td>320, AUS63</td>
</tr>
<tr>
<td>850–890 MHz</td>
<td>Fixed Mobile 317A Radiolocation AUS11, AUS29</td>
<td>320</td>
</tr>
</tbody>
</table>

Table 5.3 sets out the applicable technology and equipment standards that would enable the 850 MHz expansion band to be used for mobile broadband and other wireless applications.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GPP 36 series specifications</td>
<td>E-UTRA FDD (LTE &amp; LTE-Advanced)</td>
<td>815–830/860–875 MHz</td>
</tr>
</tbody>
</table>

The 850 MHz expansion band has been identified as a band for future LTE services by 3GPP and the use of the band was supported by Ericsson in their submission to the 2011–2015 FYSO.46

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46 Ericsson’s submission to the five-year spectrum outlook can be viewed on the ACMA website at: www.acma.gov.au/webwr/assets/main/lib311829/fc08-2010_ericsson_aust_pl.pdf.
5.2.1 Regulatory arrangements

Any proposal for replanning activities in this band will require significant consultation with affected licensees before potential re-allocation/allocation decisions can be considered.

Further information on plans for the 850 MHz expansion band can be found in the 900 MHz review discussion paper available on the ACMA website.

5.3 The 1.5 GHz band

The frequency range considered in this section is 1427.9–1462.9 MHz and 1475.9–1510.9 MHz and is referred to as the 1.5 GHz band. The 1.5 GHz band currently supports a number of radiocommunications services, including:

- fixed point-to-point services
- fixed point-to-multipoint services in rural and remote areas for the operation of digital radio concentrator systems (DRCS) used for the delivery of public telecommunications services
- aeronautical mobile telemetry services.

A band plan was developed for the 1.5 GHz band (1.5 GHz Band Plan) in 1996 that shows the purposes that the band may be used, in accordance with the ARSP. The 1.5 GHz Band Plan also includes some restrictions in the frequency ranges 1452–1492 MHz that prevents any new assignments for mobile services. This segment of the band was allocated for broadcast satellite services to support digital radio services in accordance with a decision made at the World Administrative Radio Conference in 1992 (WARC-92).

Table 5.4 provides a summary of services allocated in the 1.5 GHz band. The services are identified as primary services in accordance with the ARSP. There are no secondary services identified in the segment of the band under analysis.

<table>
<thead>
<tr>
<th>Frequency band (MHz)</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 427–1 429</td>
<td>Space operation (Earth-to-space) Fixed Mobile (except aeronautical mobile)</td>
<td>338A, 341, AUS87</td>
</tr>
<tr>
<td>1 429–1 452</td>
<td>Fixed Mobile AUS3</td>
<td>338A, 341, AUS3, AUS87</td>
</tr>
<tr>
<td>1 452–1 492</td>
<td>Fixed (no new assignments accepted) Mobile AUS3 (no new assignments accepted) Broadcasting satellite 208B, 345 Broadcasting 345</td>
<td>208B, 341, 345, AUS3, AUS87</td>
</tr>
<tr>
<td>1 492–1 518</td>
<td>Fixed Mobile AUS3</td>
<td>341, AUS3, AUS87</td>
</tr>
</tbody>
</table>

Table 5.5 sets out the applicable technologies and equipment standards that enable the 1.5 GHz band to be used for mobile broadband and other wireless applications.

Table 5.5 Applicable standards and available technologies for mobile broadband in the 1.5 GHz band

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GPP 25 series specifications</td>
<td>UMTS FDD (WCDMA, HSPA, HSPA+)</td>
<td>1427.9–1447.9 and 1475.9–1495.9 MHz &lt;br&gt; 1447.9–1462.9 and 1495.9–1510.9 MHz</td>
</tr>
<tr>
<td>3GPP 36 series specifications</td>
<td>E-UTRA FDD (LTE, LTE-Advanced)</td>
<td>1427.9–1447.9 and 1475.9–1495.9 MHz &lt;br&gt; 1447.9–1462.9 and 1495.9–1510.9 MHz</td>
</tr>
<tr>
<td>IEEE 802.16 series</td>
<td>WiMAX TDD/FDD</td>
<td>1.4–1.5 GHz&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

There is limited support at the international level for TDD operation in the 1.5 GHz band. At this stage, Japan is the only country that has identified arrangements to support FDD use of the band using LTE technology. The ACMA is monitoring technology developments in this band.

### 5.3.1 Regulatory arrangements

The overlap of spectrum specified for use by Digital Sound Broadcasting (DSB) in the 1.5 GHz Band Plan is problematic. Under current arrangements, no new fixed links or mobile services are able to be allocated in this band. Because this segment of spectrum is not used by the intended service, and the ACMA is unaware of any imminent plans to deploy a digital radio service in this band, the ACMA could review the 1.5 GHz Band Plan with a view to removing the restriction on assigning new mobile services. In order for the ACMA to consider licensing other services, including mobile broadband services, the 1.5 GHz Band Plan would need to be amended, or revoked.

Further to this, there are a large number of existing services and licences issued in the 1.5 GHz band and any clearance activity would take some time to plan for and implement. The use of the band for DRCS by Telstra to fulfil its Universal Service Obligations (USO) also raises some regulatory issues requiring further investigation. For example, it may be difficult to remove operating DRCS services unless an equivalent service is able to be provided to consumers. The ACMA understands that the NBN may take over responsibility for the USO; however, how this arrangement is to be implemented is yet to be decided. Consequently, it is likely that a lengthy conversion process may occur.

In light of the above information, it is evident that the 1.5 GHz band is not immediately available for use by mobile broadband types of services. The ACMA would need to undertake a significant amount of regulatory and technical work in order to make the band available.

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<sup>a</sup> This is based on technical specifications for one manufacturer that produces 802.11d compliant equipment in this band.
5.4 The mobile satellite services bands

The FCC’s proposal to use the mobile satellite service (MSS) bands to support the deployment of mobile broadband and cellular communication services was outlined. The FCC’s proposed approach allows terrestrial mobile networks to co-exist with the MSS. This type of service is commonly referred to as an Ancillary Terrestrial Component (ATC) meaning that the end user would connect to the terrestrial network within range of a mobile base station and connect via satellite when outside the coverage area of the terrestrial network. The FCC has recently provided a waiver to allow devices to operate solely on the terrestrial network. This is discussed further in Section 5.3.1.

Figure 5.1 shows there is some overlap in the Australian and American MSS bands; it is therefore worth considering whether equipment developed for the American market for mobile broadband services can also be utilised in the Australian MSS bands. This would improve the economies of scale and encourage harmonisation of bands between Regions 2 and 3 for mobile broadband. The Australian MSS bands are coloured green/gold, and the bands identified by the FCC are red/white stripes.

Table 5.6 provides a summary of the allocations in the MSS bands outlined in Figure 5.1. The services set out in the table are identified in accordance with the ARSP showing both primary and secondary allocations. The secondary allocations are shown in italics.

5.4.1 Regulatory arrangements

Embargo 23 currently prevents applicants from obtaining apparatus licences for fixed and mobile services in the 1980–2010 MHz and 2170–2200 MHz MSS bands. Applications for Earth receive, fixed Earth and other fixed services in low density areas are considered on a case-by-case basis.

The purpose of Embargo 23 is to facilitate the introduction of the mobile-satellite service in accordance with the Mobile-Satellite Service (2 GHz) Frequency Band Plan; and to support re-planning activities in the band generally.
Table 5.6 Frequency allocation table for the MSS bands in Australia

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 518–1 525</td>
<td>Fixed Mobile AUS3</td>
<td></td>
</tr>
<tr>
<td>1 525–1 530</td>
<td>Space Operation (space-to-Earth) Fixed Mobile Satellite (space-to-Earth) 208B, 351A</td>
<td>208B, 341, 349, 351, 351A, 354, AUS3, AUS87</td>
</tr>
<tr>
<td></td>
<td>Earth Exploration Satellite Mobile 349 AUS3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Earth Exploration Satellite Mobile 349 AUS3</td>
<td></td>
</tr>
<tr>
<td>1 535–1 559</td>
<td>Mobile Satellite (space-to-Earth)</td>
<td>208B, 341, 351, 351A, 353A, 354, AUS3, AUS87</td>
</tr>
<tr>
<td>1 610–1 610.6</td>
<td>Mobile Satellite (Earth-to-space) 351A Aeronautical Radionavigation Radiodetermination Satellite (Earth-to-space)</td>
<td>341, 351A, 364, 366, 367, 368, 369, 372, AUS87</td>
</tr>
<tr>
<td>1 610.6–1 613.8</td>
<td>Mobile Satellite (Earth-to-space) 351A Aeronautical Radionavigation Radiodetermination Satellite (Earth-to-space)</td>
<td>149, 341, 351A, 364, 366, 367, 368, 369, 372, AUS87</td>
</tr>
<tr>
<td>1 613.8–1 626.5</td>
<td>Mobile Satellite (Earth-to-space) 351A Aeronautical Radionavigation Radiodetermination Satellite (Earth-to-space) Mobile Satellite (space-to-Earth) 208B</td>
<td>208B, 341, 351A, 364, 365, 366, 367, 368, 369, 372, AUS87</td>
</tr>
<tr>
<td>1 626.5–1 660</td>
<td>Mobile Satellite (Earth-to-space) 351A</td>
<td>341, 351, 351A, 353A, 354, 357, 357A, 362A, AUS87</td>
</tr>
<tr>
<td>1 980–2 010</td>
<td>Fixed Mobile Mobile Satellite (Earth-to-space) 351A</td>
<td>351A, 388, 389A</td>
</tr>
<tr>
<td>2 170–2 200</td>
<td>Fixed Mobile Mobile Satellite (space-to-Earth) 351A</td>
<td>351A, 388, 389A</td>
</tr>
<tr>
<td>2 483.5–2 500</td>
<td>Fixed Mobile Mobile Satellite (space-to-Earth) 351A Radiolocation Radiodetermination Satellite (space-to-Earth) 398</td>
<td>150, 351A, 398, 402, AUS87</td>
</tr>
</tbody>
</table>
5.5 The Meteorological Satellite Service band

The frequency range considered in this section is 1675–1710 MHz and is referred to as the Meteorological Services band, as it is used by both Meteorological Satellite (or MetSat) Services as well as Meteorological Aids. The FCC highlighted the development of possible sharing arrangements in the Meteorological Services band with mobile broadband services. Consequently, if the FCC is able to make the band available and there is a market for equipment, it is reasonable for the ACMA to also consider the feasibility for use of this band in the Australian context.

Table 5.7 provides a summary of allocations in the frequency range 1675–1710 MHz. The services set out in the table are identified in accordance with the ARSP showing both primary and secondary allocations. The secondary allocations are shown in italics.

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1675–1690 MHz</td>
<td>Meteorological Aids</td>
<td>341, AUS87</td>
</tr>
<tr>
<td></td>
<td>Fixed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meteorological Satellite (space-to-Earth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile except aeronautical mobile</td>
<td></td>
</tr>
<tr>
<td>1690–1700 MHz</td>
<td>Meteorological Aids</td>
<td>289, 341, AUS87</td>
</tr>
<tr>
<td></td>
<td>Meteorological Satellite (space-to-Earth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile except aeronautical mobile</td>
<td></td>
</tr>
<tr>
<td>1700–1710 MHz</td>
<td>Fixed</td>
<td>289, 341, AUS87</td>
</tr>
<tr>
<td></td>
<td>Meteorological Satellite (space-to-Earth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile except aeronautical mobile</td>
<td></td>
</tr>
</tbody>
</table>

Footnote AUS87 identifies radio astronomy facilities that are susceptible to interference. RALI MS31 identifies procedures for the notification of proposed new services around radio astronomy facilities covered by this footnote.

5.5.1 Regulatory arrangements

The Meteorological Services band also overlaps with the lower end of the 1.8 GHz fixed link band which occupies the 1706.5–1797.5/1825.5–1916.5 MHz band.

The FCC noted that interference to MetSat downlink transmissions could occur at a small number of sites. The FCC suggested that where such interference occurred, the information could be distributed via terrestrial services, or mobile broadband. The FCC also noted that it may be possible for radiosondes to use less bandwidth which would have the effect of freeing up spectrum for use by other services.

Initial study by the ACMA indicates that existing MetSat Services operated by the Bureau of Meteorology (BoM) may be significantly affected by the introduction of mobile broadband services in the 1675–1710 MHz band. Consideration would also need to be given to Meteorological Aids operating in the band. The ACMA understands that the BoM would be impacted if this approach were to be adopted in Australia. The ACMA intends to monitor the FCC’s progress on this issue.
### 5.6 The 2010–2025 MHz band

The frequency range considered in this section is 2010–2025 MHz and band was identified by the ITU-R as a potential band to support time division duplex (TDD) 3G IMT services in 2004. The Australian Communications Authority included the band in the 1900–1920 MHz and 2010–2025 MHz bands Frequency Band Plan 2004 to support the deployment of broadband wireless access services.

The ACMA originally embargoed this band to support planning for wireless access services (WAS). It has also been identified as a potential candidate band for electronic news gathering (ENG) services.

There are currently 34 point-to-point links with emissions that overlap into this band.

Table 5.8 provides a summary of allocations in the frequency range 2010–2025 MHz. The services set out in the table are identified in accordance with the ARSP. There are no secondary services in the band.

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010–2025 MHz</td>
<td>Fixed Mobile</td>
<td>388, 388A</td>
</tr>
</tbody>
</table>

Table 5.9 sets out the applicable technologies and equipment standards that enable the 2 GHz band to be used for mobile broadband and other wireless applications.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GPP 36 series specifications</td>
<td>E-UTRA TDD (LTE, LTE-Advanced)</td>
<td>2010–2025 MHz</td>
</tr>
<tr>
<td>3GPP 25 series specifications</td>
<td>UMTS FDD (WCDMA, HSPA, HSPA+)</td>
<td>2010–2025 MHz</td>
</tr>
</tbody>
</table>

### 5.6.1 Regulatory arrangements

The ACMA attempted to auction the 2 GHz band in 2006. The minister re-allocated the band for spectrum licensing to issue licences supporting wireless broadband services using TDD 3G technologies. The ACMA did not issue any spectrum licences at the time of the allocation process. As a result of the expiration of the re-allocation declaration on 1 January 2007, the band reverted to apparatus licensing. At this time, the band is subject to Embargo 38.

There has been some commentary regarding the use of this band for mobile broadband services at the international level. For example, Ofcom is considering allowing the PMSE sector to use the band during the London Olympic Games before allocating the band via auction for mobile broadband services.\(^{49}\)

\(^{49}\) Programme Making and Special Events.
The ACMA is monitoring the outcome of this issue; however, it should be noted that this band has been included by the ACMA in its proposed arrangements for alternative bands to support the transition of ENG services from the 2.5 GHz band.

The ACMA consulted on the review of the 2.5 GHz band in January 2010 and proposed that ENG operators could have access to the following ‘alternative bands’:  

> shared use of 2025-2110 MHz and 2200-2300 MHz  
> exclusive use of 2010-2025 MHz in capital cities  
> access to 1980–2010 MHz and 2170–2200 MHz with a caveat that MSS may be introduced in the future.

In the response to submissions paper released in October 2010, the ACMA indicated that this was still the preferred option. However, potential opportunities may still exist for accessing this band in areas outside of the capital cities in each state.

20. What impact would the introduction of mobile broadband services in regional and remote areas have on the future operation of ENG services in the band?

5.7 The 3.3 GHz band

The frequency range considered in this section is 3300–3400 MHz and is referred to as the 3.3 GHz band. This band has been highlighted for use by IMT-Advanced technologies by the IEEE; however, the ACMA has not considered making any arrangements in the band to date.

Table 5.10 provides a summary of allocations in the 3.3 GHz band. The services set out in the table are identified in accordance with the ARSP showing both primary and secondary allocations. The secondary allocations are shown in italics.

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3300–3400 MHz</td>
<td>Radiolocation AUS11</td>
<td>149, AUS11</td>
</tr>
<tr>
<td></td>
<td>Amateur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed AUS11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile AUS11</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.11 sets out the applicable technologies and equipment standards that enable the band to be used for mobile broadband and other wireless applications.

---


### 5.11 Applicable standards and available technologies for the 3.3 GHz band

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.16</td>
<td>FDD</td>
<td>3300–3800 MHz$^52$</td>
</tr>
<tr>
<td>IEEE 802.16</td>
<td>TDD</td>
<td>3300–3800 MHz</td>
</tr>
</tbody>
</table>

---

5.7.1 Regulatory arrangements

There are only three services that have obtained apparatus licences in this band including two amateur repeater stations and a single Defence licence authorised on an Australia-wide basis. Although it appears that the band has limited use, the ACMA is aware of the strategic importance of this band to Defence, in particular to support new radar systems operating on board naval vessels in the frequency range 2900–3400 MHz.$^53$ This is further supported by the application of the AUS11 footnote to other service allocations in the band.

Despite the application of this footnote, it is possible to consider changing the existing allocations to make the secondary service allocations co-primary in status noting the need to develop applicable sharing and coordination criteria.

The ACMA is seeking comment from Defence in particular, and interested stakeholders on the potential for all or part of this band (in both geography and frequency) to be used for mobile broadband services.

5.8 The 3.4 GHz band

The frequency range considered in this section is 3400–3600 MHz and is referred to as the 3.4 GHz band. The 3.4 GHz band has been planned to support the operation of both apparatus and spectrum licensing arrangements. The 3.4 GHz band currently supports a number of services including:

- fixed point-to-point services
- fixed point-to-multipoint services
- Earth receive
- spectrum licensed services.

The majority of services operating in the band are fixed stations using point-to-multipoint systems to offer different types of wireless access services (WAS). The majority of spectrum licensed services in the 3.4 GHz band are located in metropolitan areas and are due to expire in 2015.

The ACMA is undertaking an internal review of the existing technical framework for the band to enable the operation of new technologies and services. The ACMA’s proposed changes will be considered by a Technical Liaison Group (TLG) established as part of the ACMA’s normal consultation processes for the development or review of spectrum licence technical frameworks.

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$^52$ The WiMAX standard specifies that while the duplex range is adjustable, there is a minimum required duplex of 100 MHz.

Table 5.12 provides a summary of allocations in the 3.4 GHz band. The table shows the frequency range 3400–3600 MHz and is in accordance with the ARSP. The table also shows both primary and secondary allocations with the secondary allocations in italics. In addition to this, all or part of the 3400–3600 MHz band was identified by over 100 countries at WRC-07 for the implementation of IMT as indicated by footnotes 430A, 432A, 432B, 433A.

Table 5.12 Frequency allocation table for the 3.4 GHz band

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3400–3600 MHz</td>
<td>Fixed Radiolocation 433 AUS11</td>
<td>282, 433, AUS11</td>
</tr>
<tr>
<td></td>
<td>Amateur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed Satellite (space-to-Earth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.2 provides an overview of the licensing arrangements in the 3.4 GHz band.

Figure 5.2 Licensing arrangements in the 3.4 GHz band

No arrangements in place
The ACMA’s focus for the 3.4 GHz band in this section is not on the spectrum licensed segments of the band, but on the following segments:

> 25 MHz in the frequency range 3400–3425 MHz Australia-wide
> 2 x 32.5 MHz paired spectrum in the frequency range 3442.5–3475 MHz/3542.5–3575 MHz in remote areas of Australia
> 50 MHz in the frequency range 3492.5–3542.5 MHz Australia-wide
> 25 MHz available in the 3575–3600 MHz band in metropolitan areas.

Table 5.13 sets out the applicable technologies and equipment standards that enable the 3.4 GHz band to be used for mobile broadband and other wireless applications. It should be noted that proposed FDD technologies require a 100 MHz duplex split in order to operate in this band. As such there may be benefits in reviewing existing licensing arrangements in the 3.4 GHz band. For example, the 3425–3442.5/3475–3492.5 MHz sub-band imposes a 50 MHz duplex split on FDD equipment. The identified candidate bands for mobile broadband could be used to accommodate a change in these arrangements; and could increase the amount of FDD spectrum available with a 100 MHz duplex split. Such changes may also allow wider bandwidth systems to more efficiently use the spectrum available.

Although it appears TDD technologies can make use of existing and potential segments of the 3400–3600 MHz band, similar consideration (as for FDD systems) of aligning existing spectrum allocations with the identified bands may help to optimise use of the spectrum for new technologies.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.16\textsuperscript{54}</td>
<td>WiMAX FDD/TDD</td>
<td>3300–3800 MHz</td>
</tr>
<tr>
<td>3GPP 36 series specifications</td>
<td>E-UTRA FDD (LTE,LTE-Advanced)</td>
<td>3410–3500/3510–3600 MHz</td>
</tr>
<tr>
<td>3GPP 36 series specifications</td>
<td>E-UTRA TDD (LTE,LTE-Advanced)</td>
<td>3400–3600 MHz</td>
</tr>
</tbody>
</table>

Licensing and coordination arrangements would need to be developed for each of the bands, taking into account the operation of existing and in some cases proposed future services. These include the FSS, Radiolocation services, spectrum licences and point-to-point links. Any developments would be subject to further consultation with stakeholders if this band is considered to be of use for deployment of mobile broadband services by industry.

5.8.1 Regulatory arrangements: 3400–3425 MHz

The limited number of amateur services operating in the range 3400–3425 MHz provides an opportunity for this 25 MHz of bandwidth to be considered for use by mobile broadband services Australia-wide. However consideration of existing and future radiolocation services operating in this and adjacent bands will need to be given when making decisions on the future use of this band.

\textsuperscript{54} The WiMAX standard specifies that while the duplex range is adjustable, there is a minimum required duplex of 100 MHz.
The ACMA is aware that there may be some concern expressed by Defence as the lower segment of the band is used for radiolocation services. However, this concern may be mitigated by the use of a guard band in some geographic areas.

### 5.8.2 Regulatory arrangements: 3442.5–3475 MHz/3542.5–3575 MHz

2 x 32.5 MHz is potentially available; however, there are currently no services operating in this band outside spectrum licence areas. The band is highlighted in the ACMA’s Five-year spectrum outlook 2011–2015 as a potential band for future mobile broadband services in remote areas of Australia. This segment of the band is subject to spectrum licensing arrangements in metropolitan and some regional areas of Australia. The ACMA anticipates that making spectrum available for mobile broadband in areas that are not subject to spectrum licensing will be of interest to service providers and mining companies seeking to operate dedicated wireless services, including remote control and other applications.

### 5.8.3 Regulatory arrangements: 3492.5–3542.5 MHz

The ACMA believes that the frequency range 3492.5–3542.5 MHz could be a potential candidate band to provide mobile broadband services and is included in the Five-year spectrum outlook 2011–2015 as a band subject for review. The band is currently unplanned, with only a limited number of amateur services operating in it.

As a result, the ACMA believes the band could be made available for mobile broadband services in the short term. However, this is dependent on whether there is demand to replan the 3.4 GHz band as a whole to better align with international standards.

### 5.9 The 3.8 GHz band

The frequency range considered in this section is 3600–4200 MHz and is referred to as the 3.8 GHz band. The 3.8 GHz band currently supports a number of radiocommunications services, including:

- fixed point-to-point services
- fixed point-to-multipoint services
- Fixed Satellite Services (FSS).

Table 5.14 provides a summary of allocations in the 3.8 GHz band. The table shows the frequency range 3600–4200 MHz and is in accordance with the ARSP.

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Service allocation</th>
<th>ARSP footnotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3600–4200 MHz</td>
<td>Fixed Satellite (space-to-Earth)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Mobile except aeronautical mobile</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.15 sets out the applicable technologies and equipment standards that enable the 3.8 GHz band to be used for mobile broadband and other wireless applications.
Table 5.15 Applicable standards and available technologies for mobile broadband in the 3.8 GHz band

<table>
<thead>
<tr>
<th>Standard</th>
<th>Technology</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.16</td>
<td>WiMAX FDD/TDD</td>
<td>3300–3800 MHz</td>
</tr>
<tr>
<td>IEEE 802.11</td>
<td>WiFi (TDD)</td>
<td>3650–3700 MHz</td>
</tr>
<tr>
<td>3GPP 36 series specifications</td>
<td>E-UTRA TDD (LTE,LTE-Advanced)</td>
<td>3600–3800 MHz</td>
</tr>
</tbody>
</table>

The 3.8 GHz band has been identified in Europe for the deployment of BWA services from 2012. The FCC has also released 3650–3700 MHz for BWA services in the US and recently announced the potential use of the 3500–3650 MHz band for WAS within the next five years.

This band formed part of the original fixed WiMAX profile bands and a number of manufacturers produce equipment that operates in this band. The band has also been identified as an operating band for IEEE 802.16m (WiMAX 2) in submissions to the ITU-R.

In 2008, the WiFi standard has also modified to enable high powered systems to operate in the 3650-3700 MHz band, specifically for the US market.

5.9.1 Regulatory arrangements

The 3.6–4.2 GHz band (C-band) is used worldwide by the FSS. There are approximately 160 geostationary satellites currently operating in C-band worldwide. In 2007 (with a revision in 2008) the Asia-Pacific Telecommunity (APT) Wireless Forum (AWF) finalised a report on the co-existence of Broadband Wireless Access (BWA) in the 3.4–4.2 GHz band titled, Report on the co-existence of Broadband Wireless Access in the 3.4–3.6 GHz Band and Fixed Satellite Service in 3.4–4.2 GHz Band. Working parties 5A and 4A of the ITU have also finalised a report regarding Studies on compatibility of broadband wireless access (BWA) systems and fixed-satellite service (FSS) networks in the 3 400–4 200 MHz band (ITU-R Report S.2199). Both these papers outline the studies that have been conducted on the technical implications of co-existence of the BWA and the FSS.

Along with the APT and ITU, it is clear that the satellite industry is committed to defining the impact of sharing the C-band frequencies, and identifying if the FSS and BWA can co-exist. While the ACMA has not yet formally included the standard C-band as a potential band for consideration towards mobile broadband in the Five-year spectrum outlook 2010–2014, the ACMA is aware that other countries are already investigating the possibility of mobile broadband (or fixed broadband) using this band.

55 The WiMAX standard specifies that while the duplex range is adjustable, there is a minimum required duplex of 100 MHz.
56 Although this is not considered to be a mobile technology, it is considered here as it represents an important BWA global standard.
57 Refer to European Commission Decision 2008/411/EC.
Embargo 42 prevents licensing of point-to-point and the FSS in the 3575–3710 MHz band in order to allow WAS to be deployed. The ACMA previously announced that the status of these services would be reviewed by the ACMA approximately one year after the band’s release for WAS. The ACMA is still releasing the band for WAS and the review will occur once all geographic areas have been released.

5.10 Bands greater than 4.2 GHz
The ACMA is also considering bands between 4.2 and 6 GHz for future mobile broadband applications.

Internationally, there has been limited focus on the use of bands above 4.2 GHz for the purposes of providing mobile broadband services to users. There are valid reasons for the focus remaining below 4.2 GHz; however, with the availability of spectrum below 4.2 GHz becoming scarce, it is prudent to consider mobile broadband use in bands not traditionally recognised for their use.

The Radiocommunications (Low Interference Potential Devices) Class Licence 2000 identifies several bands above 4.2 GHz that could potentially provide spectrum for operators to deploy femtocells to increase coverage in the home and in coverage black spots. These bands include the:

- 5150–5250 MHz (RLAN transmitters indoors)
- 5250–5350 MHz (RLAN transmitters indoors)
- 5470–5600 MHz (RLAN transmitters)
- 5650–5725 MHz (RLAN transmitters)
- 5725–5875 MHz (ISM band).

Bands above 4.2 GHz are primarily allocated to fixed and satellite services where the use of large antennae and transmission facilities are well suited to the power requirements needed to enable effective communications over large distances. However, these bands may be useful for high bandwidth mobile applications if spread spectrum and diversity techniques are used. Ultra wide-band (UWB) devices are a key example of technologies that are well suited to frequencies above 4.2 GHz.

Devices using spectrum above 4.2 GHz could be used to provide in-home and personal communications services, similar to those already provided by 802.11 technologies in the 2.4 GHz and 5.8 GHz class licensed bands.

The primary benefit of considering bands greater than 4.2 GHz is to support the rollout of femtocell-like infrastructure which has the potential to increase spectral efficiency by offloading capacity from macro network environments to personal networks. The ACMA has not yet identified any bands above 4.2 GHz for mobile broadband services or technologies.

---

21. What bands above 6 GHz do stakeholders feel could be released for mobile broadband?

22. What international activities are stakeholders aware of that could result in the potential release of bands above 4.2 GHz for the purposes of mobile broadband?

23. What are the expected timeframes the ACMA could release bands above 4.2 GHz for the purposes of mobile broadband?

24. Could bands above 4.2 GHz provide the necessary spectrum to support femtocell infrastructure? If so, how much contiguous (or non-contiguous) spectrum would be required (please specify the bands identified)?
6. Summary

It is expected that this paper will facilitate continued dialogue with stakeholders focused on identifying spectrum for mobile broadband, and satisfying the needs of incumbent operators. This paper is anticipated to be the first in a series of papers underpinning the ACMA’s project, *Future spectrum requirements for mobile broadband*, flagged at item 4.2.4 in the ACMA’s *Five-year spectrum outlook 2011–2015*.64

The paper identifies that there is still a remaining shortfall in mobile broadband spectrum out to 2015, and that this shortfall will remain until 2020 unless additional spectrum is made available to meet demand. The ACMA has proposed a number of candidate bands in Chapter 5 that it feels may meet the requirements of the mobile broadband community, however; the ACMA notes that in some cases these bands are heavily utilised and that further dialogue with incumbents needs to be continued in order to satisfy both arguments.

In order to provide additional mobile broadband spectrum, it is recognised that backhaul is required to provide the raw bandwidth to each of the transmission towers. In considering the bands identified in Chapter 5, the ACMA asks stakeholders to consider the requirements on backhaul, especially microwave backhaul. The ACMA recognises that some of the backhaul pressure currently experienced in some of the fixed service bands below 5 GHz may be alleviated through the introduction of the NBN, so long as the fibre footprint follows major trunk and arterial routes where mobile broadband infrastructure is required.

25. Where do stakeholders believe additional pressure will be placed on backhaul requirements in relation to specific frequency bands and geographic areas as a result of the increasing demand for mobile broadband?

26. Do stakeholders believe the NBN will provide a role in reducing the requirement for microwave backhaul in bands below 5 GHz?

6.1 Issues for comment

The ACMA welcomes submissions on the range of issues in this discussion paper and requests comments from stakeholders. Below are all of the questions raised throughout the body of the paper:

1. Are there any other issues not addressed in this paper that the ACMA should consider in the context of its analysis of future spectrum requirements for mobile broadband services out to 2020?
2. How should the ACMA encourage a band to move to its highest value use?
3. What allocation mechanisms should the ACMA take into account when considering the highest value use of the spectrum?
4. What public interest arguments are there for reviewing the existing arrangements for a band, or alternatively, not reviewing the existing arrangements for a band?
5. What factors should the ACMA take into account when attempting to balance both ‘certainty’ and ‘flexibility’ in its spectrum management arrangements?

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The baseline demand for mobile broadband spectrum in Australia

6. Are the ACMA’s assumptions on establishing a baseline for demand correct?
7. Are there other strategies to establish spectrum demand that the ACMA has not thought of, or applied?

Strategies to address increased demand

8. What are some of the emerging technologies that providers may consider deploying in their respective network architecture in the next five- to 10-year period?
9. Should particular new or emerging technologies be considered a higher priority than others? Why is this the case?
10. The ACMA notes that some providers have indicated that there may be some constraints on using new technologies, such as femtocells, in current network architecture. What are the current constraints and what arrangements could the ACMA consider introducing that would facilitate their use?
11. What types of network or system architecture could be implemented by 2015 and beyond?
12. What frequency ranges of operation would these networks or systems require operating in?

Candidate bands for mobile broadband

The following questions are applicable to each of the frequency bands identified in Chapter 5:

13. What interest is there in the identified band for access to provide mobile broadband services? Alternatively, if there is no interest, please indicate why.
14. What impact would the introduction of mobile broadband services have on the operation of existing services in the identified band in areas of high, medium and low density areas?
15. Is there interest in replanning the identified band to better align spectrum allocations with international standards to support mobile broadband, or more generally?
16. Could sharing arrangements be developed to support the coexistence of mobile broadband services with incumbent services?
17. What quantum of spectrum could be made available for mobile broadband services in the band? How much contiguous spectrum would be required (FDD, TDD or both)?
18. Is there interest in FDD, TDD or both access methods operating in the band?

Specific questions raised in Chapter 5 include:

The MSS bands:
19. What interest is there in industry for ATC systems to be deployed in Australia?

The 2010–2025 MHz band:
20. What impact would the introduction of mobile broadband services in regional and remote areas have on the future operation of ENG services in the band?

Bands greater than 6 GHz:
21. What bands above 6 GHz do stakeholders feel could be released for mobile broadband?
22. What international activities are stakeholders aware of that could result in the potential release of bands above 4.2 GHz for the purposes of mobile broadband?
23. What international activities are stakeholders aware of that could result in the potential release of bands above 4.2 GHz for the purposes of mobile broadband?

24. What are the expected timeframes the ACMA could release bands above 4.2 GHz for the purposes of mobile broadband?

25. Could bands above 4.2 GHz provide the necessary spectrum to support femtocell infrastructure? If so, how much contiguous (or non-contiguous) spectrum would be required (please specify the bands identified)?

Summary

26. Where do stakeholders believe additional pressure will be placed on backhaul requirements in relation to specific frequency bands and geographic areas as a result of the increasing demand for mobile broadband?

27. Do stakeholders believe the NBN will provide a role in reducing the requirement for microwave backhaul in bands below 5 GHz?

The ACMA encourages respondents to quantify, wherever possible, any costs and benefits identified in their submissions.
Appendix A: Analysis of the international environment

The national regulatory authorities of the countries included in the following analysis focus on the improvement of spectrum management strategies and competition in their spectrum allocations, including spectrum trading techniques, to facilitate the movement of spectrum to its highest value use. The analysis below is separated into the different ITU Regions (Region 1, 2 and 3).

A1.1 Region 1

A1.1.1 European Union

In 2007, the European Commission published plans to introduce greater flexibility in the use of spectrum in 2G and 3G bands that would encourage the use and deployment of new technologies for mobile broadband. Following on from this, a directive was published in 2009 stating that the 900 MHz and 1800 MHz bands, previously used for the provision of GSM technologies, could be re-planned for use by new technologies to provide 3G and 4G services.65

The European Union (EU) released its Digital Agenda for Europe: 2010–2020 in May 2010 setting out the following objectives:66

> ensure broadband coverage of all EU citizens by 2013
> offer broadband coverage at 30 Mbps or more for at least half of EU households by 2020.

The Digital Agenda for Europe: 2010–2020 also included a strategy designed to improve spectrum allocations in Europe through the creation of a coordinated and strategic spectrum policy directed at the EU level that would increase the efficiency of spectrum management and, in turn, maximise the benefits for consumers and industry. The details of this strategy are expected to include recommendations on stimulating investments and propose a comprehensive spectrum plan, in accordance with Recommendation 4 – Very Fast Internet.67 However, these details are yet to be released.

The discussion below provides examples of some of the spectrum management and planning activities being undertaken by individual members of the European Union.

A1.1.2 United Kingdom

On 16 June 2009, the UK Government published its Digital Britain: Final Report68 in which the government proposed, inter alia, a combined auction of the 800 MHz and 2.6 GHz bands in conjunction with a relinquishment of spectrum in the 1.8 GHz or 2.1 GHz bands by mobile network operators.69 The objective is to increase mobile

68 Department for Business Innovation and Skills and the Department for Culture, Media and Sport, Digital Britain: Final Report, June 2009 available at interactive.bis.gov.uk/digitalbritain/report/.
69 Which had also been a recommendation in the earlier report of the Independent Spectrum Broker at www.dcms.gov.uk/images/publications/ISB_final_report.doc.
network operators’ capacity to provide mobile broadband access in urban and rural areas.

In December 2010, the UK Government released a paper titled *Britain’s Superfast Broadband Future* the paper that echoed the announcement of the FCC in 2010 and recommended at least 500 MHz of spectrum be made available for mobile broadband within 10 years. This quantum of spectrum would assist in ensuring that virtually all homes in the UK have access to a minimum service level of 2Mbps by 2015.

The service mix highlighted in the paper aligns heavily with those of the Australian NBN; that is, a mixture of fixed, mobile and satellite services. The paper suggests that part of the spectrum requirements may be met through the Ministry of Defence reviewing its spectrum holdings and relinquishing some spectrum for release to the market in 2013. The government target of 500 MHz is to be found below 5 GHz in bands not already allocated to mobile broadband. It should be noted that the suggestions set out in the paper have not been supported by Ofcom to date.

**A1.2 Region 2**

**A1.2.1 United States of America**

The Federal Communications Commission (FCC) released its *National Broadband Plan* announcing that 500 MHz of spectrum needed to be made available by 2020 to meet the telecommunications industry’s projected demand for mobile broadband. The report stated that 300 MHz of the required spectrum in the frequency range 225 MHz and 3.7 GHz could be made available by 2015. Some of the recommendations in the *National Broadband Plan* to achieve this include:

> making 20 MHz available for mobile broadband use in the 2.3 GHz band
> auctioning 10 MHz of spectrum in the 700 MHz band (Upper 700 MHz D Block) with technical parameters that make the spectrum compatible with public safety broadband services
> auctioning 60 MHz of spectrum in the Advanced Wireless Services (AWS) bands
> accelerating terrestrial deployment in 90 MHz of spectrum allocated for use by Mobile Satellite Services (MSS)
> re-allocating 120 MHz from broadcast television bands.

The FCC has subsequently released two papers detailing the *Plan and Timetable to Make Available 500 MHz of Spectrum for Wireless Broadband* (the Plan and Timetable) and *An Assessment of the Near-Term Viability of Accommodating Wireless*

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71 The recommendations discussed in this section relate directly to the recommendations made in Chapter 5 of the National Broadband Plan that directly relate to the release of further spectrum for mobile broadband. The National Broadband Plan makes a number of other recommendations in relation to regulatory changes that would facilitate greater spectrum utilisation and sharing, however these issues are not discussed in this paper. Announcement made in chapter 5 of the FCC’s *Connecting America: The National Broadband Plan*, 2010, p.75 available at [www.broadband.gov/plan/](http://www.broadband.gov/plan/).

72 Advanced Wireless Services (AWS) bands includes the paired frequency range 1710–1755 MHz and 2110–2155 MHz allocated in blocks A to F; and proposed new paired frequency bands 1915–1920 MHz/1995–2000 MHz and 2020–2025 MHz/2175–2180 MHz.

73 The MSS bands affected by the proposed arrangements operate in the frequency ranges 1525–1559 MHz and 1626.5–1660.5 MHz; 1610–1626.5 MHz and 2483.5–2500 MHz; and 2000–2020 MHz and 2180–2200 MHz.


Broadband Systems in the 1675–1710 MHz, 1755–1780 MHz, 3500–3650 MHz, and 4200–4220, 4380–4400 MHz Bands (the Assessment).76

The Plan and Timetable identifies more than 2200 MHz of federal and non-federal spectrum the NTIA and FCC consider viable for mobile broadband between the frequency 225 MHz and 4400 MHz. The Plan and Timetable sets out an aggressive program to make 500 MHz of spectrum available through government coordination. The program takes into account the review, replanning and relocation activities for this to occur.

The Assessment identifies various portions of the candidate bands totalling 115 MHz to be made available for sharing with fixed and/or mobile broadband services within the next five years. It is also noted in the Assessment that recommendations are unable to be made for some of the candidate bands due to the fact that many federal agencies use common spectrum and re-allocation options must be identified and made available prior to the release of spectrum.

A1.2.2 Canada

Like the USA and many other countries, Canada is also experiencing high and growing demand for mobile broadband. Canada’s wireless sector has only recently become more competitive with the three dominant telecommunications providers deploying HSPA networks providing coverage to 93 per cent of its population in 2009.77 In June 2010, the Canadian Senate’s Standing Committee on Transport and Communications released a report titled Plan for a Digital Canada that made a number of recommendations designed to transition Canadians from being digital tourists opposed to fully functioning citizens within a digital society.78

In order to meet the growing demand for mobile broadband services and applications, Industry Canada, the communications regulator, intends to undertake the following activities:79

> re-plan the 2.5 GHz band to allow for flexible use, including mobile broadband
> plan the 700 MHz band to support next generation wireless as a result of the digital dividend process in 2011
> investigate the use of broadcasting white spaces for new low power techniques;
> consider options for removing regulatory blocks to provide market efficiencies and ease secondary trading
> develop a new licence fee structure to encourage efficient spectrum use.

Industry Canada’s plans to auction spectrum in both the 700 MHz and 2.5/2.6 GHz bands in 2011 may be delayed until 2012 as a result of associated delays in the digital television transition process. This may cause some concern for Industry Canada as existing spectrum licences in the 2.5/2.6 GHz band expire in 2011.80

78 Senate of Canada, Standing Committee on Transport and Communications, Plan for a Digital Canada, June 2010.
80 Ibid
A1.3 Region 3

A1.3.1 Japan

The Ministry of Internal Affairs and Communications (MIC) has allocated, or intends to allocate, the following frequency bands for use by mobile broadband and other 3G or 4G services:

- 800 MHz band for 3G mobile telecommunications
- 1.5 GHz, 1.7 GHz, 2 GHz and 2.5 GHz bands for mobile broadband and telecommunications services
- 3.4–4.2 GHz and 4.4–4.9 GHz bands for mobile broadband services.

The 700 MHz band will be made available after the switch off of analogue broadcasting; and the 900 MHz band will be available after the re-allocation of mobile phone frequencies in the 800/900 MHz bands. Broadcasters are vacating the 700 MHz band in July 2010 but allocation arrangements for the ‘dividend’ have not yet been proposed. As the available 700 MHz band is insufficient for sharing by the major mobile carriers, the MIC is reported to be considering pairing the 700 MHz and 900 MHz bands instead of implementing the standardised band plan arrangements for the 700 MHz band.\(^{81}\)

A1.3.2 Korea

There appears to be a significant amount of spectrum transfer, or re-allocation, occurring in Korea.\(^{82}\) For example, the Korea Communications Commission (KCC) announced that in 2011 it will re-allocate 20 MHz of wireless spectrum currently held by SK Telecom in the 800 MHz band to the smaller operators, KT Corp and LG Telecom. In exchange for access to the re-allocated 800 MHz spectrum, KT Corp and LG Telecom may be required to relinquish their licences in the 1.8 GHz band.

Other re-allocation activities are also planned by the KCC including:

- the re-allocation of 20 MHz of spectrum in the 900 MHz band to KT Corp, LG Telecom and other possible new entrants
- the allocation of an additional 20 MHz in the 2.1 GHz band, with SK Telecom the likely recipient.

The outcome of these activities will transfer 60 MHz of spectrum between existing and proposed licensees in the 800 MHz, 900 MHz and 2.1 GHz bands.

A1.3.3 India

India’s Department of Telecommunications has recently allocated spectrum in the 2.1 GHz, 2.3 GHz and 2.5 GHz bands to support 3G services and broadband wireless access (BWA) services respectively.\(^{83}\)

The Department of Telecommunications is undertaking spectrum reform initiatives in the following frequency bands to make them available for mobile services and other IMT applications:\(^{84}\)

- 450–470 MHz (450.5–457.5 MHz/460.5–467.5 MHz)
- 698–806 MHz


\(^{83}\) Ibid

\(^{84}\) Ibid
> 1900–1910 MHz/1980–1990 MHz
> 3300–3600 MHz.